CALIFORNIA COASTAL COMMISSION
South Coast Area Office
301 E. Ocean Blvd. Suite 300
Long Beach, CA 90802-4302
(562) 590-5071

F17a

CDP 5-21-0640 (City of Newport Beach)

October 14, 2022

CORRESPONDENCE

ATTACHMENT C: CORRESPONDENCE RECEIVED FOR THE OCTOBER 14, 2022 HEARING SINCE THE STAFF REPORT WAS PUBLISHED ON SEPTEMBER 30, 2022

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 5:03 PM
To: Revell, Mandy@Coastal
Subject: FW: California Coastal Commission - OPPOSED to Application #5-21-0640, Agenda F17a, October 14,2022 (please see below)

From: Stacey Brown <staceybrown@me.com>
Sent: Friday, October 7, 2022 4:58 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>; Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Cc: Greg D Brown <gbrown@mac.com>; Stacey Brown <staceybrown@me.com>
Subject: California Coastal Commission - OPPOSED to Application #5-21-0640, Agenda F17a, October 14,2022 (please see below)

Hello -

My name is Stacey Kirkpatrick Brown, 211 Via Ravenna, Newport Beach, CA 92663

949-500-2156 (mobile)

I am **OPPOSED** to Application #5-21-0640
Agenda F17a
October 14, 2022

Please accept this into your email receipts as completely OPPOSED to the above.

Revell, Mandy@Coastal

From:	dave@earsi.com
Sent:	Friday, October 7, 2022 5:00 PM
To:	Revell, Mandy@Coastal
Subject:	FW: Application # 5-21-0640
Attachments:	Ltr to Coastal Commission App # 5-21-0640.pdf

From: dave@earsi.com <dave@earsi.com>
Sent: Friday, October 07, 2022 4:22 PM
To: 'mandy.revelll@coastal.ca.gov' <mandy.revelll@coastal.ca.gov>
Subject: Application # 5-21-0640

Hi Mandy,

I appreciate the opportunity to comment on Coastal Permit Application #5-21-0640.

<u>I oppose the permit application as proposed</u>.

<u>I would support this application with added conditions (see attached).</u>

Thank you for this opportunity to comment.

Feel free to call or email questions.

Sincerely,

Dave Tanner
223 62nd Street
Newport Beach, CA 92663
949 233-0895 cell

October 7, 2022

Ms. Donne Brownsey, Chair
California Coastal Commission,
South Coast Area Office
301 East Ocean Blvd., Suite 300
Long Beach, CA 90802-4302

Coastal Permit Application No. 5-21-0640 (City of Newport Beach, Newport Beach)
Hearing Date: October 14, 2022
Agenda Item F17a

Madam Chair and Members of the Commission,

I appreciate the opportunity to comment on this Coastal Permit Application. I oppose the permit application as proposed. I would support this application with the following added conditions:

1. Prior to dredging any material not suitable for ocean disposal, the Applicant shall return to the Commission for review and approval of an upland disposal site for all materials not suitable for ocean disposal.

2. Prior to dredging, additional testing be conducted to verify the findings of the testing conducted to date. Should a significant change in the findings result, the application be returned to the Commission for further action.

3. The disposal site(s) for material not suitable for ocean disposal be designed and sized to accommodate dredging from all sources and all contaminants, including private docks within the harbor.

I support dredging. I do not support the use of a CAP. The CAP is a temporary action to bury material not suitable for ocean disposal. The CAP is not encapsulated, leaching of contaminates over time could occur. The use of a CAP does not reduce contamination of coastal resources. In addition, on-going use of Newport Harbor will add to the total levels of contamination of coastal resources (existing + future).

It has come to my attention there may be upland disposal sites in proximity to Newport Harbor willing to take the dredged material not suitable for ocean disposal. An upland disposal site would result in a net reduction of contaminated coastal resources.

It has come to my attention privately funded sampling of Newport Harbor sediment has found toxicity levels exceeding the levels contained in the Project EIR.

I recommend the Commission add the conditions above requiring the City of Newport Beach to verify toxicity levels and quantities, and demonstrate to the satisfaction of the Commission that no upland disposal sites exist at this time.

In way of background, until December 31, 2021 I was owner of Environmental & Regulatory Specialists, Inc., a Newport Beach consulting firm. The firm was founded in 2000 by myself and Mr. Mark Sudol. Mr. Sudol left the firm to head the Army Corps of Engineers Regulatory Branch, LA District office and later to head the ACOE Regulatory Branch in Washington D.C. I have practiced environmental planning and regulatory permitting for approximately 47 years including the preparation of well over 1,000 CEQA documents for Lead Agencies. I have retired and was not able to participate in the review of the EIR due to COVID.

I would be happy to take any questions from staff or the Commission.

Thank you for this opportunity to comment.

Sincerely,

David J. Tanner
223 62nd Street
Newport Beach, CA 92663
949 233-0895 Cell

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:56 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

From: Debra Bibb <dbibb@pacificsir.com>
Sent: Friday, October 7, 2022 4:54 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.
I am a 60 year resident and 46 year homeowner in Newport Beach.
I grew up sailing on the bay every day and water skiing in the back bay. Newport Harbor is in dire need of a major dredge. This is the best option for our harbor and it's future.
Please approve this needed project.

Thank you,

Debi Bibb
2552 Circle Drive
Newport Beach Ca 92663

949.533.5101

Debi Bibb

M 949.533.5101 |

Revell, Mandy@Coastal

From: Kim Lewand-Martin <kim@jfnovaklaw.com>
Sent: Friday, October 7, 2022 5:00 PM
To: Stefanie Sessina
Cc: SouthCoast@Coastal; Jennifer Novak; Revell, Mandy@Coastal
Subject: Re: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

Mandy et al, Please note the Exhibits support Friends of Newport's Comment Letter submitted in the same email. The file was too large to send them as one attachment.

Please feel free to reach out with any questions.

Best,

Kim

Kim Lewand Martin
Of Counsel
Law Office of Jennifer F. Novak
500 Silver Spur Road, Suite 206
Rancho Palos Verdes, California 90275
(310) 693-0775 office
(310) 291-4476 mobile
(310) 627 0172 fax
www.jfnovaklaw.com

The Law Office of Jennifer F. Novak Environmental Law

On Oct 7, 2022, at 4:43 PM, Stefanie Sessina <stefanie@jfnovaklaw.com> wrote:

EXHIBITS 1 - 7.pdf

Respectfully,
Stefanie

Law Office of Jennifer F. Novak
500 Silver Spur Road, Suite 206
Rancho Palos Verdes, California 90275
(310) 693-0775 office
www.jfnovaklaw.com
stefanie@jfnovaklaw.com

<2022.10.07_FNH comment ltr CCC Final SIGNED PDF.pdf>

The Law Office of
Jennifer F. Novak
Environmental Law

500 Silver Spur Road, Suite 206
Rancho Palos Verdes, California 90275
T: (310) 693-0775
novak@jfnovaklaw.com

October 7, 2022

Mandy Revell, Coastal Program Analyst
California Coastal Commission, South Coast District
301 Ocean Boulevard, Suite 300
Long Beach, California 90802

Sent by electronic mail: mandy.revell@coastal.ca.gov

RE: **Request for Denial (or, Alternatively Postponement) of October Agenda Item F (17)(a)**
CDP Application NO. 5-21-0640

To: CDP Application No. 5-21-0640,
City of Newport Beach proposed Confined Aquatic Disposal (CAD) Facility:

On behalf of Friends of Newport Harbor, LLC (Friends), we provide these comments for consideration by the California Coastal Commission (Coastal Commission) regarding the City of Newport Beach's (City) application for a Coastal Development Permit (CDP) for construction of a Confined Aquatic Disposal (CAD) in Newport Bay. Friends of Newport Harbor represents a significant number of local citizens and directly affected residents who are gravely concerned about the proposed CAD and the long and short-term effects on Lower Newport Bay's water quality, animal, and plant species, and designated beneficial uses.

1. **The Coastal Commission Should Deny The City's Application For Failure to Fully Analyze the Proposed Dredge Material or, Alternatively, Ask The City to Extend Its Application For 90 Days.**

Despite the Staff Report's implication that a full and appropriate environmental review has been conducted, and that the required sampling and analysis has been performed, **that is not true.** The City failed to perform an entire suite of sampling that, according to U.S. Army Corps of Engineers (USACE) technical guidance documents, *must* be performed *before* a CAD may be considered and constructed to accept contaminated material. We have searched through all the City's offered evidence and documentation for this project, as well as the Coastal Commission Staff Report and Exhibits. While the City references its compliance with *other* USACE guidance documents for *other* methods of disposal, none of the environmental review documents, nor any testimony or correspondence from the City, even acknowledge the applicable process.

As the Commission is aware, there are three ways to dispose of dredged material, and each method has its own unique corresponding guidance documents that must be followed. These are:

1) nearshore disposal (with its related *USACE Upland Testing Manual*; 2) open ocean disposal (with its related *USACE Evaluation for Open Ocean Disposal of Dredge Material)*; and 3) disposal into a CAD (with its related *USACE Subaqueous Capping Technical Guidance)*. We have attached as Exhibit 1 a flow chart prepared by Friends' scientific expert to better illustrate the above. Because the City proposes to place the material into a CAD, it must follow the *USACE Subaqueous Capping Technical Guidance.* We invite the Commission to both examine the City's application and to have its staff evaluate whether the City's modeling to determine predicted potential contaminant levels provides the same quality of data provided by actual chemical analysis. Modeling predicted levels of contaminants, then using those predictions to model environmental effects, compounds the problem of lack of adequate sampling data and creates unfounded assumptions. This is especially concerning when it appears that no government agency will require the City (or anyone) to test the actual dredged material before it is placed in the CAD; the monitoring proposed by the Regional Water Board and the Commission require sampling only after the material has already been placed in the CAD.

The City followed other USACE manuals for open ocean and land disposal when determining that the material to be dredged from Newport Harbor would be inappropriate for either of those disposal methods. Relying upon one round of limited sediment sampling, the City was able to determine the material was "unsuitable" for open ocean or nearshore disposal. This is the amount of, and quality of, sampling that the Staff Report references on page four. At that point, the City stopped further examination of the material. The City's limited sampling was sufficient only to form a basic understanding of the unsuitability of the material for open ocean disposal. Unfortunately, this limited and insufficient sampling led the City to choose a CAD for its disposal. This is where they erred. Once the City determined the material was unsuitable, it could no longer rely upon USACE manuals for non-CAD disposal to continue with the process of planning for the CAD. Rather, at that point, the City was required to follow the *USACE Subaqueous Capping Technical Guidance.* This manual makes it clear that the guidance applies to permit applicants like the City, and not just the Army Corps of Engineers:

"The technical guidance in this report is intended for use by USACE and EPA personnel, State regulatory personnel, as well as dredging permit applicants and others (e.g., scientists, engineers, managers, and other involved or concerned individuals)." (*USACE Subaqueous Capping Technical Guidance,* Page 2)

The *USACE Subaqueous Capping Technical Guidance*, which we have attached for the Commission's convenience as Exhibit 2, requires chemical, physical, and biological testing of any material proposed for CAD disposal. The manual sets forth the need to fully understand the nature of material proposed for disposal *before* a CAD is selected, designed, and permitted. Thus, each type of testing and characterization is required. One cannot substitute for another. As the manual states:

- "The contaminated sediment *must* be characterized from physical, chemical, and biological standpoints." p. 10, *USACE Subaqueous Capping Technical Guidance.*

- Characterization of the contaminated sediment is necessary to evaluate environmental acceptability and determine physical and engineering properties necessary to predict short and long-term behavior of the sediments. p. 16.
- Even when the material will be capped, the testing is still required to understand the effects on the water column. p. 18.

Yet no oversight agency, nor the City, can demonstrate that this requirement was met. Indeed, none of these agencies even reference or acknowledge the process required by the *USACE Subaqueous Capping Technical Guidance.* Instead, the City has consistently pointed to its adherence to the *USACE Evaluation for Open Ocean Disposal of Dredge Material* to argue proper sampling guidance was followed. However, even if the City followed the *USACE Subaqueous Capping Technical Guidance*, it was still required to follow sampling protocols outlined in the *USACE Subaqueous Capping Technical Guidance*. The Staff Report notes on page 37 that "Pursuant to the requirements of the Army Corps of Engineers and under the direction of the U.S. Environmental Protection Agency (EPA), the applicant conducted physical, chemical, and biological tests on the sediments within the proposed dredging areas of Newport Bay." However, as noted, the applicant did not follow the proper USACE requirements, so this statement is incorrect.

When the City conducted its sampling, it did so as a composite: it blended unsuitable material with suitable material. <u>It was also supposed to test the unsuitable material alone to determine its chemistry</u>. Under the required process to select, design, and construct CADs, chemical testing is a critical component, as it helps to determine whether material is suitable for a CAD, and the types of engineering construction necessary to contain that material. The sampling data inform the project. The City's claimed "rigorous environmental analyses" is a **single sampling event in 2019** that took a limited number of samples in each dredged area and did not measure the chemistry of each layer of material. For a proposal as significant as burying contaminants near people's homes, one sampling event conducted by the City, while never individually testing the contaminated material for its effects on water quality or toxicity of laboratory animals, is severely insufficient.

The project cannot be selected and designed, then justified ad hoc, after-the-fact. Chemical testing of the CAD placement material is required to be done as part of the planning process to determine whether a CAD is appropriate, where it should be placed, and how it should be constructed. Any requirements to sample *after* the planning process has already occurred are an after-the-fact justification, not a true consideration of the environmental and health effects.

Neither the City or the Coastal Commission may look to the Water Board Clean Water Act Section 401 Water Quality Certification and Order for the Lower Newport Bay Confined Aquatic Disposal Construction Project (SARWQCB WDID #302021-09) (401 Order) to remedy this fatal flaw. While the RWQCB is requiring, and the Coastal Commission Staff Report recommends, ongoing future monitoring, this does not remedy the fact that there is no plan to find out what is in the unsuitable material in the first place. And the prospect of future monitoring rings hollow when neither agency proposes any measures to shut down the CAD project if futures exceedance of water quality is detected.[1]

This is not simply a procedural defect; as Friends has consistently maintained, this required testing of unsuitable material makes logical sense as it is critically needed to protect human health and the health of the marine environment of Newport Bay. And Friends' concern about the unsuitable sediments containing elevated levels of contaminants is not simply hypothetical. We direct you to recent sampling conducted by Brent Mardian of PI Environmental and referenced in his comments to the Coastal Commission (attached as Exhibit 3), which detected mercury levels in the over dredge material of 9.32 mg/kg.! These testing results make clear that the risks are far more than previously reported and, more importantly, the City's interpolation through "Kriging" failed to come close to predicting levels of mercury that high. In addition, this finding of deeper contamination in the over dredge layer means that staff has inappropriately concluded that dredging will not expose any more contaminated materials than is already exposed to harbor tides and currents. Staff cannot make that assumption where the City has not identified the level of contaminants in that layer.

When the City's modeling grossly underestimates the level of contaminants that will now be exposed to the harbor, we question why the Commission has not called for *any* sampling of the dredged material and might instead choose to permit this project based upon modeling based upon predictions based upon composites. Given the high level of mercury found in these samples taken by Mr. Mardian, and that the City never sampled unsuitable material down to the Z-layer as Mr. Mardian did, Friends finds it concerning the Staff Report would claim the CAD "may ultimately help enhance water quality within the Bay." This failure to perform the appropriate testing pursuant to the *USACE Subaqueous Capping Technical Guidance* is in addition to the issues with the modeling and sampling that actually was conducted. To this end, we reference all prior comments submitted to the Coastal Commission by Brent Mardian, PI Environmental.

There also remain further concerns that the City has not adequately planned for material exposure, resuspension, or pluming during its operations, and during the time when the CAD will remain open and exposed. No agency to date has identified a plan to immediately halt and immediately remediate any exposure of toxic sediment should the City's data and assumptions prove inaccurate, thereby threatening the residents and many people who recreate in Newport Harbor.

In sum, the environmental review needed for the City's proposed CAD is incomplete. Friends believe this omission and lack of information creates a fatal impact and prevents the relevant agencies, including the Coastal Commission, from being able to rely upon the environmental review that has previously been done. This reason alone is sufficient for Friends to request that the Coastal Commission reject the proposed CAD project.

[1] In recent correspondence dated October 6, 2022, the City Attorney argues the failure to follow the correct USACE manual should not be a problem here because other CADs were built that also did not follow the manual. However, the fact that other CADs may have mistakenly been permitted and built in the past does not mean the Coastal Commission should condone or enable the City to knowingly fail to follow required guidance here. This is particularly so given how close this CAD would be to a Marine Protected Area, homeowners, and beneficial uses for recreational swimming, boating, and fishing unlike those CADs referenced by the City.

Alternatively, Friends of Newport Harbor ask the Commission to, at a minimum, postpone its decision on this item and provide the allowed 90-day extension. We believe a 90-day will provide the time necessary to assess this omission and take any necessary actions to remedy it.

2. Alternative Methods Other Than In-Harbor Disposal (the CAD) Have NOT Been – And Should Be - Fully Considered.

Especially considering the required testing that should have been, but was not done, Friends of Newport Harbor believes further analysis of safer alternatives is warranted. The City and Coastal Commission Staff Report has failed to look at a reasonable range of alternatives, defined as alternatives actually designed to reduce and avoid the impacts of the project. That is a cornerstone of CEQA. Among other issues, and as explained below, the City and Coastal Commission Staff Report is using completely surmountable issues to claim infeasibility. An EIR must analyze alternatives designed to avoid or substantially lessen a project's environmental impact. (Pub. Resources Code s. 21002.). The Staff Report references alternatives to the project, but these do not demonstrate that staff or, to the extent staff relies upon the City, that the City actually examined options besides burying the sediment somewhere *in* Newport Bay. Where sediment may contain high levels of pollutants (like the mercury, DDT, and PCBs found in the Newport Harbor samples taken), the preferred method for storing contaminated material is to take it out of water. Put simply, a CAD in a recreational harbor like Newport Bay is inappropriate and dangerous.

Neither the City, nor the Coastal Commission, have pointed to a single CAD anywhere in California, or in the country for that matter, that is factually comparable and sited in a recreational harbor with the immense variety of contact recreation activities that exist in Newport Bay. Newport Harbor has been designated as “REC-1” by the California Regional Water Quality Control Board, Santa Ana Region, where people have immediate contact with its waters. The proposed CAD will be less than 500 feet from people’s homes, less than 1/2 mile from a Marine Protected Area (MPA), and less than 1200 feet from where communities, including children, play at the beach at Bayshore. Attached as Exhibit 4 is a graphic visual of just how close the proposed CAD will be to homes and recreational activities.

The Coastal Commission Staff Report references CADs at Port Hueneme, Port of Los Angeles, the Port of Long Beach, and a pilot CAD project near the mouth of the LA River offshore of Long Beach. All of these are highly industrialized areas and thus not comparable to Newport Harbor, which is a highly urbanized area as the Staff Report itself acknowledges on page 18. The City has also previously referenced other CADs to argue they are similar to this project and, therefore, that it should be inferred that this project is appropriate and safe. In addition to the CADs at Port Hueneme, Long Beach, and Los Angeles referenced in the Staff Report, the City has pointed to CADs at Boston, New Bedford, Chesapeake Bay, Humboldt Bay, and Baltimore. To the extent the Coastal Commission may rely on these CADs, it should be aware that our research of those CADs shows the City is wrong. None of those CADs are remotely similar to what the City proposes for Newport Harbor.[2] For Boston, Baltimore, Port Hueneme, and to at least a large

[2] Citation to New Bedford and Port Hueneme CADs can be found in the City’s Letter Response to Friends of Newport Harbor, LLC Correspondence, dated Sept. 1, 2022.)

degree, New Bedford, the sites are more accurately characterized as heavily industrial or commercial (with residences nearby but not fronting), and often with substantial legacy pollution issues. While a referenced Seattle site may go through some residential neighborhoods, it is also in an area designated as a "Superfund" site with a major legacy of industrial and other pollution.[3] In contrast, the City repeatedly notes the proposed Newport Harbor CAD location is a "clean" area from which it can remove good sediment and use it for beach replenishment. Then, the City proposes to put unsuitable material into this previously clean area of Newport Harbor.

To demonstrate the superficial nature of the City's reliance upon the fact that CADs were deemed appropriate in other locations, we distinguish some examples below[4].

a) <u>Port Hueneme, California</u>

The Port Hueneme CAD is located in a deep-water port in the Port of Hueneme Harbor, which is characterized by berths owned by the Oxnard Harbor District and the U.S. Navy. The CAD is located some 1,200 to 1,500 feet into the harbor channel and does not border on residential property. (See figure 1.) While Hueneme Beach, Silver Strand Beach, public swimming, and recreation beaches bracket the harbor, they are located at least 1,200 feet from the CAD site and are open to the ocean and tidal/wave action and flushing. The closest homes to the port channel are separated from the channel by harbor facilities or the Naval base.

[3] https://www.seattle.gov/utilities/neighborhood-projects/lower-duwamish-waterway
[4] Please see attached Exhibit 5 for a summary of the backup for this research.

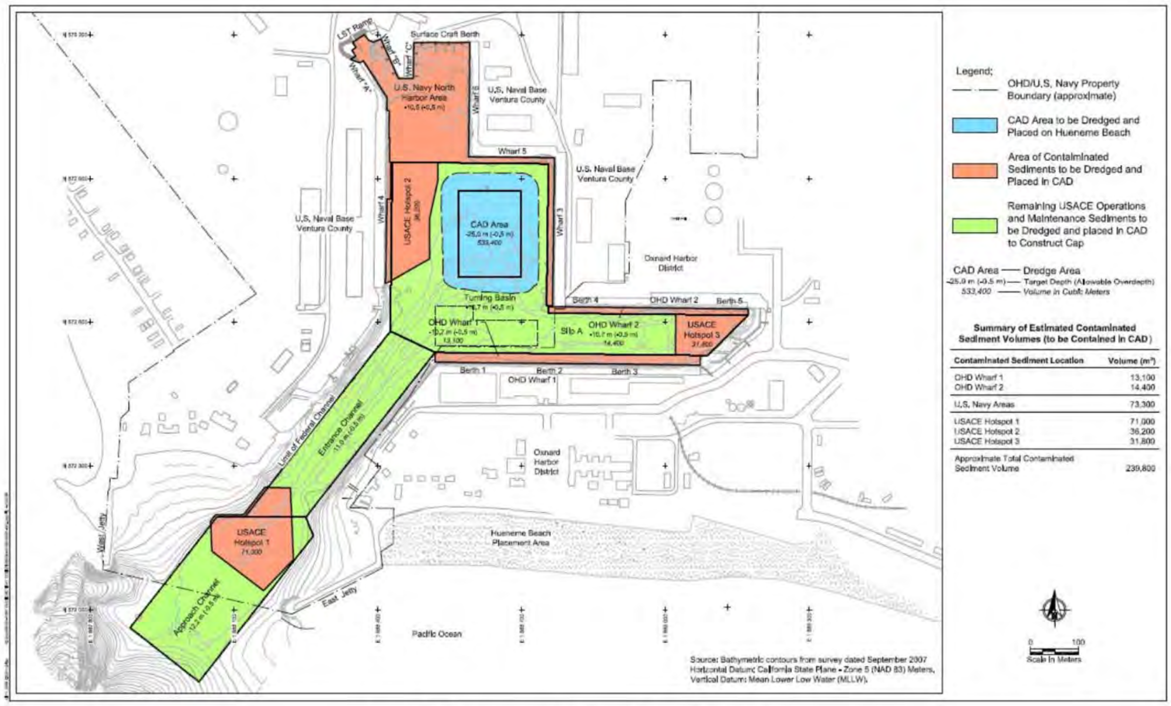


Figure 2. Project area site plan including key structures.

Figure 1: CAD at Port Hueneme.

b) <u>New Bedford, Massachusetts</u>

This CAD site is located in the inner harbor, in between an industrial and commercial waterfront on the west side and more residential neighborhood on the east. (See Figure 2.) The Harbor includes a historic Superfund site for polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) with human health risks from direct contact with PCBs in the sediment and ingestion of fish and shellfish. While there are residential properties close to the waterfront on the eastern side of the harbor, they are further south and generally separated from the water by a commercial wharf or marina facilities. The closest swimming beaches appear to be across the harbor, approximately 1-mile distant (Fort Phoenix State Reservation), or on the same side of the harbor nearly 3-miles distant (East Beach). It is an old, industrial setting.

Figure 2. Setting for New Bedford, MA CAD, sited closer to industrial areas.

c) **Baltimore Harbors CAD**

This CAD is adjacent to a marine terminal and is in a highly industrialized commercial waterfront in Baltimore Harbor. The harbor water is generally known to be polluted, though some fishing may take place. There is no obvious housing or contact recreation locations. (See attached pdf from Western Dredging as Exhibit 6).

d) **Boston, MA**

It is difficult to determine what CAD the City references from the Boston area as justification to allow a CAD in Newport Harbor. There appear to be multiple possible sites with the most likely being the Mystic and Chelsea Creek intersection completed in the early 2000s (see map below (Figure 3), this is a heavily industrialized harbor with legacy pollution issues (particularly Chelsea creek). Mystic River has preserved public sites upstream of Boston Harbor that technically allow swimming and several beaches in South Boston or Boston Harbor Islands, but all of them are several miles distant and separated by Logan Airport. And while there is some residential housing immediately adjacent to Chelsea Creek, it is unclear whether contact recreation is possible, or fishing allowed. This is an entirely different scale of urban waterfront than presented in Newport Harbor.[5]

It is clear from our research that CADs are not common in general, and that CADs in areas of heavy recreation and residences are definitely not common. This is of even bigger concern due to the risks being so much higher with a proposed CAD being cited so close to an extensive amount of recreational activity and beneficial uses in Newport Harbor. This underscores the lack of real consideration of alternatives.

As noted in the Staff Report, the alternatives considered were no dredge, dredge with upland disposal, and dredge with CAD disposal. While the City considered upland disposal, it dismissed it as being too expensive. However, since that time, the City has acknowledged the cost of the proposed CAD has increased significantly due to inflation.[6] Friends of Newport also note that the cost of the proposed CAD is also expected to increase substantially due to the monitoring and sampling required by the Santa Ana RWQCB in its 401 Certification and Order. None of these increased costs were taken into account in the environmental review relied upon in the Staff Report or in the City's EIR. The impact of the cost of the proposed CAD project adjusting significantly upwards should have been, but to date has not, been analyzed.

Moreover, given that the City's EIR (upon which the Staff Report relies for its analysis of alternatives) does not seem to have fully analyzed either the CAD project's true size or its compliance with the applicable Army Corps Guidance, neither the City nor the Coastal Commission know the CAD project's true impacts. The City's composite sampling lacks any true delineation of the amount of "unsuitable" material that dredging will generate. Our recent

---

[5] See additional presentation on Boston CAD and New England sites here: https://ebcne.org/wp-content/uploads/2021/05/Presentations-Ocean-and-Coastal-Resources-Webinar-CAD-Cells.pdf

[6] In its July 26, 2022, City Council Staff Report, attached hereto as Exhibit 7, the City states *"However, in today' s current economic climate, including volatile fuel prices, the project may exceed the original estimate after bidding in the fall."*

sampling suggests that some dredge areas might contain more suitable material than previously assumed. Even a few samples taken from the dredge areas might have provided data, rather than predictions, to show how much unsuitable material the project will generate. And yet, all analyses of alternatives are based upon the assumption that the City needs to find a method of disposing that predicted amount of material, that the amount of material cannot be addressed in a less harmful way, and that only a CAD would therefore be appropriate.

The California Supreme Court has declared the alternatives analysis the "core of the EIR." (*Citizens of Goleta Valley v. Board of Supervisors* (1990) 52 Cal 3d 553, 564.) CEQA imposes a high standard when a lead agency is proposing to reject an alternative considered in an EIR. "One of [an EIR's] major functions . . . is to ensure that *all reasonable alternatives* to proposed projects are thoroughly assessed by the responsible official." (*Laurel Heights Improvement Ass'n. v. Regents of the University of California* (1988) 47 Cal. 3d 376, 400.) Further, "Under CEQA, the public agency bears the burden of *affirmatively demonstrating* that…the agency's approval of the proposed project *followed meaningful consideration of alternatives* and mitigation measures." (*Mountain Lion Foundation v. Fish and Game Commission* (1997) 16 Cal.4th 105, 134, emphasis added.) Such an alternative or mitigation measure *must* be adopted by the lead agency unless the lead agency can demonstrate that the mitigation is "truly infeasible." (*City of Marina v. Board of Trustees of the California State University* (2006) 39 Cal. 4th 341, 368; see also Pub. Res. Code § 21002 ["public agencies should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects of such projects"].)

This is particularly important because both the City's EIR and the Coastal Commission's Staff Reports reject land-based disposal sites for the dredged material as infeasible. Yet, without the testing required by the Army Corps Guidance, it is unclear whether CAD disposal is appropriate or even permissible for the unsuitable dredged material. Thus, the City and Commission's rejection of land-based disposal sites is both premature and unsupported by the evidence. Indeed, it seems the City and Coastal Commission Staff Report rejected the notion of upland disposal outright before even considering concrete sites that could potentially work. They make premature arguments that upland disposal would in fact create environmental and environmental justice problems, when, in reality, that analysis depends on the specific upland disposal site to be considered.

Relatedly, the Coastal Commission Staff Report points to two landfills as examples of where the contaminated material could potentially go, but then argues those landfills would pose environmental justice concerns since they are cited next to disadvantaged communities. While Friends of Newport Harbor represents a diverse group of concerned citizens and is sensitive to environmental justice concerns, it notes the referenced landfills are already existing, legally permitted landfills for the very purpose of taking the type of waste at issue here. Adding the unsuitable material to these landfills would not create any additional impact to the adjacent communities. Finally, the Staff Report notes the proposed CAD would be cited next to residential communities that are not disadvantaged. However, the Staff Report fails entirely to consider that the area of Newport Harbor where the proposed CAD is to be cited is in a highly recreational area used by a widely diverse group of people, not just the referenced homeowners. The Coastal

Commission cannot only look at who lives in that vicinity but must consider all the people who visit the area for recreational purposes.

Finally, we take issue with the Staff Report's assertion on page 22 that the No CAD Construction alternative would result in a loss of beach sand and thus a potential decrease in recreational opportunities in Newport Harbor. As explained in comments by Brent Mardian, PI Environmental, the material will be disposed of in the near shore environment at a minimum depth of -13 feet, and it is therefore unclear how much will actually make it back to the beach for replenishment. Moreover, we find it disconcerting that the Coastal Commission, of all government agencies, would find any beach replenishment to outweigh adding significantly contaminated sediments that have not been properly sampled and characterized to an admittedly clean area. You cannot point to the pros of the beach replenishment without considering the con putting unsuitable materials in the proposed CAD with the potential to adversely impact both the marine environment there, as well as the area's beneficial uses.

In sum, an earnest **study of potential alternatives is needed.**

3. As Proposed, The CAD Will Leave Contaminated Material Exposed And Vulnerable to Disturbance For Over Two Years.

Undoubtedly, the most important part of the CAD design are its interim and final "caps" – the "clean" material that isolates contaminants from release into the water column. Friends has several concerns about this critical component. First, neither the City nor the Coastal Commission Staff Report have identified what material will serve as either the interim or the final caps. At this time, the City does not know from where it will obtain this material, the amount of environmental impacts it will create to obtain it, the quality of the material, whether it will need additional replenishment material to secure the integrity of the cap, etc. The City and Coastal Commission Staff Report state only that the interim cap material would be clean sand excavated from the federal channels. As for the final cap, the City and Coastal Commission Staff Report have suggested the City could, as a backstop, potentially obtain clean material from the Santa Ana River or RGP 54 Program. But the City and Coastal Commission Staff Report have not identified where in the River the City could obtain the material or whether obtaining that material would harm the River or habitat. Without knowing from where it will obtain the material, the City cannot know the sediment's characteristics and what additional pollutants it will introduce into Newport Harbor. We also note that to create the interim cap, the City will require approximately 9,000 cubic yards of material. For the final cap, the City will require approximately 33,600 cubic yards of "additional sediment sourced by the City." The City and Coastal Commission Staff Report's analysis lacks any consideration of how it will move this cap material into the Harbor, how many trucks or barges may be required, how many miles those trucks or barges will travel, how long the process will take, or whether people in affected communities will suffer through increased traffic, noise, and air quality problems in order for the City of Newport Beach to move sediment down to Newport Harbor.

No government agency, including the Coastal Commission in its Staff Report, has required the City to identify the cap material before it starts CAD construction or receipt of contaminated material into the CAD. This means the City can release contaminated material into the CAD and leave it exposed and uncovered for an unknown period while it seeks Regional Board and

Commission approval for capping. This too may create greater impacts on the environment than one of the alternatives to the project (upland disposal) that it dismissed.

As a related concern, even if the City can find suitable material in an environmentally acceptable way to serve as the interim cap, the consolidated contaminants placed into the CAD will only be covered by an extremely thin one-foot layer of sand, significantly less than the recommended three-foot cap thickness of the final layer. This interim one-foot cap will be the only means of isolating the contaminants from the marine life who live in, and the people who recreate in, the Bay for over two years, creating a higher risk of exposing the highly contaminated sediment. Friends of Newport is gravely concerned about whether, over the course of the proposed two years, the interim cap will hold its integrity. The fact the unsuitable CAD materials have not been adequately tested makes this even more concerning.

4. The Coastal Commission Cannot Meet its Burden to Show the proposed CAD project is compliant with CEQA

The Commission must consider whether the CDP complies with the policies of Chapter 3 of the Coastal Act. The Commission's determinations that the CDP complies with the policies of Chapter 3 must be supported by evidence. The Coastal Commission derives its authority under CEQA to review the CDPs from at least two sources. First, the Coastal Commission's program for reviewing and granting CDPs is a certified regulatory program that serves as a "functional equivalent" of CEQA. (Pub. Resources Code § 21080.5 (c); 14 CCR § 15251(c).) The Commission's administrative regulations require CDP application approvals to be supported by a finding that the application, as modified by any conditions of approval, is consistent with any applicable requirements of CEQA. (Section 13096.) The Commission typically complies with these requirements through the information and analysis contained in the staff reports it prepares during consideration of a CDP.

Second, the Commission is a responsible agency for the Project under CEQA, although the City has served as the lead agency for environmental impact report (EIR) preparation. (14 CCR § 15381.) Because the Commission must take discretionary action regarding the Project's CDP, it must comply with CEQA. While CEQA permits a responsible agency to rely on a lead agency's CEQA document, the Commission complies with CEQA "by considering the EIR or negative declaration prepared by the Lead Agency and by reaching its own conclusions on whether and how to approve the project involved." (14 CCR § 15096(a).) The Commission retains responsibility for mitigating or avoiding the direct or indirect environmental impacts of the portions of the project that approves. (14 CCR § 15096(g)(1).) **Where the lead agency fails to comply with CEQA, the Commission is authorized to undertake that compliance and may be required to do so to make an independent judgment.**

CEQA's primary purpose is to ensure that the environmental consequences of an action are disclosed to the public and to agency decisionmakers before that action is taken. Put another way:

> The CEQA process is intended to be a careful examination, fully open to the public, of the environmental consequences of a given project, covering the entire project, from start to finish. This examination is intended to provide the fullest information reasonably available upon which the decision makers

> and the public they serve can rely in determining whether or not to start the project at all, not merely to decide whether to finish it. The EIR is intended to furnish both the road map and the environmental price tag for a project, so that the decision maker and the public both know, before the journey begins, just where the journey will lead, and how much they-and the environment-will have to give up in order to take that journey."

(*Natural Resources Defense Council v. City of Los Angeles* (2002) 103 Cal.App.4th 268, 271.) CEQA further contains a substantive mandate that a project's adverse environmental impacts must be avoided or reduced to the extent feasible through the incorporation of project alternatives or mitigation measures. (Pub. Resources Code § 21002.) For this reason, it is imperative that alternatives and mitigation measures not be foreclosed prior to project approval. (*Save Tara v. City of West Hollywood* (2008) 45 Cal.4th 116, 138.) Environmental review must occur prior to project approval.

a. CEQA Requires Additional Environmental Review of the Changes to the Project that Increased the Size of the Project.

The City has made changes to the proposed CAD project since it completed its CEQA review. These changes include expansion of the CAD project by 5,600 cubic yards, an amount likely to require substantial increases in barge trips. As these material changes could increase the magnitude of the Project's environmental effects, or introduce new effects not previously analyzed, CEQA requires that these changes be analyzed before the CAD project is formally approved. As a certified regulatory program, the Coastal Commission need not prepare an environmental impact report, but it must carry out CEQA's requirements to fully analyze and mitigate a project's adverse environmental effects. Thus, there is a colorable argument that the Coastal Commission's Staff Report for the requested CDP must be revised to take into account the substantial Project expansion before the Commission may lawfully approve the Confined Area Disposal operation.

The City of Newport Beach certified an environmental impact report for the Project on May 25, 2021. The City's December 20202 Draft EIR ("DEIR") described the Project as

> The CAD facility is being constructed ***to accommodate approximately 106,900 cy*** of unsuitable dredged material anticipated to be generated by the Federal Channels maintenance dredging program and an additional 50,000 cy resulting from maintenance dredging primarily of unsuitable material from outside the Federal Channels, for a total of 156,900 cy. Clean material excavated during construction of the CAD facility will be transported to, and disposed along, the nearshore ocean beaches or transported to LA-3 for open ocean disposal… Following construction of the CAD facility, unsuitable sediment will be dredged using mechanical equipment and placed within the CAD facility using a bottom-dump barge. During the time that the CAD facility is open (i.e., during placement of the unsuitable material in the CAD facility), the City and its residents will have an initial opportunity to place material dredged from outside the Federal Channels into the CAD facility.

> Sediment within the CAD facility will then be covered with clean sediment dredged from the remainder of the Federal Channels as part of USACE's maintenance dredging program. This clean sediment will serve as an interim cover containment layer to isolate the unsuitable material placed as part of Federal Channels maintenance dredging. Approximately 2 years following completion of construction of the CAD facility and placement of an interim cover containment layer, there will be a second opportunity during a 6-month period for the City and its residents to place material determined unsuitable for open ocean disposal in the CAD facility. The combined total allowance for the initial and second opportunity will be 50,000 cy of unsuitable material.

(DEIR pp. 31-32.) The 106,900 cubic yard size of the CAD Project is echoed in the May 2021 Final EIR. (FEIR, p. 18.)

In August 2022, the City submitted a Permit Application Supplement that again describes the Project as:

> [B]eing constructed to ***accommodate approximately 106,900 cubic yards (cy)*** of unsuitable dredged material anticipated to be generated by the Federal Channels maintenance dredging program and an additional 50,000 cy resulting from maintenance dredging primarily of unsuitable material from outside the Federal Channels (to be permitted separately at a later time). Clean material excavated during construction of the CAD facility will be transported to, and disposed along, the nearshore ocean beaches.

(Permit Application Supplement, p. 3.)

Yet, by the time the Coastal Commission issued its Staff Report for the September 2022 meeting on August 26, 2022, the Project description was modified to:

> The CAD cell would be excavated in the central portion of the Lower Harbor between Bay Island, Lido Isle, and Harbor Island ***to accommodate approximately 112,500 cubic yards*** of unsuitable dredged material anticipated to be generated by the Federal Channels maintenance dredging program and an additional 50,000 cubic yards resulting from maintenance dredging of primarily unsuitable material from outside the Federal Channels to be permitted separately at a later time. The proposed size of the CAD is approximately 590 feet by 590 feet and would require dredging of approximately 282,400 cubic yards of sediment from the existing mudline to the 1-foot over dredge limit, with a final floor elevation approximately 45 feet below the floor of the harbor. Up to approximately 282,400 cubic yards of clean sediment excavated from the harbor floor to create the CAD cell would be transported by bottom dump scow and placed in the littoral zone along the nearshore ocean beach, where the waves and currents would move the sand onto Newport Beach. Next, approximately 106,900 cubic yards of contaminated dredged material from the federal channels within Newport

> Harbor would be placed within the CAD using bottom-dump barges. The contaminated sediments at the bottom of the CAD would then be covered with approximately 9,000 cu. yds. of clean sand excavated from the federal channels to create a one-foot-thick interim cap that is proposed to be in place for approximately two years. Then there would be a 6-month period for the City and its residents to place up to 50,000 cubic yards of material with a priority for material determined unsuitable for open ocean disposal in the CAD facility followed by material suitable for open ocean disposal. At the end of the 6-month placement period, the final cap layer would be placed in the CAD cell by the City to physically isolate the underlying sediments from burrowing organisms and biota residing in the overlying water column. This clean sediment final cap layer has been designed to a thickness of 3 feet (made up of 33,600 cy) of additional sediment sourced by the City.

(August 26, 2022, Coastal Commission Staff Report, p. 2, with deletions.) The larger, 112,500 cubic-yard size remains in the Commission's updated, September 30, 2022, Staff Report. (See, September 30, 2022, Coastal Commission Staff Report, p. 2.)

The Project apparently grew in size by 5,600 yards between the City's certification of its May final EIR (the completion of its CEQA review) and the September 2022 Staff Report on the CDP for this project.

We acknowledge that environmental impacts for ***portions*** of the Project have been certified. **However, we see no evidence that environmental review has been conducted for the 5,600 additional cubic yards of CAD Facility expansion that occurred after the completion of the City's CEQA process.** The August 2022 Permit Application Supplement discusses a 106,900-cubic yard Project. The August 26, 2022, Staff Report discusses a 112,500-cubic yard Project. Accordingly, it is unclear when this environmental review would even have occurred. In any case, the additional 5,600 cubic yards of CAD capacity requires additional excavation and additional fill, along with hundreds or thousands of barge trips to accommodate the additional dredge and fill. **The impacts of these trips on benthic communities, air quality, recreation, and other environmental concerns have not, but must be, analyzed**.

CEQA also requires that environmental documents evaluate mitigation measures – both the adverse environmental impacts caused ***by*** mitigation and the efficacy ***of*** that mitigation. (14 CCR § 15126.4; *San Joaquin Raptor Rescue Center v. County of Merced* (2007) 149 Cal.App.4th 645.) Here, Special Condition 6, concerning the "Nearshore Sand Placement Monitoring Plan" provides that, prior to issuance of the Coastal Development Permit, "the applicant shall submit a Sand Placement Monitoring Plan that will: A. Establish a framework for the City and/or its contractor(s) to monitor, record, and report the location and depth of sand placement events to verify material has been placed as shallow as possible." (September 30 Staff Report, p. 16.) Based on the language of the Special Condition, it appears that this monitoring plan has not yet been prepared, meaning its adequacy and potential efficacy have not been evaluated by Coastal Commission Staff. This was not remedied in the updated Staff Report. **Thus, the Commission does not yet know if the sand replenishment, recreation, and coastal access benefits of the**

Project will accrue, or if the Project will merely cause the need for dredging elsewhere. This analysis should occur prior to project approval.

While CEQA permits reliance on prior EIRs, this reliance does not extend to changes to a Project that occur between EIR certification and the grant of a new discretionary approval when those changes and their impacts were not analyzed in the certified EIR. (Pub. Resources Code § 21166.) Subsequent or supplemental environmental review must occur when changes to a Project necessitate revisions to the EIR for it to retain relevance and accuracy. (14 CCR §§ 15162, 15163.) In particular, CEQA requires preparation of subsequent environmental review when:

(1) Substantial changes are proposed in the project which will require major revisions of the previous EIR or negative declaration due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects.

(2) Substantial changes occur with respect to the circumstances under which the project is undertaken which will require major revisions of the previous EIR or negative declaration due to the involvement of new significant environmental effects or a substantial increase in the severity of previously identified significant effects; or

(3) New information of substantial importance, which was not known and could not have been known with the exercise of reasonable diligence at the time the previous EIR was certified as complete or the negative declaration was adopted, shows any of the following:

(A) The project will have one or more significant effects not discussed in the previous EIR or negative declaration.

(B) Significant effects previously examined will be substantially more severe than shown in the previous EIR.

(C) Mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project, but the project proponents decline to adopt the mitigation measure or alternative; or

(D) Mitigation measures or alternatives which are considerably different from those analyzed in the previous EIR would substantially reduce one or more significant effects on the environment, but the project proponents decline to adopt the mitigation measure or alternative.

(14 CCR § 15162 (a).)

Based on the change in size alone, it can be argued that substantial changes have been incorporated into the Project. In *Voices for Rural Living v. El Dorado Irrigation District* (2012) 209 Cal.App.4th 1096, 1107, the court reversed a staff finding that a 10 percent increase in water demand was not a substantial change in available supplies and required additional review. Depending on how the Project expansion will affect Project construction, mitigation, and operation, there may also be supportable arguments that the circumstances under which the Project is being evaluated have changed, or that new information of substantial importance has been developed since the Project's last relevant environmental review. It does not appear that the September 30 Staff Report has undertaken additional analysis, based on the additional 5,600 cubic yards of CAD capacity, since the August 26, 2022, Staff Report. To the extent that the Commission's analysis relies on facts taken from an EIR that is based on a smaller Project footprint, the Commission's analysis is inadequate and cannot support findings needed to approve the Project. While the Commission may be using larger and accurate numbers for purposes of determining impacts to eelgrass (See, September 30, 2022, Staff Report p. 34), we would have expected some acknowledgment of the extra barge trips or time needed to construct and fill the larger CAD. This information is relevant to the Project's potential impacts on recreational boating, swimming, or channel navigation, as well as to the Project's greenhouse gas emissions attributable to barge traffic, thereby implicating several provisions of the Coastal Act (See, e.g., Coastal Act Section 30224 [Recreational Boating] and Coastal Act Section 30220 [Protection of Water-Oriented Activities].). This information does not appear to have been included in the revised September 30 Staff Report, particularly in the Report's analysis of impacts to recreation. (September 30 Staff Report, p. 45.)

b. The Failure to Conduct Required Testing of Contaminated Sediment Undercuts the City's CEQA Analysis and the Commission's Findings.

Although the City's documents claim to have complied with all required federal guidance, the City's CAD Project is an in-bay placement of sediment, not an open ocean placement. Thus, as noted above, the applicable guidance document is the Army Corps' *Subaqueous Capping Guidance Manual*. In this document, the Army Corps requires that sediment proposed for CAP disposal undergo elutriate testing, in addition to the other tests performed by the Applicant. Accordingly, neither the STFate model, nor the Suspended particulate phase (SPP) testing performed as part of the open ocean assessment can be substituted. This failure implicates CEQA in a number of ways.

The failure of the City to undertake testing of the contaminated sediment, alone, means that the City – and by extension, the Commission – cannot know whether the sediment proposed for disposal in the CAP meets federal guidelines for CAP disposal. If sediments are too toxic, they may require disposal on land. The City's EIR found land disposal infeasible. Thus, the City's EIR may require substantial revision of its alternatives analysis, based on the results of this omitted, and required, testing. Further, the Staff Report rejects land disposal as infeasible, without knowing whether the sediments are appropriate for CAD disposal, as defined by the Army Corps Guidance Manual. The Commission's conclusions lack the requisite substantial evidence.

Even if the omitted testing demonstrates that CAD disposal is appropriate, it remains unclear whether the CAD project would require redesign or changes to mitigation measures based on the level or types of contamination found in the elutriate testing. Accordingly, the City's and the Commission's findings about the safety of the CAD project design and the adequacy and efficacy of mitigation lack support.

If the Project will accept sediments that the Army Corps Guidance Manual would not permit for CAD disposal, the environmental effects of this disposal have not been analyzed in the City's EIR or the Commission's Staff Reports, in violation of CEQA and the Coastal Act.

Further, as discussed above, **the failure of the City or the Commission to analyze the contaminated sediment as required by the *USACE Subaqueous Capping Guidance Manual* also implicates whether is new information of substantial importance that must be considered.** If the contaminated sediment undergoes elutriate testing, as required, it may be determined that the sediment does not meet the standards for disposal in a CAD. Land disposal may be required. Thus, "Mitigation measures or alternatives previously found not to be feasible would in fact be feasible and would substantially reduce one or more significant effects of the project" per CEQA Guidelines section 15162 (a). Additional environmental review is necessary once this testing is conducted.

Finally, because the Commission currently lacks required information about the contaminants contained in the sediment, it lacks information needed to adequately support its findings that the Project has been fully conditioned to avoid impacts to marine organisms and water quality, as required by the Coastal Act. Thus, the Commission's findings that the Project complies with the Coastal Act lack the required support and may be vulnerable to legal challenge.

For example, at page 26, the September 30 Staff Report seems to tie its water quality conclusions to the idea that the area has only moderate contamination, like that found at Port Hueneme, where a CAD has been deemed successful. However, if neither the City nor the Commission have done the required testing, it is unclear whether the Commission has sufficient information to determine that the sediment contamination is merely "moderate."

c. Environmental Review of the Dredging and CAD Projects Appears to Be Impermissibly Piecemealed.

California courts are clear that Projects must not be separated into smaller parts, or piecemealed, for purposes of environmental review. The separation of the federal dredging of Newport Harbor from the disposal of the dredged material implicates impermissible piecemealing. "The CEQA process is intended to be a careful examination, fully open to the public, of the environmental consequences of a given project, covering the entire project, from start to finish." (*Natural Resources Defense Council v. City of Los Angeles* (2002) 103 Cal.App.4th 268, 271.) Thus, CEQA requires analysis of "the whole of an action" and prohibits evading comprehensive CEQA analysis by "chopping a large project into many little ones -- each with a minimal potential impact on the environment -- which cumulatively may have disastrous consequences." (CEQA Guidelines § 15378; *Bozung v. LAFCO.* (1975) 13 Cal.3d 263, 283-84; *Orinda Assn v. Board of*

Supervisors (1986) 182 Cal.App.3d 1145, 1171.) The whole of the action for which environmental review must occur includes "all phases of project planning, implementation, and operation." (CEQA Guidelines §15063, subd. (a)(1).)

Further, "[I]f projects are 'various steps which taken together obtain an objective,' they are a single project for the purposes of CEQA." (*Aptos Council v. County of Santa Cruz* (2017) 10 Cal.App.5th 266, 283, citations omitted.) This is also true for projects that are "integrally related." (*Nelson v. County of Kern* (2010) 190 Cal.App.4th 252, 272.)

Finally, the law is clear that, "[t]he term 'project' does not mean each separate governmental approval." (CEQA Guidelines § 15378, subd. (c); see also *Citizens for a Green San Mateo v. San Mateo County Community College Dist*. (2014) 226 Cal.App.4th 1572, 1592.) Instead, lead and responsible agencies must "construe the project broadly to capture the whole of the action and its environmental impacts." (*Save Berkeley's Neighborhoods v. Regents of University of California* (2020) 51 Cal.App. 5th 226, 239.) **A project conditioned upon completion of another project constitutes a single Project under CEQA.** (*Tuolumne County Citizens for Responsible Growth, Inc. v. City of Sonora* (2007) 155 Cal.App.4th 1214, 1226.)

According to the Permit Application Supplement, the City's original application to the Coastal Commission was for a project with two components: "(1) maintenance

dredging within the Federal Channels to re-establish safe navigation, including dredging of material that has been determined suitable for open ocean disposal and material that is unsuitable for open ocean disposal; and (2) construction of a CAD facility in the central portion of Lower Newport Bay between Bay Island, Lido Isle, and Harbor Island where dredged sediment unsuitable for open ocean disposal can be contained." (Permit Application Supplement p. 1.) This procedure would have allowed for proper environmental review of the "whole of the" CAD Project. The Project is dredging of the Federal Channels *and* the disposal of the dredged material. The Projects obtain a single objective and are integrally related. **While the federal dredging would occur regardless of the existence of the CAD Project, the CAD Project's only purpose is to accommodate the federal dredging.**

However, the Permit Application Supplement continues, "Based on coordination and collaboration with the U.S. Army Corps of Engineers (USACE), the City is

submitting a revised project description that only entails construction of the CAD facility and placement of a final cap layer. Maintenance dredging of the Federal Channels is being permitted separately by the USACE." (Permit Application Supplement p. 1.) Thus, the Application has now separated the Projects, even though the CAD Project is intended as the disposal site for the dredging.

The Permit Application Supplement appears to claim the legal compliance will be achieved because:

> USACE will be responsible for ensuring National Environmental Policy Act compliance to support the separate Federal Channels maintenance dredging program and will be preparing an environmental assessment separately from this CAD construction permit application. As the lead federal agency—and

> as part of the Federal Channels maintenance dredging program—USACE will assume
> responsibility for coordinating with resource agencies such as National Marine Fisheries Service and California Department of Fish and Wildlife and for ensuring compliance with statutes such as the Endangered Species Act and the Magnuson-Stevens Fishery Conservation and Management Act. USACE has also assumed the lead role in addressing cultural and historic resource issues, including requirements of Section 106 of the National Historic Properties Act. In addition, USACE will obtain a federal Consistency Determination from the California Coastal Commission, which will satisfy requirements of the Coastal Zone Management Act, and a Clean Water Act Section 401 water quality
> certification from the Santa Ana RWQCB for the Federal Channels maintenance dredging program.

(Permit Application Supplement, p. 2.) Instead of protecting against piecemealing, however, this statement appears to admit piecemealing.

In sum, it does not appear either lead agency will analyze the full effects of the dredge and disposal operation under either state or federal environmental laws. CEQA requires the entirety of a project be analyzed at once so that the cumulative impacts of the smaller steps – here the dredging and the disposal of that dredged material – are not lost.[7]

We ask that the Commission act in the most protective means possible, that it not simply push issues off into the future, and to do everything it can to protect the residents of Newport Bay, visitors to the area, Bay marine life, and the quality of Lower Newport Bay's waters. We therefore ask the Commission to reject the proposed CAD in Newport Harbor.

Regards,

Kim Lewand Martin

Kim Lewand Martin
Law Office of Jennifer F. Novak
Counsel for Friends of Newport Harbor

cc:
Chatten-Brown, Carstens & Minteer, LLP
Douglas P. Carstens (dpc@cbcearthlaw.com)
Michelle Black (mnb@cbcearthlaw.com)

[7] This is bolstered by the Coastal Commission Staff Report referencing both the USACE and the City of Newport jointly 3 separate times on pages 26 and 27: 1) as "CAD developers"; 2) that the OMMP was developed for implementation by the City and USACE as a communication plan covering the entire CAD construction and sediment process; and 3) as the entities that will "conduct the disposal of their dredged material".

2022.10.07_FNH_Comment ltr CCC Final

Final Audit Report 2022-10-10

Created:	2022-10-10
By:	Yolandé Venter (yolande@jfnovaklaw.com)
Status:	Signed
Transaction ID:	CBJCHBCAABAAZFjVeYXJrfw51aFqOBvfSNv5F93_qjqd

"2022.10.07_FNH_Comment ltr CCC Final" History

Document created by Yolandé Venter (yolande@jfnovaklaw.com)
2022-10-10 - 3:58:06 PM GMT- IP address: 191.101.41.232

Document emailed to Kim Lewand Martin (kim@jfnovaklaw.com) for signature
2022-10-10 - 3:59:06 PM GMT

Email viewed by Kim Lewand Martin (kim@jfnovaklaw.com)
2022-10-10 - 5:00:28 PM GMT- IP address: 172.114.229.48

Document e-signed by Kim Lewand Martin (kim@jfnovaklaw.com)
Signature Date: 2022-10-10 - 5:00:42 PM GMT - Time Source: server- IP address: 172.114.229.48

Agreement completed.
2022-10-10 - 5:00:42 PM GMT

EXHIBIT 1

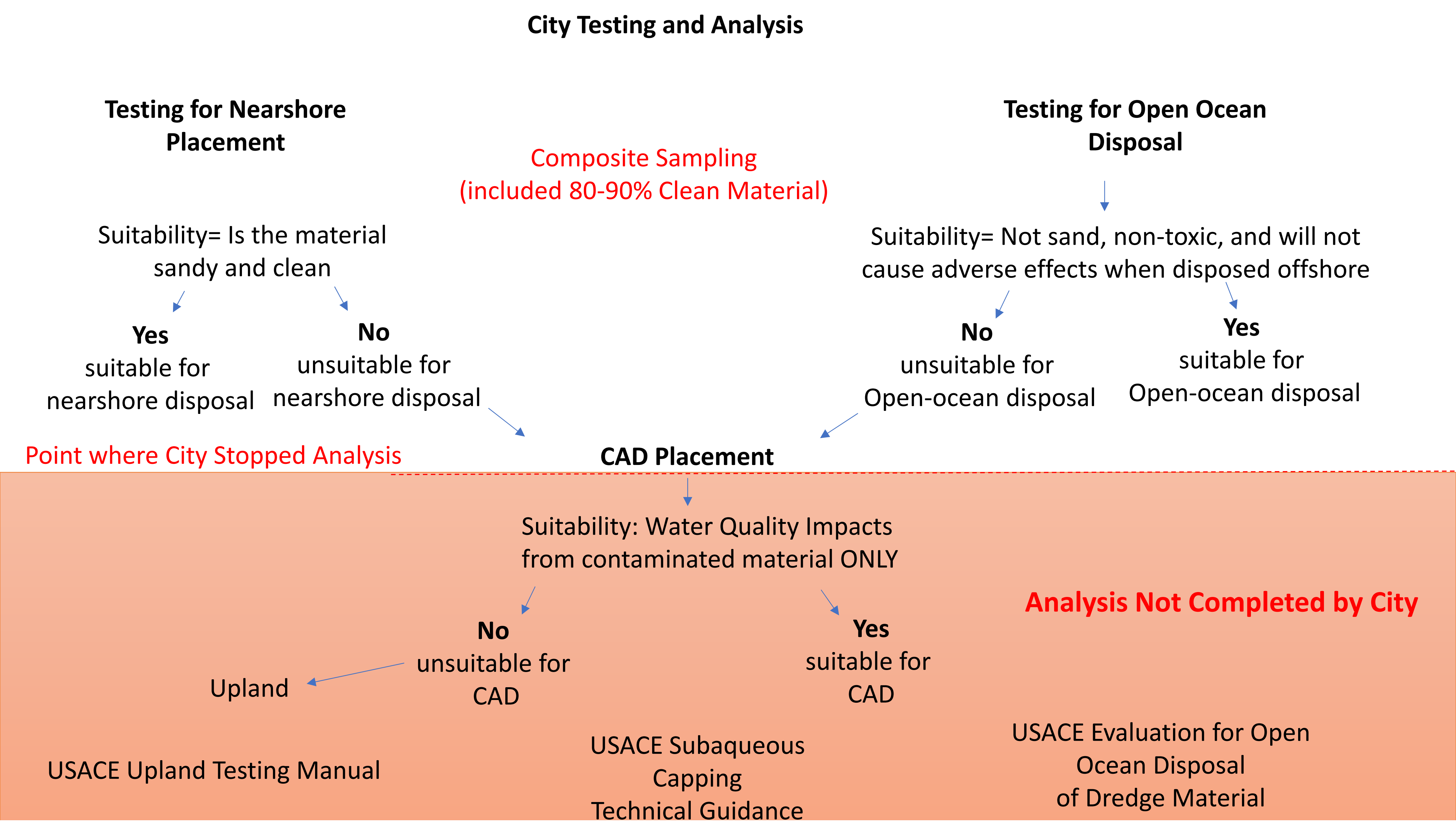

City Testing and Analysis
Testing for Nearshore Placement
Composite Sampling (included 80-90% Clean Material)
Testing for Open Ocean Disposal
Suitability= Is the material sandy and clean
Yes suitable for nearshore disposal
No unsuitable for nearshore disposal
Suitability= Not sand, non-toxic, and will not cause adverse effects when disposed offshore
No unsuitable for Open-ocean disposal
Yes suitable for Open-ocean disposal
Point where City Stopped Analysis
CAD Placement
Suitability: Water Quality Impacts from contaminated material ONLY
Analysis Not Completed by City
No unsuitable for CAD
Yes suitable for CAD
Upland
USACE Upland Testing Manual
USACE Subaqueous Capping Technical Guidance
USACE Evaluation for Open Ocean Disposal of Dredge Material

EXHIBIT 2

Technical Report DOER-1
June 1998

US Army Corps of Engineers
Waterways Experiment Station

Dredging Operations and Environmental Research Program

Guidance for Subaqueous Dredged Material Capping

by *Michael R. Palermo, James E. Clausner, Marian P. Rollings*
Gregory L. Williams, Tommy E. Myers, WES
Thomas J. Fredette, New England District
Robert E. Randall, Texas A&M University

Prepared for Headquarters, U.S. Army Corps of Engineers

Dredging Operations and
Environmental Research Program

Technical Report DOER-1
June 1998

Guidance for Subaqueous Dredged Material Capping

by Michael R. Palermo, James E. Clausner, Marian P. Rollings
Gregory L. Williams, Tommy E. Myers

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Thomas J. Fredette

U.S. Army Engineer District, New England
696 Virginia Road
Concord, MA 01742-2751

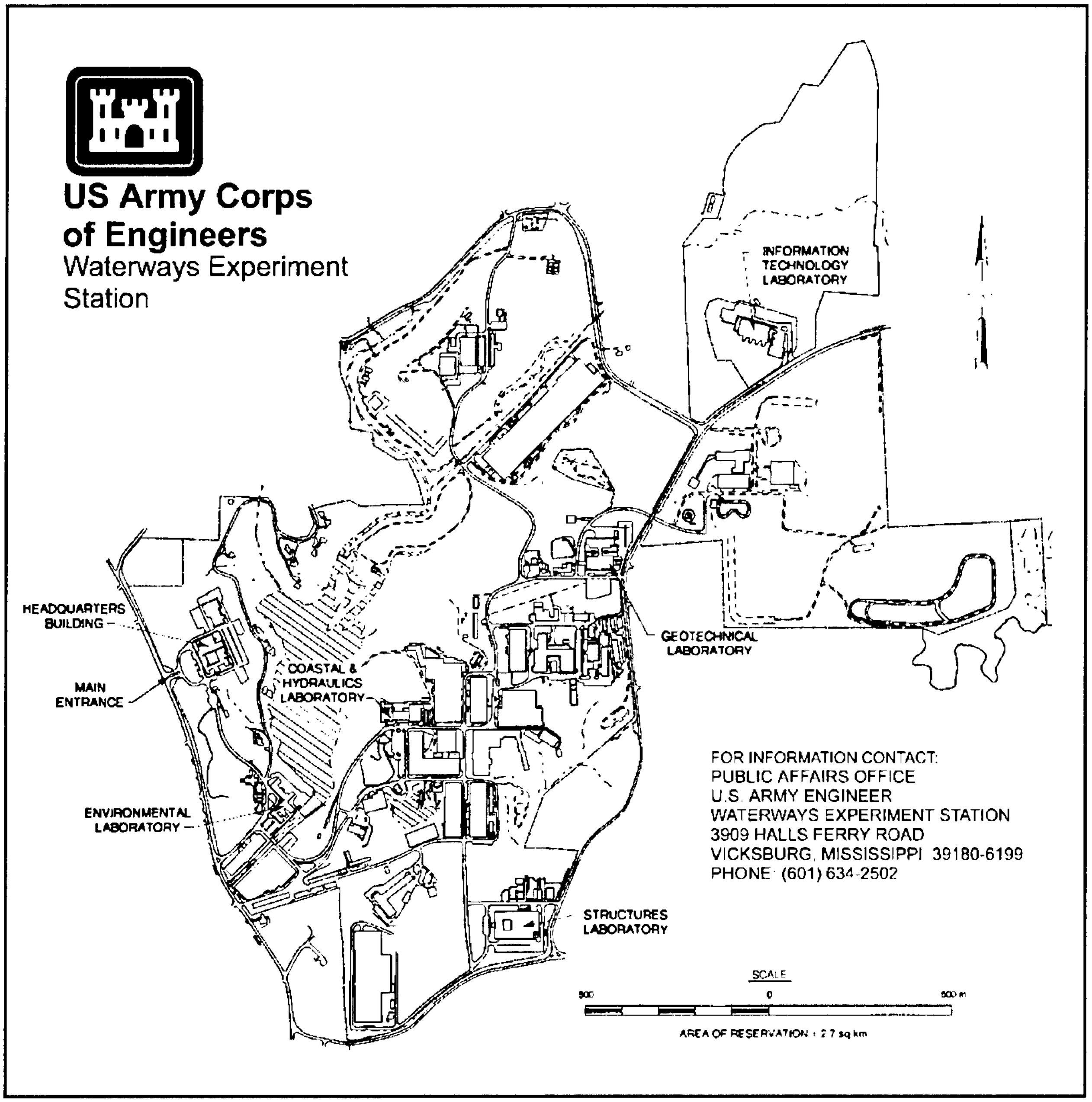
Robert E. Randall

Texas A&M University
College Station, TX 77843

Final report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000



Waterways Experiment Station Cataloging-in-Publication Data

Guidance for subaqueous dredged material capping / by Michael R. Palermo ... [et al.] ;
prepared for U.S. Army Corps of Engineers.
302 p. : ill. ; 28 cm. -- (Technical report ; DOER-1)
Includes bibliographic references.
1. Sediment capping -- Guidebooks. 2. Hazardous waste site remediation -- Guidebooks. 3. In situ remediation -- Guidebooks. 4. Contaminated sediments -- Guidebooks. I. Palermo, Michael R. II. United States. Army. Corps of Engineers. III. U.S. Army Engineer Waterways Experiment Station. IV. Dredging Operations and Environmental Research Program (U.S.) V. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; DOER-1.
TA7 W34 no.DOER-1

U.S. Army Corps of Engineers Research Report Summary, June 1998
Dredging Operations and Environmental Research Program

Dredging: Contaminated Sediments

Guidance for Subaqueous Dredged Material Capping (TR DOER-1)

ISSUE: Potential for water column and benthic effects related to sediment contamination must be evaluated when considering open-water placement. Management options aimed at reducing the release of contaminants to the water column during placement and/or subsequent isolation of the material from benthic organisms may control potential contaminant effects. Subaqueous capping is the controlled, accurate placement of contaminated dredged material at an appropriately selected open-water placement site, followed by a covering (cap) of suitable isolating material. Although conventional placement equipment and techniques may be used for a capping project, these practices must be more precisely controlled in this application.

RESEARCH: The objective was to develop a comprehensive approach for evaluation of subaqueous capping projects, including these goals:

- Refine and adapt numerical models, laboratory testing procedures, and engineering design approaches for capping evaluations.
- Develop design requirements and a design sequence for capping.
- Document equipment and placement techniques for contaminated material and capping material placement.
- Define capping project site selection considerations.
- Develop guidelines for cap monitoring.

SUMMARY: The research resulted in technical guidance for evaluation of subaqueous dredged material capping. Guidance includes level-bottom capping, contained aquatic disposal, design requirements, a design sequence, site selection, equipment and placement techniques, geotechnical considerations, mixing and dispersion during placement, required capping sediment thickness, material spread and mounding during placement, cap stability, and monitoring plans. This guidance is applicable to dredged material capping projects in ocean waters as well as inland and near-coastal waters.

AVAILABILITY OF REPORT: The report is available in .pdf format on the World Wide Web at *http://www.wes.army.mil/el/dots* and through Interlibrary Loan Service from the U.S. Army Engineer Waterways Experiment Station (WES) Library, telephone (601) 634-2355. To purchase a copy of the report, call NTIS at (703) 487-4780.

About the Authors: Dr. Michael R. Palermo, Messrs. Tommy E. Myers, James E. Clausner, Gregory L. Williams, and Dr. Marian E. Rollings perform research at WES; contract support was provided by Dr. Robert E. Randall, Civil Engineering Department, Texas A&M University; and Dr. Thomas J. Fredette, the U.S. Army Engineer District, New England. **Point of Contact**: Dr. Palermo, Principal Investigator, telephone (601) 634-3753 or e-mail *palermm@ex1.wes.army.mil.*

Contents

List of Figures

List of Tables

Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), and initiated as part of the "Management of Dredging Projects" Technical Area 5 of the Dredging Research Program (DRP). The work was performed under Work Unit 32489 for which Mr. James E. Clausner was Technical Manager. Mr. John G. Housley was the DRP Technical Monitor for the work. Mr. Robert H. Campbell, HQUSACE, was the Chief DRP Technical Monitor.

The work was completed as part of the Dredging Operations and Environmental Research (DOER) program "Contaminated Sediment Characterization and Management" Focus Area, managed by Dr. Michael R. Palermo. DOER Program Monitors are Messrs. Barry Holliday, Joseph Wilson, John Bianco, and Charles Chestnutt, HQUSACE.

The work was performed by Dr. Palermo, Principal Investigator and Mr. Tommy E. Myers, U.S. Army Engineer Waterways Experiment Station (WES) Environmental Laboratory (EL); Dr. Marian P. Rollings, WES Geotechnical Laboratory (GL); Messrs. Clausner and Gregory L. Williams, WES Coastal and Hydraulics Laboratory (CHL); Dr. Thomas J. Fredette, U.S. Army Engineer District, New England; and Dr. Robert E. Randall, Texas A&M University. The contributions of Drs. Paul R. Schroeder, Doug Clarke, and Joe Gailani, WES, and Danny D. Reible, Louisiana State Universsity, who authored Appendix B, are gratefully acknowledged.

The study was conducted by or under the following WES supervision:

EL—Dr. Palermo, Special Projects Group, Environmental Engineering Division (EED); and Mr. Myers, Environmental Restoration Branch (ERB), EED. Additional supervision was provided by Mr. Daniel E. Averett, Chief, ERB; Mr. Norman R. Francingues, Jr., Chief, EED; Dr. Raymond L. Montgomery (retired), former Chief, EED; Dr. John W. Keeley, Assistant Director, EL; and Dr. John Harrison, Director, EL.

CHL—Messrs. Clausner and Williams, Coastal Evaluation and Design Branch (CEDB), Coastal Sediments and Engineering Division (CSED). Additional supervision was provided by Ms. Joan Pope, Chief, CEDB; Mr. Thomas W. Richardson, Chief, CSED; Messrs. Charles C. Calhoun, Jr., and Richard A. Sager, Assistant Directors, CHL; and Dr. James R. Houston, Director, CHL.

GL—Dr. Rollings, Materials Analysis Branch (MAB), Airfields and Pavements Division (APD). Additional supervision was provided by Mr. Timothy W. Vollor, Chief, MAB; Dr. David Pittman, Chief, APD; and Dr. William F. Marcuson III, Director, GL.

Mr. E. Clark McNair, Jr., CHL, was the DRP Program Manager, and is the DOER Operational Program Manager. Dr. Robert M. Engler, EL, is the DOER Executive Program Manager.

Technical review of this report was provided by a joint U.S. Army Corps of Engineers (USACE)/U.S. Environmental Protection Agency (EPA) workgroup comprised of individuals from Headquarters, field offices, and research laboratories of both agencies with scientific and/or programmatic experience related to dredged material disposal management.

Members of the workgroup are as follows:

Joe Wilson	USACE Headquarters	John Lishman	EPA Headquarters
Dave Mathis	USACE Headquarters	Bev Baker	EPA Headquarters
Jan Miller	USACE North Central District	Dave Redford	EPA Headquarters
Tom Fredette	USACE New England District	Tom Chase	EPA Headquarters
John Tavolaro	USACE New York District	Kimberlee Keckler	EPA Region I
Alex Sumeri	USACE Seattle District	Dan Forger	EPA Region II
Douglas Pirie	USACE South Pacific Division	Andrey Massa	EPA Region II
Mike Palermo	USACE WES	Bill Muir	EPA Region III
Jim Clausner	USACE WES	Robert Howard	EPA Region IV
Tom Myers	USACE WES	Phil Murphy	EPA Region IV
Clark McNair	USACE WES	Steve Johnson	EPA Region V
Robert Engler	USACE WES	Suzie McKinney	EPA Region VI
		Norm Sears	EPA Region VI
		Brian Ross	EPA Region IX
		Justine Barton	EPA Region X

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

This report should be cited as follows:

Palermo, M. R., Clausner, J. E., Rollings, M. P., Williams, G. L., Myers, T. E., Fredette, T. J., and Randall, R. E. (1998). "Guidance for subaqueous dredged material capping," Technical Report DOER-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Conversion Factors, Non-SI to SI Units of Measurement

Non-Si units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
inches	25.4	millimeters
miles (U.S. statute)	1.609347	kilometers

1 Introduction

Background

The U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA) have statutory responsibilities with regard to the management of dredged material placement in both ocean and inland and nearshore waters. When dredged materials proposed for open-water placement are found to require isolation from the benthic environment, capping may be appropriate for consideration as a management action. The report herein is intended to provide technical guidance for evaluation of capping projects.

This is one of a series of guidance reports pertaining to dredged material management. This series includes a document entitled "Evaluating Environmental Effects of Dredged Material Management Alternatives - A Technical Framework" (Framework Document - USACE/EPA 1992). The Framework Document articulates those factors to be considered in identifying the environmental effects of dredged material management alternatives on a continuum of discharge sites from uplands to the oceans (management alternatives include open-water, confined, and beneficial-use situations) that meet the substantive and procedural requirements of the National Environmental Policy Act (NEPA), The Federal Water Pollution Control Act of 1972, Public Law 92-500, as amended by the Clean Water Act of 1977 (CWA), and the Marine Protection, Research, and Sanctuaries Act (MPRSA). Application of the technical guidance in this report will allow for consistency in decision making with respect to capping within the Technical Framework.

Potential for water column and benthic effects related to sediment contamination must be evaluated when considering open-water placement of dredged material. Management options aimed at reducing the release of contaminants to the water column during placement and/or subsequent isolation of the material from benthic organisms may be considered to control potential contaminant effects. Such options include operational modifications, use of subaqueous discharge points, diffusers, subaqueous lateral confinement of material, or capping of contaminated material with suitable material (Francingues et al. 1985; USACE/EPA 1992).

Subaqueous dredged material capping is the controlled, accurate placement of contaminated dredged material at an appropriately selected open-water placement site, followed by a covering or cap of suitable isolating material (a glossary of terms used in this report is found in Appendix A). Capping of contaminated dredged material in open-water sites began in the late 1970s, and a number of capping operations under a variety of placement conditions have been accomplished. Conventional placement equipment and techniques are frequently used for a capping project, but these practices must be controlled more precisely than for conventional placement.

Purpose and Scope

This report provides guidance for evaluation of subaqueous dredged material capping projects. Design requirements, a design sequence, site selection, equipment and placement techniques, geotechnical considerations, mixing and dispersion during placement, required capping sediment thickness, material spread and mounding during placement, cap stability, and monitoring are included. From a technical perspective, this guidance is applicable to dredged material capping projects in ocean waters as well as inland and near-coastal waters.

The technical guidance in this report is intended for use by USACE and EPA personnel, State regulatory personnel, as well as dredging permit applicants and others (e.g., scientists, engineers, managers, and other involved or concerned individuals).

Regulatory Setting

Capping involves placement of dredged material in either ocean waters or inland and near-coastal waters (waters of the United States). The primary Federal environmental statute governing transportation of dredged material to the ocean for purpose of placement is the MPRSA, also called the Ocean Dumping Act. The primary Federal environmental statute governing the discharge of dredged and/or fill material into waters of the United States (inland of the baseline to the territorial sea) is the Federal Water Pollution Control Act Amendments of 1972, also called the CWA. All proposed dredged material placement activities regulated by the MPRSA and CWA must also comply with the applicable requirements of the NEPA and its implementing regulations. In addition to MPRSA, CWA, and NEPA, there are a number of other Federal laws, Executive Orders, etc., that must be considered in the evaluation of dredging projects.

The London Convention (Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter, December 29, 1972 (26 UST 2403:TIAS 8165)), to which the United States is a signatory, is an international treaty that deals with marine-waste placement, with jurisdiction that includes all waters seaward of the baseline of the territorial sea. The ocean-dumping criteria developed under MPRSA are required to "apply the standards and criteria binding upon the United States under the

Convention, including its Annexes," to the extent this would not result in relaxation of MPRSA requirements.

In evaluating proposed ocean placement activities, the USACE is required to apply criteria developed by the EPA relating to the effects of the proposed placement activity. The MPRSA criteria are given in 40 CFR 220-227. In evaluating proposed placement activities in inland or coastal waters, the USACE is required to apply guidelines given by Section 404 of the CWA to ensure that such proposed discharge will not result in unacceptable adverse environmental impacts to waters of the United States. The guidelines are given in 40 CFR 230. A tiered approach to sediment testing and assessments is described in detail in the dredged material testing manuals for MPRSA and CWA (EPA/USACE 1991; EPA/USACE 1998).

This report addresses technical and scientific issues associated with capping and does not address the various regulatory requirements of the CWA and MPRSA. Whether or not a particular project involving capping satisfies the relevant regulatory criteria can only be determined by applying the relevant requirements of the regulation and consulting, as necessary, with legal counsel.

Overview and Description of the Capping Process

Capping defined

For purposes of this report, the term "contaminated" refers to material for which isolation from the benthic environment is appropriate because of potential contaminant effects, while the term "clean" refers to material found to be acceptable for open-water placement. Capping is the controlled accurate placement of contaminated material at an open-water placement site, followed by a covering or cap of clean isolating material. For most navigation dredging projects, capping alternatives involving armor stone layers or other nonsediment materials for capping would not normally be considered.

Level-bottom capping (LBC) is defined as the placement of a contaminated material in a mounded configuration and the subsequent covering of the mound with clean sediment. Contained aquatic disposal (CAD) is similar to LBC but with the additional provision of some form of lateral confinement (e.g., placement in natural-bottom depressions, constructed subaqueous pits, or behind subaqueous berms) to minimize spread of the materials on the bottom. An illustration of LBC and CAD is shown in Figure 1.

The objective of LBC is to place a discrete mound of contaminated material on an existing flat or gently sloping natural bottom. A cap is then applied over the mound by one of several techniques, but usually in a series of placement sequences to ensure adequate coverage. CAD is generally used

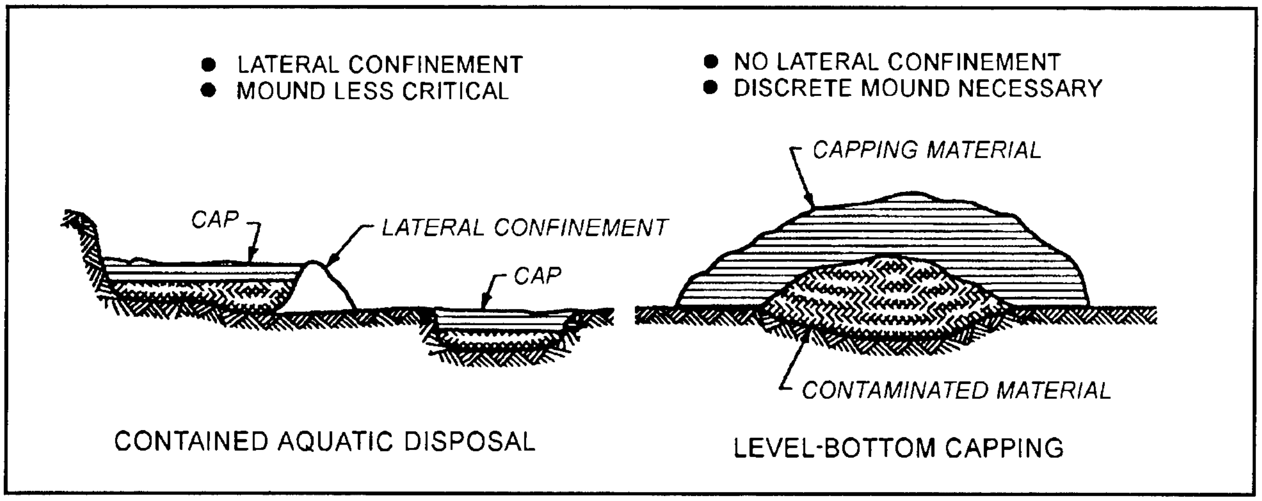


Figure 1. Schematic illustrating LBC and CAD

where the mechanical properties of the contaminated material and/or bottom conditions (e.g., slopes) require positive lateral control measures during placement. Use of CAD can also reduce the required quantity of cap material and thus the costs. Options might include the use of an existing natural or excavated depression, preexcavation of a placement pit, or construction of one or more submerged dikes for confinement (Truitt 1987a).

Dredged material capping versus in situ capping for remediation

Capping is also a potential alternative for remediation of contaminated sediments in place or in situ. However, a clear distinction should be made between navigation dredged material capping and capping in the remediation context. For dredged material capping associated with navigation projects, the sediment of concern would typically require capping because it may exhibit potential for toxicity or significant bioaccumulation in benthic organisms. Often these sediments are only marginally contaminated in comparison with other sediments in the area. The objective of capping in this context is to effectively eliminate direct exposure of benthic organisms to the contaminated sediments and thus virtually eliminate potential benthic toxicity or bioaccumulation.

For in situ capping in the remediation context, the sediments of concern are sufficiently contaminated to warrant some sort of cleanup action. The objective of capping in the remediation context may involve objectives over and above isolation of the sediment from the benthic environment. Guidance for in situ capping for sediment remediation is presented in Palermo et al. (1996).

Design issues for capping

Capping is a contaminant control measure to prevent impacts. However, dredged material capping requires initial placement of a contaminated material at an open-water site. Several issues, therefore, must be carefully considered within the context of a capping project design. These include the following:

a. Potential water column impacts during placement. Assessment should consider evaluation of potential release of contaminants to the water column, evaluation of potential water column toxicity, and evaluation of initial mixing. Elutriate test procedures for water quality, water column bioassay tests, and computer models for dispersion and mixing are available to address these requirements. The mass loss of contaminants during placement (fraction dispersed offsite and remaining uncapped) may also be predicted using these same tests and models.

b. Efficacy of cap placement. Assessment should consider available capping materials, methods for dredging and placement of both contaminated material and cap material, compatibility of site conditions, material physical properties, and dredging and placement techniques. Guidance on selection of appropriate methods, compatibility with site conditions and material properties, and computer models for predicting mound development and spreading behavior are available.

c. Long-term cap integrity. Assessment should consider the physical isolation of contaminants, potential bioturbation of the cap by benthos, consolidation of the sediments, long-term contaminant flux through the cap due to advection/diffusion, and potential for physical disturbance or erosion of the cap by currents, waves, and other forces such as anchors, ship traffic, ice, etc. Test procedures for contaminant isolation and consolidation and computer models for evaluation of long-term contaminant flux, consolidation, and resistance to erosion are available.

Each of these issues must be appropriately addressed by the project design.

Viability of capping as an alternative

Capping is only one of several alternatives that may be considered for dredged material that is excessively contaminated and would need isolation from the benthic environment if proposed for open-water placement. If the issues described above can be satisfactorily addressed in the project design for the specific set of sediment, site, and operational conditions under consideration, capping is a technically viable option.

Capping is not a technically viable option for a specific set of sediment, site, and operational conditions described below:

a. Contaminant release and dispersion behavior of the contaminated material (even with consideration of controls) results in unacceptable water column impacts during placement.

b. Spreading or mounding behavior of the contaminated material or cap material (even with consideration of controls) indicates that the required cap cannot be effectively placed.

c. Energy conditions or operational conditions at the site are such that the required cap thickness cannot be effectively maintained in the long term.

d. Institutional constraints do not provide the ability to commit to the long-term monitoring and management requirements.

Under such circumstances, other options for placement of the contaminated sediments must be considered.

Organization of this Report

The main body of this report describes specific procedures for all aspects of capping-project evaluation and design. A number of appendixes are also included that provide detailed information on specific testing procedures, predictive models, etc. Chapter 2 describes the recommended sequence of design activities, and specific design steps are organized into flowcharts as necessary.

2 Design/Management Sequence for Capping

Design Philosophy for Capping

Capping is not a form of unrestricted open-water placement. A capping operation is an engineered project with carefully considered design, construction, monitoring, and maintenance to ensure that the design is adequate. A successful capping project requires a team approach with input from engineers, biologists/ecologists, chemists, and dredging operations experts. The basic criterion for a successful capping operation is that the cap thickness required to isolate the contaminated material from the environment be successfully placed and maintained.

Dredged Material Capping Functions

A dredged material cap can serve three primary functions:

a. Physical isolation of the contaminated dredged material from the benthic environment.

b. Stabilization of contaminated material, preventing resuspension and transport to other sites.

c. Reduction of the flux of dissolved contaminants into the cap and overlying water column.

If a dredged material is unsuitable for open-water placement due to potential contaminant impacts, physical isolation of the dredged material from the benthic environment and from resuspension and transport offsite would normally be primary functions of a dredged material cap. Control of contaminant flux may be a desired function, depending on the sediment characteristics, site conditions, and other factors.

Summary of Design Sequence for Capping

The flowchart shown in Figure 2 illustrates the major design requirements for a capping project and the sequence in which the design requirements should be considered. There is a strong interdependence between all components of design for a capping project. For example, the initial consideration of a capping site and placement techniques for both the contaminated and capping materials strongly influence all subsequent evaluations, and these initial choices must also be compatible for a successful project (Shields and Montgomery 1984). Each step in the process must be clearly identified and documented before a decision can be made to proceed.

When an efficient sequence of activities for the design of a capping project is followed, unnecessary data collection and evaluations can be avoided. General descriptions of the various design requirements are given below corresponding to the recommended design sequence (Palermo 1991a). Each block in the flowchart (Figure 2) is numbered, and a description of each block is referenced by the number in parentheses in this chapter. More detailed guidance on various aspects of the design is provided in Chapters 3 through 9 and Appendixes B through I of this report. Chapter 10 describes capping case studies and field experience for major capping projects under a range of project conditions. Chapter 11 summarizes the guidance provided in this document.

Gather project data and select design criteria (1)

The first step in any capping project design is to gather and evaluate the existing project data, which normally include surveys of the dredging area, physical and chemical characteristics of the contaminated sediment, equipment used for dredging and placement, and characteristics of potential placement sites (i.e., area erosion trends, wind-wave resuspension, wave-current interaction effects). Since capping is under consideration, data on the suitability of the material to be dredged for open-water placement may exist. These data may include results of physical, chemical, and biological tests required under Section 404 of the CWA or Section 103 of the MPRSA. Data on potential placement sites may vary. Bathymetry, currents, storm frequencies, wave heights, and bottom-sediment characterization are normally available for open-water sites under consideration.

Once the existing data have been gathered, the design functions of the cap can be determined and design criteria selected. Specific design criteria will depend on the selected design functions for the cap, i.e., physical isolation, stabilization, or reduction of contaminant flux. Design criteria may be developed in a number of ways: providing cap thickness for isolation of benthic organisms to a given bioturbation depth; reducing contaminant flux rates to achieve specific sediment, pore water, or water column target concentrations; specific storm or flood flow return periods for cap stability; limits on mound elevation to meet navigation or erosion constraints; placement of all material within given site boundaries, etc. Such criteria should be defined prior to starting design of the capping project. Three main aspects of capping design must be examined: aspects related to

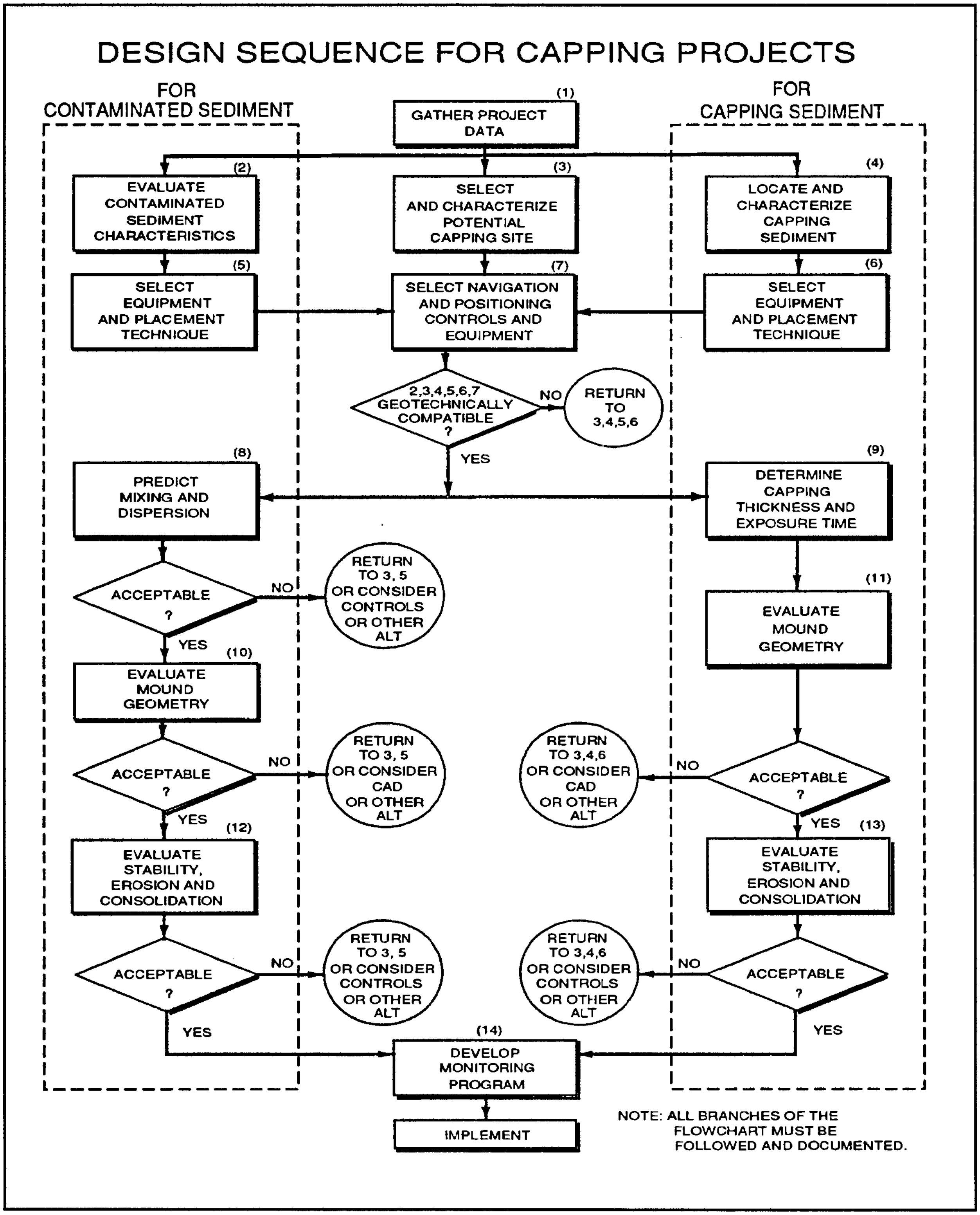


Figure 2. Flowchart illustrating design sequence for dredged material capping projects (after Palermo 1991a)

characterization and placement of the contaminated material, aspects related to the characterization and placement of the capping material, and aspects related to the capping site under consideration. Each of these aspects must be initially examined in a parallel fashion (see Blocks 2, 3, and 4 of Figure 2). Further, the interrelationship and compatibility of these three aspects of the design are critical.

Characterize contaminated sediment (2)

The contaminated sediment must be characterized from physical, chemical, and biological standpoints. Physical characteristics are of importance in determining the behavior of the material during and following placement at a capping site. In situ volume (to be dredged), in situ density (or water content), shear strength, compressibility, and grain-size distribution are needed for evaluations of dispersion and spread during placement, mounding characteristics, consolidation, and long-term stability and resistance to erosion. These data should be developed using standard techniques.

Some chemical and biological characterization of the contaminated sediment is normally performed as a part of the overall evaluation for suitability for open-water placement. Guidance on characterization of contaminated sediments is found in Chapter 3.

Select a potential capping site (3)

The selection of a potential site for capping is subject to the same constraints and tradeoffs as any other open-water placement site. The major considerations in site selection include bathymetry, bottom slopes, currents, water depths, water column density stratification, erosion/accretion trends, proximity to navigation channels and anchorages, bottom-sediment characteristics, and operational requirements such as distance to the site and wave climate. However, in addition to normal considerations, the capping site should ideally be in a relatively low-energy environment with little potential for erosion or disturbance of the cap. While capping at a low-energy site is desirable, such sites are not always available. Higher energy sites can be considered for dredged material capping, but a detailed study of erosion potential is required; increases in cap thickness to account for potential erosion or use of a coarser grain-size material may be required.

Consideration should be given to the following factors during selection of a potential capping site. Bathymetry forming a natural depression will tend to confine the material, resulting in a CAD project. Placement of material on steep bottom slopes should generally be avoided for a capping project. Water column currents affect the degree of dispersion during placement and the location of the mound with respect to the point of discharge. Of more importance are the bottom currents, which could potentially cause resuspension and erosion of the mound and cap. The effects of storm-induced waves on bottom-current velocities must be considered. For some sites, other processes such as prop wash may need to be considered. The deeper the water is at the site, the greater the potential is for water entrainment and dispersion during placement. However, deeper water depths also generally provide more stable conditions on the bottom with less potential for erosion. Numerical models for prediction of water column behavior, mound development, and long-term stability against erosion may be used in evaluating site conditions. Guidance on site selection for capping is found in Chapter 4.

Select and characterize capping sediment (4)

The cap sediment used in a project should be carefully selected. However, for economic reasons, a capping sediment is usually taken from an area that also requires dredging or is considered advanced maintenance dredging. If this is the case, there may be a choice between projects. Scheduling of the dredging is also an important consideration. In other cases, removal of bottom sediments from areas adjacent to the capping site may be considered.

The capping sediment is characterized as described above for the contaminated sediment. However, the capping sediment must be one that is suitable for open-water placement (i.e., a clean sediment). The evaluation of a potential capping sediment for open-water placement acceptability must be accomplished using appropriate techniques under either CWA or MPRSA. Physical characteristics of the capping sediment are also of particular interest in capping design. Density (or water content), grain-size distribution, and cohesiveness of the capping sediment must be evaluated. Selection of the capping sediment should be carefully considered because the capping material must be compatible with the contaminated sediment and this compatibility is related to dredging and placement equipment and techniques. Previous studies have shown that both fine-grained materials and sandy materials can be effective capping materials. Guidance on selecting and characterizing capping sediment is found in Chapter 3.

Select equipment and placement technique for contaminated sediment (5)

A variety of equipment types and placement techniques have been used for capping projects. The important factors in the placement of contaminated material are reducing water column dispersion and bottom spread to the greatest possible extent. This minimizes the release of contaminants during placement and provides for easier capping. For LBC the dredging equipment and placement technique for contaminated sediment must provide a tight, compact mound. This is most easily accomplished with mechanical dredging and barge release (point dumping). If CAD is under consideration, hydraulic placement of the contaminated material may be acceptable.

Specialized equipment and placement techniques can also be considered to increase control during placement and reduce potential dispersion and spread of contaminated material. These might include use of submerged diffusers or submerged discharge points for hydraulic pipeline placement, hopper dredge pump-down with diffuser, or gravity-fed tremie for mechanical or hydraulic placement or use of geosynthetic fabric containers. Guidance for equipment and placement techniques is found in Chapter 5.

Select equipment and placement technique for capping sediment (6)

The major design requirement in the selection of equipment and placement of the cap is the need for controlled, accurate placement and the resulting density and rate of application of capping material. In general, the cap material should be placed so that it accumulates in a layer covering the contaminated material. The use of equipment or placement rates that might result in the capping material displacing or mixing with the previously placed contaminated material must be avoided. Placement of capping material at equal or lesser density than the contaminated material or use of placement methods to spread thin layers to gradually build up the cap thickness usually meets this requirement.

Specialized equipment and placement techniques can be considered to increase control of capping material placement. The movement of submerged diffusers, energy dissipaters, submerged discharge points, or tremies can be controlled to spread capping material over an area to a required thickness. Incremental opening of split-hull or multicompartment barges along with controlled movement of the barges during surface release, direct pump-out through pipes, and direct washing by hoses have been used for placing mechanically dredged sandy capping material. Energy dissipaters for hydraulic placement of capping materials have been successfully used. Guidance on selection of equipment and placement techniques is found in Chapter 5.

Select navigation and positioning equipment and controls (7)

Placement of both the contaminated and capping material must be carefully controlled, regardless of the equipment and placement technique selected. Electronic positioning systems, taut-moored buoys, mooring barges, various acoustical positioning devices, and computer-assisted, real-time helmsman's aids should be considered in selecting the equipment and placement technique. Guidance on selection of navigation and positioning equipment and controls is found in Chapter 5.

Evaluate compatibility of site, materials, and equipment

At this point in the design, the contaminated material has been characterized; a site has been identified and characterized; a capping sediment has been selected and characterized; equipment and placement techniques have been selected for both materials and navigation; and positioning needs have been addressed. These essential components of the design (Blocks 2, 3, 4, 5, 6, and 7 in Figure 2) must now be examined as a whole, with compatibility in mind, to evaluate the efficacy of cap placement for the sediments, site conditions, equipment availability and capabilities under consideration, and cost. The primary concern with compatibility relates to geotechnical considerations and the ability of the contaminated material to support the cap, considering the material characteristics and dredging and placement techniques.

Guidance on the compatibility of various dredging and placement techniques for differing material types has been developed based on field experience and knowledge of the resulting dispersion and spreading behavior and physical stability of the materials. If the various site, sediment, and selected equipment components are compatible, additional and more detailed design requirements can be addressed. If there is a lack of compatibility at this point, a different capping site (3), a different capping sediment (4), or different dredging and placement equipment and techniques (5,6) must be considered. A close examination of the project design components at this decision point is essential before performing the more detailed and costly evaluations that come later in the design process. Guidance on evaluation of sediment, site, and equipment compatibility is found in Chapter 5.

Predict water column mixing and dispersion effects of contaminated sediment during placement (8)

If water column effects during placement of the contaminated material are of concern, an evaluation of the suitability of the material from the standpoint of water column effects must be performed. This evaluation involves the comparison of predicted water column contaminant concentrations with water quality criteria and predicted water column dredged material concentrations with bioassay test results. Use of available mathematical models and/or case study field-monitoring results to predict the water column dispersion and concentrations is an integral part of such evaluations. In addition, the prediction indicates what portion of the contaminated material is released during placement and thus is not capped. Evaluation of initial deposition and spread of material is used in determining the mounding characteristics for the entire contaminated material volume to be placed. If water column release is unacceptable, control measures need to be considered to reduce the potential for water column effects, or other dredging equipment and placement techniques (5) or use of another capping site (3) must be considered. Guidance on prediction of water column effects during placement is found in Chapter 6 and Appendix D.

Determine cap design (9)

The cap must be designed to adequately isolate the contaminated material from the aquatic environment and achieve the intended cap functions. The composition and dimensions (thickness) of the components of a cap can be referred to as the cap design. The composition of caps for dredged material projects is typically a single layer of clean sediments because relatively large volumes of cap material are involved; clean sediments from other dredging projects are often available as cap materials; and dredged material capping sites with low potential for erosion can be selected. Guidance on dredged material cap design therefore focuses on the thickness of the cap as the major design criterion.

The determination of the required cap thickness is dependent on the physical and chemical properties of the contaminated and capping sediments, the potential for bioturbation of the cap by aquatic organisms, the potential for consolidation and the resultant expulsion of pore water from the contaminated sediment, and the potential for consolidation and erosion of the cap material. The minimum required cap thickness is considered the thickness required for physical isolation plus any thickness needed for control of contaminant flux. The integrity of the cap from the standpoint of physical changes in cap thickness and long-term migration of contaminants through the cap should also be considered. The potential for a physical reduction in cap thickness due to the effects of consolidation and erosion (12,13) can be evaluated once the overall size and configuration of the capped mound is determined. A precise calculation of the erosion thickness component requires consideration of mound shape, mound height, and water depth. Since these parameters also depend on the total capping thickness, some iterative calculations may be required. The design cap thickness is the required cap thickness for isolation plus that required for consolidation and erosion and operational considerations. Guidance on cap design is found in Chapter 7, and details on specific testing and evaluation procedures and models to support cap design are found in Chapters 6 and 8 and Appendixes B, C, E, F, G, and H.

Evaluate spread, mounding and site geometry (10,11)

For LBC sites, the mound geometry, including contaminated material mound and cap, will influence the design of the cap and volume of capping material required. The smaller the footprint of the contaminated material as placed, the less volume of capping material is required to achieve a given cap thickness. The spread and development of the contaminated material mound is dependent on the physical characteristics of the material (grain size and cohesion) and the placement technique used (hydraulic placement results in greater spread than mechanical placement). Assuming that the material from multiple barge loads or pipeline can be accurately placed at a single point, mound side slope and the total volume placed dictate the mound spread. The formation of a thin layer or apron surrounding the central mound must also be considered in defining the footprint to be capped for LBC.

For CAD projects, in which lateral containment prevents spreading and apron formation, the footprint will be determined by the site geometry. However, the volume occupied by the sediments will govern the capacity of the CAD site and must be considered as a factor in site design. If the mound geometry or CAD site geometry is unacceptable, an alternative site (3), alternative capping sediment (4), or alternative placement techniques (5,6) can be considered. Guidance on mound spread and development and site geometry is found in Chapter 6 and Appendixes E and H.

Evaluate stability, erosion, and consolidation (12,13)

The deposit of contaminated dredged material must also be stable against excessive erosion and resuspension of material before placement of the cap. The cap material must be stable against long-term erosion for the required cap thickness to be maintained. The potential for resuspension and erosion is dependent on bottom current velocity, potential for wave-induced currents, sediment particle size, and sediment cohesion. Site selection criteria as described above normally results in a site with low bottom-current velocity and little potential for erosion. However, if the material is hydraulically placed (as for a CAD site) or a site with higher energy potential is considered, a thorough analysis of the potential for resuspension and erosion must be performed, to include frequency considerations. Conventional methods for analysis of sediment transport can be used to evaluate erosion potential. These methods can range from simple analytical techniques to numerical modeling.

Consolidation of contaminated material needs to be examined for its effect on LBC mound slopes and volumes and on the volume occupied within CAD sites. In general, consolidation of the contaminated dredged material will result in more stable conditions. The same is true for consolidation of the cap material. However, consolidation of the cap results in a reduced cap thickness. Therefore, the potential for cap consolidation must be accounted for in the overall design of the cap thickness.

If the potential for erosion and consolidation of either the contaminated material or cap is unacceptable, an alternative site (3), alternative capping sediment (4), or alternative placement techniques (5,6) can be considered. Guidance on evaluating long-term cap stability is found in Chapter 8 and Appendixes F, G, and I.

Develop a monitoring program (14)

A monitoring program or site monitoring plan is required as a part of any capping project design. The main objectives of monitoring normally are to ensure that the contaminated sediment is placed as intended and with acceptably low levels of contaminant release, the cap is placed as intended and the required capping thickness is maintained, and the cap is effective in isolating the contaminated material from the environment. Monitoring plans for capping projects need to include a more intensive effort during and shortly after placement operations and immediately after unusual events (e.g., severe storms), with a declining level of effort in future years if no adverse effects are detected. Physical, chemical, and biological elements may be included in a monitoring plan. In all cases, the objectives of the monitoring effort and any remedial actions to be considered as a result of the monitoring must be clearly defined as a part of the overall project design. Guidance on monitoring considerations for capping is found in Chapter 9. Case studies of capping projects including conclusions drawn from field monitoring efforts are described in Chapter 10.

3 Characterization of Contaminated and Capping Sediments

Need for Sediment Characterization

Characterization of both the contaminated sediment and potential capping sediments is necessary for evaluation of the environmental acceptability of sediments for open-water placement and to determine physical and engineering properties necessary for prediction of both short- and long-term behavior of the sediments. Some characterization data may have been obtained as a part of a more general investigation of disposal alternatives prior to consideration of capping.

Characterization of Contaminated Sediment

The contaminated sediments to be capped are likely to have been characterized to some degree prior to consideration of capping. In any event, the contaminated sediment must be characterized from a physical, chemical, and biological standpoint.

Physical characterization

The physical characteristics of the contaminated sediment are of importance in predicting the behavior of the material during and following placement at a capping site. Physical characterization is needed for evaluations of dispersion and spread during placement, mounding characteristics, and long-term stability and resistance to erosion.

Physical tests and evaluations on sediment should include visual classification, natural (in situ) water content/solids concentration/bulk density, plasticity indices (Atterberg limits), organic content, grain-size distribution, specific gravity, and Unified Soil classification. Standard geotechnical laboratory test procedures, such as those of the American Society for Testing and Materials (ASTM), the American Association of State Highway

Transportation Officials (AASHTO), or the USACE, should be used for each test. Table 1 gives the standard ASTM and USACE designations for the needed tests and also cross-references these procedures to those of several other organizations that have standardized test methods.

Table 1
Standard Geotechnical Laboratory Test Procedures

Test	Designation				
	ASTM	**AASHTO**	**COE[1]**	**DoD[2,3]**	**Comments**
Soils					
Water content	D 2216	T265	I	Method 105, 2-VII	
Grain size	D 422	T88	V	2-III, 2-V, 2-VI	
Atterberg limits	D 4318	T89 T90	III	Method 103, 2-VIII	
Classification	D 2487		III		
Specific gravity	D 854	T100	IV	2-IV	
Organic content	D 2974				Use Method C
Consolidation[4]	D 2435	T216	VIII		
Permeability[5]	D 2434	T215	VII		
Shear tests	D 2573				Field test

[1] Department of the Army Laboratory Soils Manual EM 1110-2-1906.
[2] Department of Defense Military Standard MIL-STD-621A (Method 100, etc.).
[3] Department of the Army Materials Testing Field Manual FM 5-530 (2-III, etc.).
[4] Do not use the standard laboratory test for determining consolidation. Instead, use the modified standard consolidation test and the self-weight consolidation test as described in USACE (1987).
[5] One value of permeability must be calculated from the self-weight consolidation test.

Additional geotechnical data should also be collected on contaminated sediments for capping projects, including consolidation, and shear strength data. These data are useful for geotechnical evaluations of stability of the capped deposit and the development of mound or deposit geometries. Detailed information on consolidation testing is presented in Appendix I.

Physical analysis of dredging site and/or disposal site water may also be required to include suspended solids concentration and salinity. Potential stratification due to temperature and salinity differences should be considered. These data must be developed using standard techniques.

Chemical/biological characterization

Capping as a control measure is normally considered only after a sediment to be dredged is found to be contaminated. In order to make such a determination, some chemical and biological characterization of the contaminated sediment is normally performed as a part of the overall evaluation for suitability for open-water placement (EPA/USACE 1991; EPA/USACE 1998). It should be noted that even though capping is being considered because of a determination of potentially unsuitable benthic effects, the data necessary for evaluation of potential water column effects are still required.

Chemical characterization of contaminated sediment may include a sediment chemical inventory and standard elutriate test results. The chemical sediment inventory is useful in determining contaminants of concern and in the development of appropriate chemical elements of a monitoring program to determine capping effectiveness. Elutriate data are used in estimating the potential effects on water quality due to placement of the contaminated material. Biological characterization may include water column bioassays, benthic bioassays, and bioaccumulation tests. The results of these biological tests are useful in determining potential water column effects during placement and acceptable exposure times before placement of the cap begins. If these data have not been developed for the contaminated sediment, additional testing may be required.

Selection of Capping Sediment

The capping sediment used in a capping project may be a matter of choice. For economic reasons, a capping sediment is usually taken from an area that also requires dredging. If this is the case, there may be a choice between projects, and scheduling of the dredging is an important consideration. In other cases, removal of bottom sediments from areas adjacent to the capping site may be considered. If CAD is under consideration, removal of material to create CAD cells may be stockpiled and used later in the capping operation (Averett et al. 1989; Sumeri 1989).

Characterization of Capping Sediment

All dredged material capping projects to date have utilized dredged material that is suitable for open-water placement for the capping material. Use of other materials for caps or for components of a multilayer cap such as quarry sand, soil materials, geotextiles, or armor stone are possible and have been implemented in in situ capping projects. Guidance (Palermo et al. 1996) on selection and use of such materials for caps is available. This section focuses on use of dredged material as capping material.

Physical characterization

Physical characteristics of the capping sediment are similarly determined as described above for the contaminated sediment. Visual classification, natural (in situ) water content/solids concentration, plasticity indices (Atterberg limits), organic content, grain-size distribution, specific gravity, and Unified Soil classification as well as geotechnical data should be evaluated as necessary.

The characteristics of the capping sediment should be compatible with the contaminated sediment, considering the placement technique for both. Previous studies have shown that both fine-grained materials and sandy materials can be effective capping materials.

Chemical/biological characterization

The capping sediment must be one that is acceptable for unrestricted open-water placement (that is a clean sediment). Further, the capping sediment must be acceptable for open-water placement from the standpoint of both potential water column and potential benthic effects. In order to make such a determination, some chemical and biological characterization of the contaminated sediment is normally performed as a part of the overall evaluation for suitability for open-water placement (EPA/USACE 1991; EPA/USACE 1998).

Sampling and Testing Plans

Samples of sediments must be obtained for physical, chemical, or biological characterization as described above. Samples may also be required for other engineering or environmental testing such as the capping thickness testing described in Chapter 7 and Appendix C.

General guidance on design of sampling plans is available (EPA/USACE 1991; EPA/USACE 1998), but most sampling plans will be site specific. The full range of anticipated testing must be considered in developing sampling plans. Appropriate sampling equipment, sampling techniques, and sample preservation procedures should be used.

Variability can be exhibited in vertical as well as horizontal location of specific samples. Sampling should define material to the total depth of dredging. Grab samplers or box corers are generally appropriate for shallow thickness of sediment, while core samples (by vibracore or conventional coring equipment) are normally required for thicker sediment deposits or deposits in which stratification must be defined. Detailed guidance on sampling equipment and procedures is available (Mudrock and McKnight 1991.)

Testing of samples from specific locations is usually done for characterization purposes. Compositing should be considered for some engineering or environmental testing (e.g., consolidation tests, elutriate tests, bioassays, capping effectiveness tests). Administrative agreement between all concerned regulatory agencies regarding the acceptability of the sampling and testing plan should be obtained prior to sampling and testing.

4 Site Selection Considerations for Capping

General Considerations for Site Selection

The selection of an appropriate site is a critical requirement for any capping operation. Since the cap must provide long-term isolation of the contaminated material, capping sites should generally be characterized as nondispersive sites, where material is intended to remain in a stable deposit. Therefore, the considerations for site selection for a conventional nondispersive open-water disposal site also apply to capping sites (Palermo 1991b).

Sites in ocean waters are regulated by MPRSA. For MPRSA sites, a formal site designation procedure includes a detailed evaluation of site characteristics. Sites in inland and near-coastal waters (inland of the baseline of the territorial sea) are regulated by CWA. The specification of disposal sites under the CWA is addressed specifically in the Section 404 (b)(1) guidelines. Any capping project in waters of the United States must occur at a specified 404 site.

A number of site characteristics must be considered in designating or specifying an open-water disposal site. These characteristics include the following:

- Currents and wave climate.
- Water depth (including consideration of navigable depth).
- Bathymetry (particularly slopes).
- Potential changes in circulation or erosion patterns related to refraction of waves around the disposal mound.
- Groundwater flow (consideration for some nearshore sites).
- Bottom sediment physical characteristics, including sediment grain-size differences.

- Sediment deposition versus erosion to include seasonal and long-term trends.

- Salinity and temperature distributions.

- Normal level and fluctuations in background turbidity.

- Chemical and biological characterization of the site and environs (for example, relative abundance of various habitat types in the vicinity, relative adaptability of the benthos to sediment deposition, presence of submersed aquatic vegetation, presence of unique, rare, or isolated benthic populations, contaminant concentrations in sediments, background water quality).

- Potential for site recolonization

- Previous disposal operations.

- Availability of suitable equipment for disposal at the site.

- Ability to monitor the disposal site adequately and economically for management decisions.

- Technical capability to implement management options should they appear desirable.

- Ability to control placement of the material.

- Volumetric capacity of the site.

- Other site uses and potential conflicts with other activities (i.e., sport or recreational fisheries).

- Established site management or monitoring requirements.

- Public and regulatory acceptability to use of the site.

The intent of the MPRSA criteria for site designation is to avoid unacceptable adverse impacts on biota and other amenities. The Section 404(b)(1) guidelines generally address the same concerns as the MPRSA criteria, but the primary emphasis is directed toward the potential effects of the disposal activity.

The USACE has prepared an ocean site designation manual (Pequegnat, Gallaway, and Wright 1990), which provides useful guidance and procedures for conducting the appropriate investigations and studies. In addition, overview manuals for site designation are available (USACE/EPA 1984; EPA 1986).

The selection of a potential site for capping is subject to the same constraints and tradeoffs as any other nondispersive open-water disposal site. However, beyond the normal considerations, the capping site should be in a relatively low-energy environment with little potential for erosion of the cap. While capping at a low-energy site is desirable, such sites are not always available. Higher energy sites can be considered for dredged material capping, but a detailed study of erosion potential is required; increases in cap thickness to account for potential erosion may be required. Monitoring and maintenance costs may also be higher for higher energy sites.

Special consideration of site bathymetry, currents, water depths, bottom-sediment characteristics, and operational requirements such as distance, sea state, etc., are required in screening or selecting sites for capping (Truitt 1987a; Truitt, Clausner, and McLellan 1989).

Bathymetry

Site bathymetry influences the degree of spread during placement of both contaminated and capping material. The flatter the bottom slope, the more desirable it is for LBC projects, especially if material is to be placed by hopper dredge. If the bottom in a disposal area is not horizontal, a component of the gravity force influences the energy balance of the bottom surge (the lateral movement of the disposed material as it impacts sea bottom) and density flows due to slope following impact of the discharge with the bottom. It is difficult to estimate the effects of slope alone, since bottom roughness plays an equally important role in the mechanics of the spreading process. To date, LBC projects in which the material was mechanically dredged and released from a barge have been executed at sites with slopes up to 1:60 (Science Applications International Corporation (SAIC) 1995a) and in which material was placed by hopper dredge at sites with slopes up to 1:225 (i.e., New York Mud Dump site). Placement of material on steep bottom slopes (steeper than one degree 1:60) should generally be avoided for a capping project (Truitt 1987a). Bathymetry forming a natural depression tends to confine the material, resulting in a CAD project. This is the most desirable type of site bathymetry for a capping project.

Currents

Water column currents affect the degree of dispersion during placement and mound location with respect to the point of discharge. Of more importance are bottom currents, which could potentially cause resuspension and erosion of the mound and cap. The effects of storm-induced waves on bottom-current velocities must also be considered. Capping sites need to have current and wave climate characteristics that result in long-term stability of the capped mound or deposit.

Collection of basic current information is necessary at prospective disposal sites to identify site-specific conditions. The principal influence of currents in the receiving water during placement is to displace or offset the point of impact of the descending jet of material with the bottom with respect to the point of release (by a calculable amount). Water column currents need not be a serious impediment to accurate placement, nor do they result in significantly greater dispersion during placement (though the offset needs to be taken into account). Further, currents do not appear to affect the surge phase of the disposal (Bokuniewicz et al. 1978; Truitt 1986a). However, water column currents and bottom slopes are important in slow placement of sand caps where the currents and density flows can cause some waste of capping material.

Long-term effects of currents at a prospective site may still need to be investigated from the standpoint of potential erosion of the mound and cap or potential recontamination of the site from adjacent sources. Storm-induced currents are also of interest in the long-term stability of the site. However, disposal operations are not conducted during storms, so the designer does not need to consider storm-induced currents during disposal. Measured current data can be supplemented by estimates for extreme events using standard techniques; for example, see the Shore Protection Manual (HQUSACE 1984). Selection of a nondispersive site in a relatively low-energy environment normally results in a site with low bottom-current velocity and little potential for erosion. However, in some cases, particularly if the material is hydraulically placed, a thorough analysis of the potential for resuspension and erosion is necessary. In the analysis of erosion, the effects of self-armoring due to the winnowing away of finer particles are a factor that increases erosion resistance over time but is difficult to quantify.

The same technical approaches used to evaluate erosion potential and/or magnitude and rate of erosion for purposes of cap design can be used in screening and/or selecting sites. The process of screening and site evaluation for erosion potential must consider current and wave conditions for both ambient and episodic events such as storms. Conventional methods for analysis of sediment transport can be used to evaluate erosion potential (Teeter 1988; Dortch et al. 1990). These methods can range from simple analytical techniques to numerical modeling (Scheffner et al. 1995). Modeling evaluations will normally result in a varying rate of erosion for various portions of a site or mounded feature (e.g., erosion would normally be greater at the crest of a mound or at the corners of a mounded feature).

Erosion criteria for site screening should also be based on both ambient and episodic events and should account for a varying rate of erosion over the site. For projects in which no subsequent capping is anticipated for a long time period (several decades or longer) or for which materials for cap nourishment are not easily obtained, it is suggested that net cap erosion over the major portion of the mound or deposit should not exceed 1 ft[1] over a period of 20 years of normal current/wave energies or for a 100-year extreme event. The recommended criteria of 1 ft of erosion, 20-year ambient time interval, and 100-year return interval for storms is based on engineering judgement, a common sense level of conservatism, and field experience gained to date. One foot is a round number that can be measured with some precision for most locations. Twenty and one hundred years as

---

[1] The U.S. customary units of measurement are used in lieu of metric (SI) units for those cases common in dredging practice. Metric (SI) units are used in this report when consistent with standard usage. A table to convert from non-SI units of measurement to SI units can be found on page xiv.

time periods are in the range of design periods for many engineering structures. Note that erosion at localized portions of the mound or feature greater than 1 ft would be allowed using these screening criteria. The corners of a mound would normally have an overlap of capping material, and the crest of a mound would normally have a greater cap thickness; therefore, somewhat larger erosion could be tolerated over these portions of a mound. Selection of other values of erosion thickness or time periods should be based on site-specific factors (e.g., the degree of contamination, distance to other resources), the level of confidence in the calculations, and the level of risk acceptable to the parties involved.

For projects in which subsequent material placement and/or capping is planned or for which materials for cap nourishment can be easily obtained, higher erosion rates or shorter return periods for episodic events may be considered as a criterion for purposes of site screening. In areas where available capping materials are scarce and current and wave conditions are severe, a coarse-grained layer of material (coarse sand, gravel, or larger size materials) may be incorporated into the cap design to provide protection against erosive currents at the site. Detailed guidance on evaluation of erosion is found in Chapter 8 and Appendixes F and G.

Average Water Depths

Case studies have indicated that water depth is of particular interest in evaluating the potential suitability of a site for capping operations (Palermo 1989). The deepest water depth for which a capping project has been executed (as of 1995) is approximately 100 ft. However, definable dredged material mounds have been created in water depths exceeding 400 ft (Wiley 1995). Greater water depths generally provide more stable bottom conditions with less potential for erosion. However, the greater the average water depth is at the site, the greater the potential is for water entrainment and dispersion during placement. The expense and difficulty in monitoring is also increased with a greater water depth.

As water depth increases, both the contaminated and clean material must descend through a greater water column depth. More material is released to the water column during placement as compared with shallower water placement, all other factors being equal. Therefore, the fraction of the contaminated material that is not finally capped is greater.

Entrainment of ambient water causes the descending material to become more buoyant; therefore, the effect of density stratification in the water column needs to be evaluated. Although density stratification in the water column may be encountered at some deep-water sites, stratification is not likely to prevent the descent of the dredged material mass during placement. The very cohesive fraction of mechanically dredged material (clods or clumps) attains terminal speed quickly after release from a barge and does not accelerate further with depth.

The increased water entrainment with deep-water placement may also result in a greater spread of the more fluid material on the bottom, but entrainment reduces the overall potential energy at bottom impact. Field studies indicate that the bottom surge does not spread at a faster rate than that occurring in shallower depths, although because of additional entrainment, the initial thickness of the surge increases as depth increases (Bokuniewicz et al. 1978). Greater care in control of placement may therefore be required as water depth increases to develop a discrete mound of contaminated material and adequate coverage of the mound with capping material.

Comparison of predictive models for fate of placed material and field monitoring of Puget Sound Dredge Disposal Analysis (PSDDA) sites in Seattle's Elliott Bay and Everett's Port Gardner Bay show the high degree of reliability of these models for prediction of mound footprint extent in water depths of 300 to 400 ft (Wiley 1995). Also, the accuracy of available electronic positioning equipment used during disposal is validated.

The use of a deep-water site for capping generally holds an advantage over a shallower site from the standpoint of cap stability from erosive forces. Deep water acts as a buffer to wave action, and the resulting wave-induced currents from storm events are smaller than in shallow water. Therefore, deep-water sites are usually quiescent, near bottom low-energy environments that are better suited to capping from the standpoint of cap stability, but this must be balanced against potential material loss during placement. Generally, a greater water depth at a site has more favorable influence on long-term cap stability than unfavorable influence on dispersion during the placement process (Truitt 1986b).

Operational Requirements

Among the operational criteria that need to be considered in evaluating potential capping sites are site volumetric capacity, nearby obstructions or structures, haul distances, bottom shear due to ship traffic (in addition to natural currents), location of available cap material, potential use of bottom drag fishing equipment, and ice influences. The effects of shipping are especially important since bottom stresses due to anchoring, propeller wash, and direct hull contact at shallow sites are typically of a greater magnitude than the combined effects of waves and other currents (Truitt 1987a). Methods for calculating prop-wash velocities are available (Palermo et al. 1996).

5 Equipment and Placement Techniques

Equipment and techniques applicable to placement of contaminated material to be capped and clean material used for capping include conventional discharge from barges, hopper dredges, and pipelines; diffusers and tremie approaches for submerged discharge; and spreading techniques for cap placement (Palermo 1991c, 1994). This chapter describes basic dredging, transportation, and placement processes as they relate to capping and considerations in selecting equipment and placement technique for both contaminated and capping materials. Considerations for scheduling for placement of the cap, navigation and positioning needs, placement options and tolerances, and inspection and compliance are also discussed.

Flow and Mounding Versus Dredging Method

The behavior of materials upon placement (especially their tendency to mound or to flow) and the ability to cap a deposit of contaminated material depend on several factors, including the method of dredging, the method of placement, material characteristics (cohesive/noncohesive), and site conditions such as water depth or current velocities (Headquarters, U.S. Army Corps of Engineers 1983).

The dredging process may be subdivided into two categories: mechanical and hydraulic dredging. During mechanical dredging, the sediments are physically lifted from the bottom by a mechanical process such as a bucket or clamshell. Mechanically dredged material is typically placed into and transported to the disposal area in barges (also commonly known as dump scows). Barges either have hoppers with doors through which material is released to the bottom or they can be split-hull, allowing the entire barge to open and release material to the bottom. Mechanically dredged material placed in this manner is ideally suited for creating subaqueous mounds because the dredged material stays close to the in situ density throughout the dredging process. This relatively constant density lends to effective mound construction because less water is entrained in the material, stripping during descent is minimized, and material spread on the bottom is reduced (Sanderson and McKnight 1986).

During hydraulic dredging, the bottom material is fluidized, lifted via pipeline by a centrifugal pump, and transported as a slurry. Material dredged by hopper dredges is also considered hydraulic dredging because of the fluidization process required to lift the material to the hoppers. Hydraulically dredged material is typically transported via pipeline to the disposal site and discharged with large amounts of entrained water. For hopper dredges, the material is transported in the hopper similar to a barge or scow as with the mechanical dredging, but excess water that is entrained during dredging remains with the material, thereby making the material less dense than when in situ or mechanically dredged. For both cases of hydraulic dredges (pipeline and hopper), the less dense material is more susceptible to stripping and creates a flatter feature covering a larger area on the bottom (Sanderson and McKnight 1986).

Alternatives are available to increase the mounding potential of material dredged by hydraulic means. For pipeline dredges, diffusers can be employed to reduce the material exit velocity from the pipe and reduce dispersion. Pump-down pipes can be added to transfer the material closer to the bottom and reduce losses due to stripping as the material falls through the water column. For hopper dredges, the spread of material on the bottom can be reduced by having the dredge come to a stop during placement.

Dredged material characteristics also contribute to mounding potential. Cohesive and noncohesive materials will tend to mound when dredged using mechanical means and point dumped (i.e., from a barge). Both cohesive and noncohesive material will tend to flow if hydraulically dredged and point dumped (i.e., discharged from a pipe). In cases where a pump-down pipe is incorporated for hydraulically dredged material, noncohesive material tends to mound, while cohesive material tends to flow.

Table 2 summarizes available information on the mounding or flowing characteristics of cohesive versus noncohesive sediments for various dredging and placement methods. This information can be used in evaluating various equipment and placement techniques for a given set of site conditions.

Considerations for Contaminated Material Dredging and Placement

Placement of contaminated material for a capping project should be accomplished so that the resulting deposit can be defined by monitoring and effectively capped. Therefore, the equipment and techniques for dredging, transport, and placement must be compatible with that of the capping material. Since capping is a contaminant control measure for potential benthic effects, the contaminated material should be placed such that the exposure of the material prior to capping is minimized. In most cases, the water column dispersion and bottom spread occurring during placement should also be reduced to the greatest possible extent. This minimizes the release of contaminants during placement and provides for easier capping. If the placement of the contaminated sediment has potentially unacceptable

Table 2
Flow Characteristics of Dredged Material Placed in Aquatic Sites (Shields and Montgomery 1994)

Dredged Material Characteristics	Placement Method: Point Dump	Placement Method: Pump Down
Nocohesive Material		
Mechanically Dredged	Tends to mound	Not applicable
Hydaulically Dredged	Tends to flow[1,2,3]	Tends to mound[4]
Cohesive Material		
Mechanically Dredged	Tends to mound[1,2]	Not applicable
Hydraulically Dredged	Tends to flow[1]	Tends to flow[2]

[1] JBF Scientific Corporation 1975.
[2] Morton 1983a.
[3] Sustar and Eker 1972.
[4] Nichols, Thompson, and Faas 1978.

water column impacts, controls to specifically reduce water column dispersion (for example, submerged discharge) may be required.

For LBC, the dredging equipment and placement technique for contaminated sediment must result in a tight, compact mound that is easily capped. Compact mounds generally result when the material is dredged and placed at or near its in situ density prior to dredging. This is most easily accomplished with mechanical dredging techniques and precision-point discharges from barges.

For CAD projects, the provision for lateral containment in the form of a bottom depression or other feature defines and limits the extent of bottom spread. For this reason, either mechanical dredging or hydraulic placement of the contaminated material may be acceptable for CAD. If the contaminated material is placed hydraulically, a suitable time period (usually a few weeks) must be allowed for settling and consolidation to occur prior to placement of the capping material to avoid potential mixing of the materials unless capped by slow sprinkling of sand.

Considerations for Capping Material Placement

Placement of capping material is accomplished so that the deposit forms a layer of the required thickness over the contaminated material. For most projects, the surface area of the contaminated material to be capped may be several hundred feet or more in diameter. Placement of a cap of required thickness over such an area may require spreading the material to some degree to achieve coverage.

The equipment and placement technique are selected and rate of application of capping material is controlled to avoid displacement or mixing with the previously placed contaminated material to the extent possible. Placement of capping material at equal or lesser density than the contaminated material or use of placement methods to spread thin layers to gradually build up the cap thickness generally meets this requirement. However, sand caps have been successfully placed over fine-grained contaminated material. Since capping materials are not contaminated, water column dispersion of capping material is not usually of concern (except for loss when slowly placing a sand cap); the use of submerged discharge for capping placement need only be considered from the standpoint of placement control.

Equipment and Placement Techniques

The equipment and placement techniques described in the following paragraphs apply to the contaminated dredged material to be capped as well as to the capping material, depending on the project conditions. Regardless of the equipment and placement techniques considered, the compatibility of contaminated material placement and capping operations must be determined considering the material characteristics and site conditions (Palermo 1991a,c).

Surface discharge using conventional equipment

Dredged material released at the water's surface using conventional equipment tends to descend rapidly to the bottom as a dense jet with minimal short-term losses to the overlying water column (Bokuniewicz et al. 1978; Truitt 1986a). Thus, the use of conventional equipment can be considered for placement of both contaminated and capping material if the bottom spread and water column dispersion resulting from such a discharge are acceptable.

The surface release of mechanically dredged material from barges results in a faster descent, tighter mound, and less water column dispersion as compared with surface discharge of hydraulically dredged material from a pipeline. Placement characteristics resulting from surface release of hydraulically dredged material from a hopper dredge fall between the characteristics resulting from surface release of hydraulically dredged material from barges and from surface discharge of hydraulically dredged material from a pipeline—that is, the descent is slower than the former but faster than the latter; the mound is looser than the former but tighter than the latter; and more water column dispersion results from the former than from the latter.

Field experiences with LBC operations in Long Island Sound and the New York Bight as described in Chapter 10 have shown that mechanically dredged silt and clay released from barges tend to remain in clumps during descent and form nonflowing discrete mounds on the bottom that can be effectively capped. Such mounds have been capped with both mechanically dredged material released from barges and with material released from hopper dredges (O'Connor and O'Connor 1983; Morton 1983a, 1987). In fact, mechanically dredged cohesive sediments often remain in a clumped condition, reflecting the shape of the dredge bucket. Mounds of such material are stable, resist displacement during capping operations, and present conditions ideal for subsequent LBC (Sanderson and McKnight 1986). However, these mounds may experience initial surface erosion due to irregular surface geometry and higher friction coefficients. A conceptual illustration showing the use of conventional equipment for capping is shown in Figure 3.

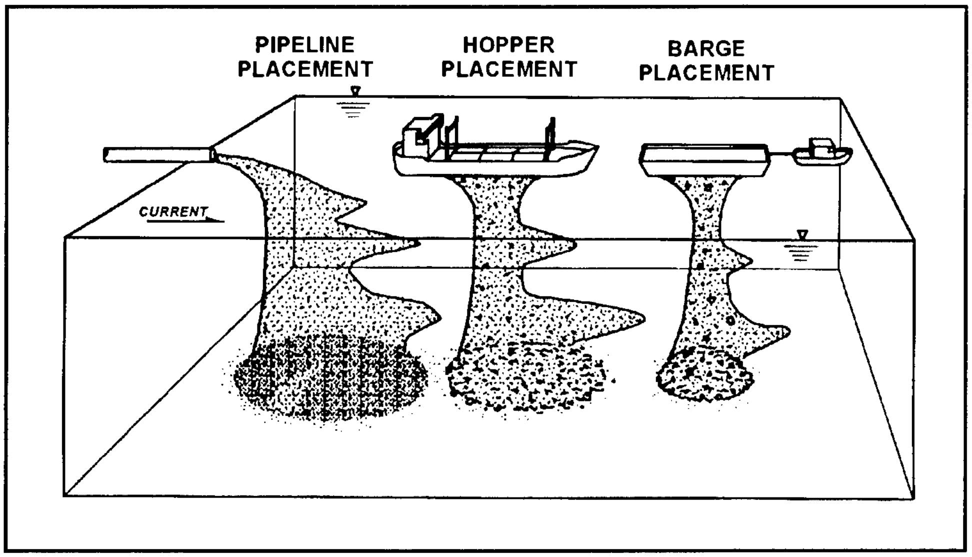


Figure 3. Conventional open-water placement for capping (after Palermo 1991c)

Spreading by barge movement

A layer of capping material can be spread or gradually built up using bottom-dump barges if provisions are made for controlled opening or movement of the barges. This can be accomplished by slowly opening a conventional split-hull barge over a period of tens of minutes, depending on the size of the barge and site conditions. Such techniques have been successfully used for controlled placement of predominantly coarse-grained, sandy capping materials (Sumeri 1989). The gradual opening of the split-hull or multicompartmented barges allows the material to be released slowly from the barge in a sprinkling manner. If tugs are used to slowly move the barge during the release, the material can be spread in a thin layer over a large area (Figure 4). Multiple barge loads are necessary to cap larger areas in an overlapping manner. The gradual release of mechanically dredged fine-grained silts and clays from barges may not be possible due to potential "bridging" action; that is, the cohesion of such materials may cause the entire barge load to "bridge" the split-hull opening until a critical point is reached at which time the entire barge load is released. If the water content of fine-grained material is high, the material exits the barge in a matter of seconds as a dense slurry, even though the barge is only partially opened.

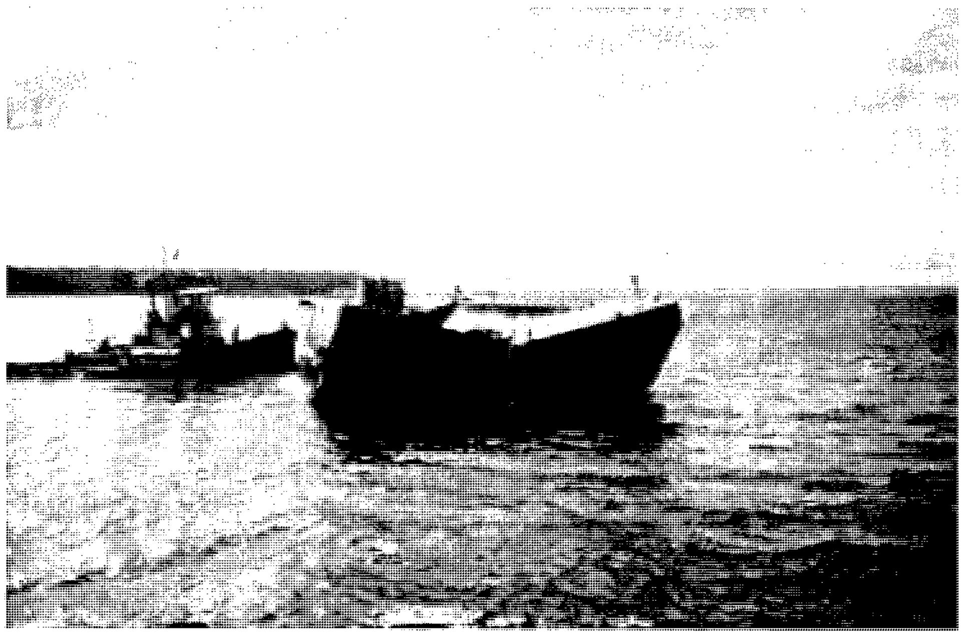


Figure 4. Spreading technique for capping by barge movement

Spreading of thin layers of cap material over large areas can also be accomplished by gradually opening a conventional split-hull barge while underway by tow. These techniques were used for in situ capping operations at Eagle Harbor, Washington (Sumeri 1995).

Hydraulic washing of coarse sand

Granular capping materials such as sand can be transported to a site in flat-topped barges and washed overboard with high-pressure hoses. Such an operation was used to cap a portion of the Eagle Harbor, Washington, Superfund site, forming a cap layer of uniform thickness (Figure 5) (Nelson, Vanderheiden, and Schuldt 1994). This technique produces a gradual buildup of cap material, prevents any sudden discharge of a large volume of sand, and may be suitable for water depths as shallow as 10 ft or less.

Spreading by hopper dredges

Hopper dredges can also be used to spread a sand cap. During the summer and fall of 1993, the Port Newark/Elizabeth capping project in New York Bight used hopper dredges to spread a sand cap over 580,000 cu yd of contaminated sediments. To facilitate spreading the cap in a thin layer (6 in.) to quickly isolate the contaminants and to lower the potential for resuspension of the contaminated material, conventional point dumping was not done. Instead, a split-hull dredge cracked the hull open 1 ft and released its load over a 20- to 30-min period while sailing at 1 to 2 knots. Also, as an alternative means of placing the cap, another dredge used pump-out over the side of the vessel through twin vertical pipes with end

Figure 5. Pressure-hose washing method of placement

plates to force the slurry into the direction the vessel was traveling. As with the cracked-hull method described above, injecting the slurry into the direction of travel of the vessel increased turbulence, reducing the downward velocity of the slurry particles and thus the potential for resuspension of the contaminated sediments. Computer models (see Chapter 6) were used to predict the width of coverage from a single pass and the maximum thickness produced (Randall, Clausner, and Johnson 1994).

Pipeline with baffle plate or sand box

Spreading placement for capping operations can be easily accomplished with surface discharge from a pipeline aided by an energy-dissipating device such as a baffle plate or sand box attached to the end of the pipeline. Hydraulic placement is well suited to placement of thin layers over large surface areas.

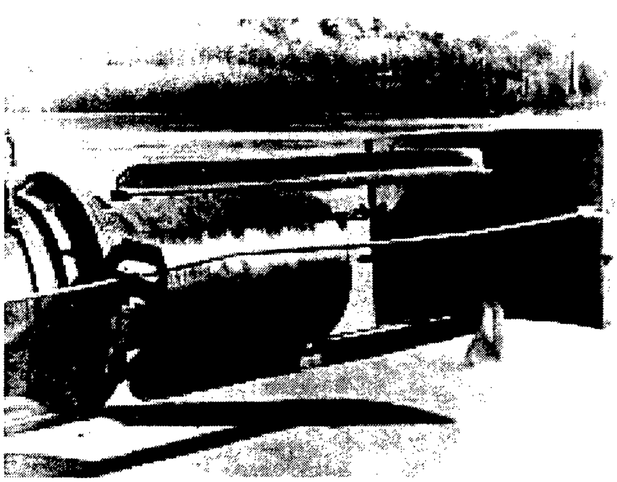


Figure 6. Spreader plate for hydraulic pipeline discharge

A baffle plate (Figure 6), sometimes called an impingement or momentum plate, serves two functions. First, as the pipeline discharge strikes the plate, the discharge is sprayed in a radial fashion; the discharge is allowed to fall vertically into the water column. The decrease in velocity reduces the potential of the discharge to erode material already in place. Second, the angle of the plate can be adjusted so that the momentum of the discharge exerts a force that can be used to swing the end of the floating pipeline in an arc. Such plates are commonly used in river dredging operations where material is deposited in thin layers in areas adjacent to the dredged channel (Elliot 1932). Such equipment can be used in capping operations to spread thin layers of material over a large area, thereby gradually building up the required capping thickness.

A device called a "sand box" (Figure 7) serves a similar function. This device acts as a diffuser box with baffles and side boards to dissipate the energy of the discharge. The bottom and sides of the box are constructed as an open grid or with a pattern of holes so that the discharge is released through the entire box. The box is mounted on the end of a spud barge so that it can be swung about the spud using anchor lines (Sumeri 1989).

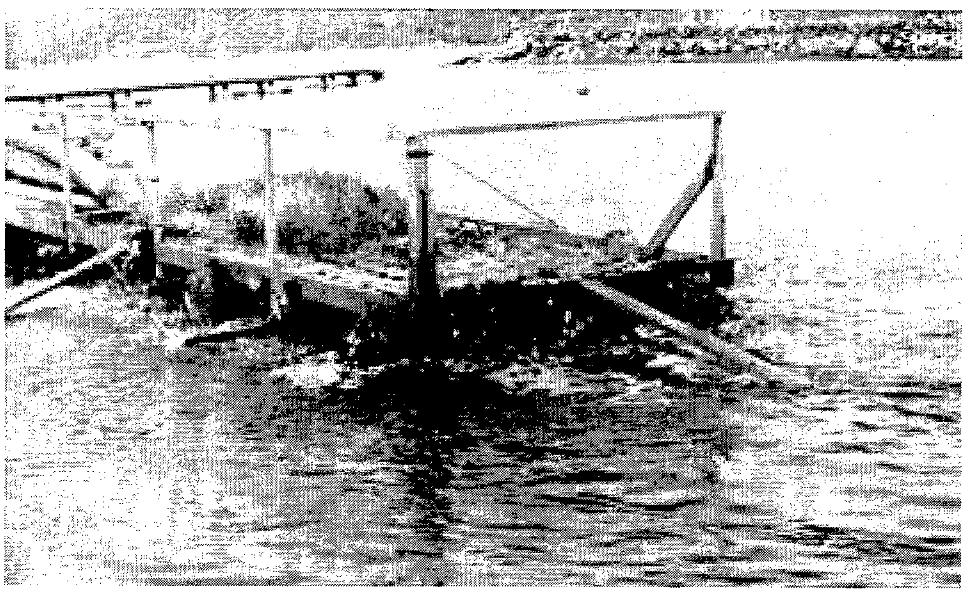


Figure 7. Spreader box or "sand box" for hydraulic pipeline discharge

Submerged discharge

If the placement of the contaminated sediment with surface discharge results in unacceptable water column impacts, or if the anticipated degree of spreading and water column dispersion for either the contaminated or capping material is unacceptable, submerged discharge is a potential control measure.

In the case of contaminated dredged material, submerged discharge serves to isolate the material from the water column during at least part of its descent. This isolation can minimize potential chemical releases due to water column dispersion and significantly reduce entrainment of site water, thereby reducing bottom spread and the area and volume to be capped. In the case of capping material, the use of submerged discharge provides additional control and accuracy during placement, thereby potentially reducing the volume of capping material required. Several equipment alternatives are available for submerged discharge (Palermo 1994) and are described in the following paragraphs.

Submerged diffuser

A submerged diffuser (Figures 8 and 9) can be used to provide additional control for submerged pipeline discharge. The diffuser consists of conical and radial sections joined to form the diffuser assembly, which is mounted to the end of the discharge pipeline. A small discharge barge is required to position the diffuser and pipeline vertically in the water column. By positioning the diffuser several feet above the bottom, the discharge is isolated from the upper water column. The diffuser design allows material to be radially discharged parallel to the bottom and with a reduced velocity. Movement of the discharge barge can serve to spread the discharge to cap larger areas. The diffuser can also be used with any hydraulic pipeline operation including hydraulic pipeline dredges, pump-out from hopper dredges, and reslurried pump-out from barges.

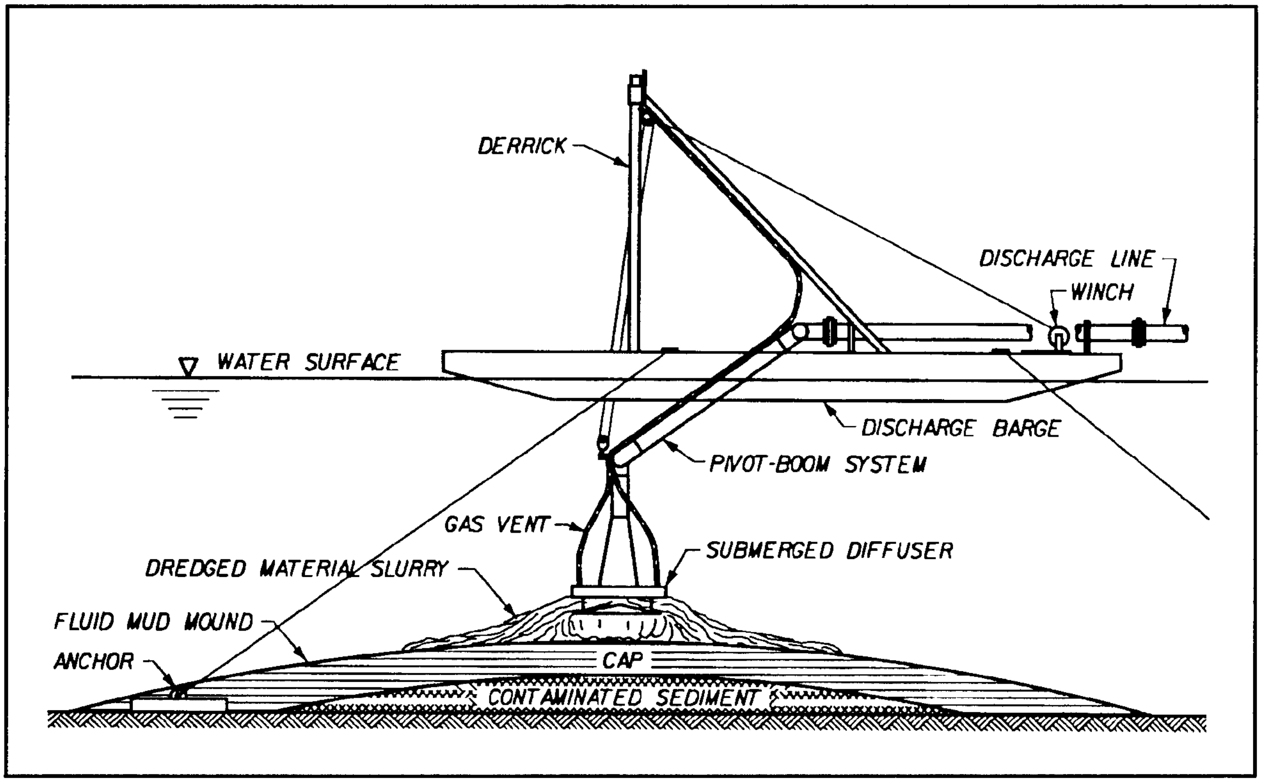


Figure 8. Submerged diffuser system, including diffuser and discharge barge

A design for a submerged diffuser system was developed by JBF Corporation as a part of the USACE Dredged Material Research Program (DMRP) (Barnard 1978; Neal, Henry, and Greene 1978). This design consists of a funnel-shaped diffuser oriented vertically at the end of a submerged pipeline section that discharges the slurry radially. The diffuser and pipe section are attached to a pivot boom system on a discharge barge.

Design specifications for this submerged diffuser system are available (Neal, Henry, and Greene 1978; Palermo, in preparation).

A variation of the DMRP diffuser design was used in an equipment demonstration at Calumet Harbor, Illinois. Although not constructed to the DMRP specifications, this diffuser significantly reduced pipeline exit velocity, confined the discharged material to the lower portion of the water column, and reduced suspended solids in the upper portion of the water column (Hayes, McLellan, and Truitt 1988). Diffusers have been constructed using the DMRP design and used at a habitat creation project in the Chesapeake Bay (Earhart, Clark, and Shipley 1988) and at a Superfund pilot dredging project at New Bedford Harbor, Massachusetts, involving subaqueous capping (USACE 1990). At the Chesapeake Bay site, the diffuser was used to effectively achieve dredged material mounding prior to placement of a layer of oyster shell to provide substrate for attachment of oyster spat. At the New Bedford site, the diffuser was used to place contaminated sediment in an excavated subaqueous cell and was effective in reducing sediment resuspension and in controlling placement of contaminated sediment. However, capping operations were started immediately, and positioning of the diffuser within 2 ft of the contaminated sediment layer resulted in mixing of cap sediment with contaminated sediment. These results indicate the need for a high degree of control when capping newly placed slurry with a diffuser and the need for adequate time to allow for some self-weight consolidation of slurry material prior to capping. Diffusers have also been successfully used to place and cap contaminated sediments at projects in Rotterdam Harbor in the Netherlands (d'Angremond, de Jong, and de Waard 1986) and in Antwerp Harbor in Belgium (Van Wijck and Smits 1991).

Figure 9. Submerged diffuser

Sand spreader barge

Specialized equipment for hydraulic spreading of sand for capping has been used by the Japanese (Kikegawa 1983; Sanderson and McKnight 1986). This equipment employs the basic features of a hydraulic dredge with submerged discharge (Figure 10). Material is brought to the spreader by barge, where water is added to slurry the sand. The spreader then pumps

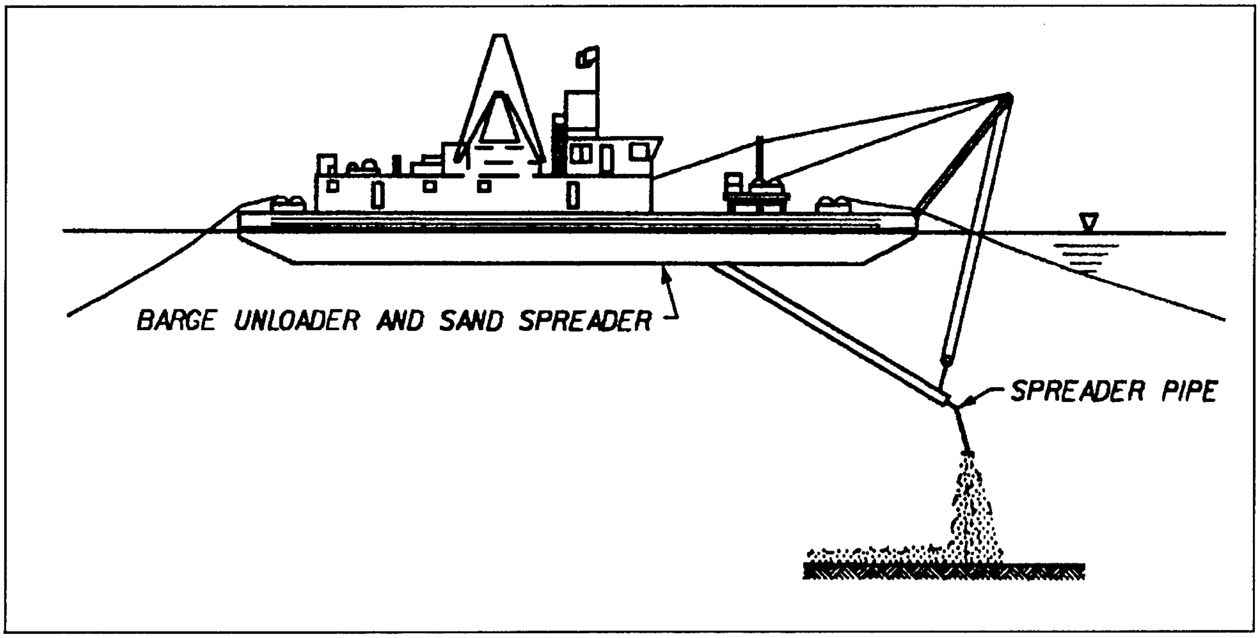


Figure 10. Hydraulic barge unloader and sand spreader barge (from Kikegawa 1983)

the slurried sand through a submerged pipeline. A winch and anchoring system are used to swing the spreader from side to side and forward, thereby capping a large area.

Gravity-fed downpipe (tremie)

Tremie equipment can be used for submerged discharge of either mechanically or hydraulically dredged material. The equipment consists of a large-diameter conduit extending vertically from the surface through the water column to some point near or above the bottom. The conduit provides the desired isolation of the discharge from the upper water column and improves placement accuracy. However, because the conduit is a large-diameter straight vertical section, there is little reduction in momentum or impact energy over conventional surface discharge. The weight and rigid nature of the conduit require a sound structural design and consideration of the forces due to currents and waves.

The Japanese have used tremie technology in the design of specialized conveyor barges for capping operations (Togashi 1983; Sanderson and McKnight 1986). This equipment consists of a tremie conduit attached to a barge equipped with a conveyor (Figure 11). The material is initially placed in the barge mechanically. The conveyor then mechanically feeds the material to the tremie conduit. A telescoping feature of the tremie allows placement at depths of up to approximately 40 ft. Anchor and winch systems are used to swing the barge from side to side and forward so that larger areas can be capped, similar to the sand spreader barge.

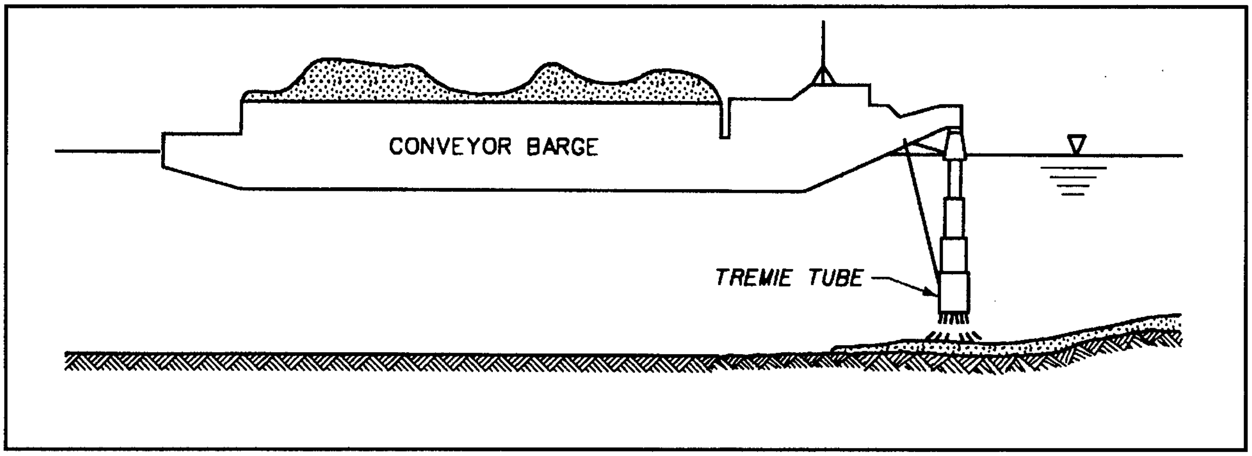


Figure 11. Conveyor unloading barge with tremie (from Togashi 1983)

Hopper dredge pump-down

Some hopper dredges have pump-out capability by which material from the hoppers is discharged like a conventional hydraulic pipeline dredge. In addition, some have further modifications that allow pumps to be reversed so that material is pumped down through the dredge's extended dragarms. Because of the expansion at the draghead, the result is similar to using a diffuser section. Pump-out depth is limited, however, to the maximum dredging depth, typically about 60-70 ft.

Use of geosynthetic fabric containers (GFCs)

Geosynthetic fabric containers (GFCs) are containers made from geosynthetic fabric that line barges. Contaminated dredged material is placed in the GFCs (either mechanically or hydraulically), which are then sewn closed prior to placing the GFC at the disposal site. The GFC acts as a filter cloth, allowing the water to escape but retaining almost all the fine (silt and clay) particles. Containing contaminated sediments in GFCs for subsequent placement from split-hull barges offers the potential to eliminate the wide, thin apron normally associated with conventional bottom dumping of fine-grained sediments, thus substantially reducing the volume of cap material required and reducing the potential for contaminated sediments to extend beyond the site boundary. GFCs also have the potential to eliminate water quality problems at the disposal site by essentially eliminating loss of fine sediment particulates and associated contaminants to the water column.

As of 1996, GFCs have been used on only two USACE projects. The first was construction of training dikes in the lower Mississippi River (Duarte, Joseph, and Satterlee 1995), and the second was placement of sandy sediment with heavy metal contaminants in a CAD site in Los Angeles Harbor (Mesa 1995). At present, costs of using GFCs are much higher than for conventional bottom placement due to costs of materials, increased dredge cycle times, increased labor requirements associated with installation of the GFCs in the barge, and possible reductions in dredge production rate. There are also considerable engineering problems associated with successfully deploying the GFCs without having them rupture. The decision to use GFCs for a capping project should be made based on the benefits versus costs rather than a blanket decision based solely on the desire to reduce losses to the water column. Data collected from a 1996 demonstration of GFCs conducted jointly by New York District and the Port of New York and New Jersey should provide additional data on GFC viability. However, additional research is needed to better define GFC abilities to reduce water column losses of contaminants and to refine engineering aspects associated with deployment. Clausner et al. (1996) summarizes the present state of the art on using GFCs with contaminated sediments.

Geotechnical Compatibility of Operations

Geotechnical considerations are important in capping because of the fact that most contaminated sediments are fine-grained silts and clays and usually have high water contents and low shear strengths in situ. Once sediments are dredged and placed at a subaqueous site, the water contents may be initially higher and the shear strengths initially lower than in situ.

Capping involves the placement of a layer of clean sediment of perhaps 3 ft or more in thickness over such low-shear-strength material. Field-monitoring data have definitively shown that contaminated sediments with low strength have been successfully capped with slow placement of sandy material. The geotechnical considerations involved can be described in terms of the ability of a capped deposit with given shear strength to support a cap from the standpoint of slope stability and/or bearing capacity (Ling et al. 1996).

Only limited geotechnical evaluations have been considered in past capping projects. In virtually all of past capping projects the design was empirical, i.e., prior field experience showed that it worked, but actual geotechnical design calculations were not conducted. Limited research on this topic is now underway, and more detailed guidance on this aspect of capping design will be provided in the future. Additional research is also planned to define geotechnical design for bearing capacity, slope failure, loading rate, impact penetration, etc. For the present time, geotechnical aspects of capping-project design are limited to the evaluation of compatibility of equipment and placement technique for contaminated and capping sediments with sediment properties. An acceptable match of equipment and placement techniques for contaminated and capping material is essential to avoid displacement of the previously placed contaminated material or excessive mixing of capping and contaminated material. The availability of certain types of equipment and the distance between dredging and placement sites may also influence selection of compatible equipment types.

The nature of the materials (cohesive versus noncohesive), the dredging method (mechanical versus hydraulic), the method of discharge (instantaneous dump from hopper dredge or barge versus continuous pipeline), the location of discharge (surface or submerged), frequency and scheduling of discharges, physical characteristics of discharge material, and other factors influence the tendency of the material to mound or flow and the tendency to displace or mix with material already placed. The primary concern with compatibility relates to geotechnical considerations and the ability of the contaminated material to support the cap, considering the material characteristics and dredging and placement techniques.

In general, if the contaminated material were mechanically dredged and released from barges, the capping material can be similarly placed or could be placed hydraulically. However, if the fine-grained contaminated material were hydraulically placed, then only hydraulic placement of the capping material is appropriate due to the potentially low shear strength of the contaminated material. An exception may be the slow controlled placement of a sand cap. The exposure of the contaminated material to the environment and need to allow consolidation of the contaminated material to occur prior to cap placement must be balanced in scheduling both placement operations.

The flow characteristics data in Table 2 plus the field experience with capping operations to date were used to develop the compatibility information shown in Table 3 (Palermo 1994). This table may be used as an initial guideline in selecting compatible equipment and placement operations. It is anticipated that the table will be updated as more field experience and monitoring data become available for a wider range of project conditions.

Exposure Time Between Placement of Contaminated Material and Cap

Scheduling of the contaminated material placement and capping operation must satisfy environmental and engineering/operational constraints. Following the placement of contaminated material, there is necessarily some time lag prior to completion of the capping operation. This results in some degree of unavoidable exposure of colonizing benthic organisms to surficial portions of the contaminated material deposit. Placement of the cap material must begin as soon as practicable following completion of the placement of contaminated material to minimize this exposure time. However, a delay of 1 to 2 weeks is desirable from an engineering standpoint to allow initial consolidation of the contaminated material to occur, with an accompanying increase in shear strength, prior to placement of the cap.

Factors to consider in arriving at an appropriate exposure time are as follows:

a. Potential effects due to exposure prior to capping.

b. Estimates of time required for initial colonization of the site by benthic organisms.

Table 3
Compatibility of Capping and Contaminated Material Placement Options

Contaminated Material		Cap Material: Hopper or Barge Spread	Barge Point Disposal			Hopper Point Disposal			Pipeline		
			Sandy[1]	Clumps[2]	Maint. silt/clay	Sandy	Clay balls[3]	Slurry[4]	Sandy	Clay balls	Slurry
Pipeline[5]	CAD slurry[6]	I[7]	I	I	I	I	I	I	C[8]	I	C
	Slurry clay balls	C	C	I	C	C	C	C	C	C	C
	Sandy	C	C	C	C	C	C	C	C	C	C
Hopper[9]	CAD slurry	I	I	I	I	I	I	I	C	I	C
	Slurry clay balls	C	C	I	C	C	C	C	C	C	C
	Sandy	C	C	C	C	C	C	C	C	C	C
Barge[10]	Maint. silt/clay	C	I	I	C	I	I	C	C	I	C
	Clumps	C	C	C	C	C	C	C	C	C	C
	Sandy	C	C	C	C	C	C	C	C	C	C

Note: The compatibility designation of incompatible (Footnote 7) and compatible (Footnote 8) is a general recommendation. Site-specific or material-specific considerations could over-ride these general designations.

1 Sand - Predominantly cohesionless material (sand).
2 Clumps - Predominantly fine-grained material mechanically dredged with in situ water content sufficiently low to cause clumping to occur and be maintained.
3 Clay balls - Small balls of clay formed during hydraulic dredging of fine-grained material.
4 Slurry - Predominantly fine-grained material hydraulically dredged (pipeline or hopper) with water content sufficiently high to allow slurry.
5 Pipeline - Material is used by hydraulic pipeline dredge (slurried) with direct pipeline transport for placement. May include use of submerged diffusers. Would include hopper dredge or barge pump-out (reslurried). For capping operations, appropriate means to spread the material is recommended. Clay balls are assumed to act as slurry.
6 Contaminated material in slurry form placed without lateral confinement (CAD) is not recommended for a capping project.
7 Generally incompatible.
8 Generally compatible.
9 Hopper - Material is dredged by trailing suction hopper (slurried) and transported directly to site for surface release. This would also include hydraulically filled barges.
10 Barge - Material is mechanically dredged, placed in barges, and transported to site for surface release (no slurry). Could either point dump or incorporate provision to sprinkle or spread material by controlled release from the barge.

c. Estimates of time required for initial consolidation of the contaminated material due to self-weight.

d. Monitoring requirements prior to cap placement.

The process of recolonization by opportunistic species may begin as soon as contaminated material placement operations are completed (Rhoads and Boyer 1982; Rhoads and Germano 1982). However, recruitment and colonization processes for many assemblages of coastal benthic organisms show definite seasonal peaks, usually a primary peak in spring and a secondary peak in fall. For example, Scott et al. (1987) determined that recolonization at a Long Island Sound dredged material disposal site showed peaks during October and December of separate years. Ideally, to minimize exposure durations of benthic organisms, placement of contaminated material and initiation of cap construction should occur prior to the onset of a seasonal recruitment pulse. During intervals between peaks, rates of colonization should be sufficiently slow to assume minimal exposure over a period of 3 to 4 weeks. Once cap construction has begun, those early colonizers of the contaminated deposit will be buried and thus physically isolated. Assuming that cap placement proceeded at a reasonable rate, it would be unlikely that any bioaccumulation that had occurred prior to cap placement would result in unacceptable effects.

Some delay between completion of contaminated material placement and initiation of capping is desirable from an engineering standpoint. Consolidation of the contaminated material and a corresponding increase in density and strength occur due to the weight of the material as it is placed in the deposit. This process is called self-weight consolidation. The contaminated material should be allowed to undergo initial self-weight consolidation prior to capping to increase its stability and resistance to displacement during cap placement. This is especially important for slurried materials placed by pipeline or by hopper dredge. For slurried materials, a large portion of the self-weight consolidation occurs within a few weeks of placement. Mechanically dredged materials placed by barge release are initially deposited at essentially the same density at which they were dredged, and the potential degree of self-weight consolidation is less than for slurried materials.

Monitoring is required to determine the areal extent of the contaminated deposit prior to capping. Surveys and other sampling and monitoring activities may require several weeks to complete. An appropriate delay between contaminated material placement and capping must balance environmental exposure with the engineering requirements of stability and scheduling constraints for monitoring and dredging required for capping. If appropriate precautions are taken to schedule the lag time for consolidation during periods of low benthic recruitment, a period of 3 to 4 weeks between completion of contaminated sediment placement and initiation of capping should have minimal environmental effect.

Navigation and Positioning Controls

Once the dredging equipment and placement techniques and potential capping site have been selected, the needs for navigation and positioning equipment and controls can be addressed. The objective here is to place both the contaminated and capping materials (whether by the bargeload, hopperload, or by pipeline) at the desired location in a consistently accurate manner so that adequate coverage by the cap is attained.

Navigation (the science of getting vessels from place to place) and positioning (accurately locating an object) are two of the most important factors in designing and implementing a successful capping project. Accurate positioning is necessary for any dredged material disposal operation in open water to ensure the material is located within the appropriate disposal site boundaries. For a capping project, contaminated material placement requirements are similar, but may be more restrictive in that placement of material within a specified radius, along a given linear transect, or similar location may be required. For the capping phase, materials must be adequately placed to cover the previously placed contaminated material. Therefore, knowing the precise navigation and positioning is of principal importance to allow proper capping.

For pipeline placement in shallow water, the desired positioning of the pipeline discharge can be maintained with little difficulty. Accurate navigation to the placement site and precise positioning during material placement by bottom-dump barge or hopper dredge is more difficult, especially for sites well offshore.

There exist a number of methods to position barges and hopper dredges for placement of dredged and cap material. One of the most common is placement near a taut-moored buoy. The other common methods are electronic positioning systems (EPS) including range-azimuth, LORAN-C (low-frequency), microwave (high-frequency), and differential global positioning system (DGPS). Detailed guidance on all aspects of hydraulic surveying to include these positioning methods is found in USACE Engineer Manual 1110-2-1003, Hydrographic Surveying (USACE 1991). Estimated positional accuracy for each of the electronic positioning systems is shown in Table 4.

Taut-moored buoys

Taut-moored buoy positioning requires locating and placing a buoy anchored and moored in such a way as to minimize buoy movement during placement operations. At USACE New England Division[1] disposal sites in 20- to 25-m depths, the taut-moored buoy has a watch circle diameter of about 20 m. Positioning of dredged material placement equipment is specified to occur within some distance of the buoy during disposal. Electronic placement errors are minimized with this method (except for initial

[1] The New England Division has been changed to the New England District.

Table 4
Accuracy of Common Positioning Systems (from USACE EM 1110-2-1003)

Positioning System	Estimated Accuracy, Meters RMS
Range-azimuth	0.5 to 3
LORAN-C (low-frequency)	50 to 2,000
Microwave (high-frequency)	1 to 4
GPS	50 to 100
DGPS	0.1 to 1.0

buoy placement), and the exact dredged material placement location is subject only to the tug or dredge captain's discretion of buoy offset distance. Placement offset from the buoy depends on local weather and safety concerns. Specific guidance varies from site to site, but the New England Division has found success with specifying placement within 25 to 50 m of buoy location depending on weather/sea conditions. Experience has shown that this type of placement tends to concentrate material at one point or in a transect along the direction of travel of the tug and barge. This factor should be taken into consideration in buoy placement or in placement specifications for tug operators.

Range-azimuth

Range-azimuth positioning is a traditional surveying technique where a shore-based station (transit, theodolite, or total station) is used to determine an angular azimuth to the vessel of interest. This azimuth is then coupled with an electronically determined distance obtained from an electronic distance measurement (EDM) device (microwave EPS, laser EDM, or infrared EDM) at the same location. Range-azimuth positioning is very accurate, but because of the shore station requirement, it is applicable only at sites where dredged material placement is relatively close to shore (USACE EM 1110-2-1003). Range-azimuth positioning has been used by the Seattle District for several capping projects, e.g., the Duwamish Water project in 1984 (Truitt 1986b) and the Denny Way project (Sumeri 1989).

Electronic positioning systems (EPS)

Generally, the higher the frequency is of EPS, the more accurate the positioning. LORAN-C is a low-frequency, time-differencing hyperbolic phase/pulse system that triangulates vessel position based on relative distances from shore-based stations. Because LORAN-C is a low-frequency system, it has a low accuracy and is the least desirable for vessel positioning. For hydrographic surveys, LORAN-C is only suitable for Class 3 surveys (reconnaissance level), and absolute accuracy without onsite calibration is 0.25 mile (USACE EM 1110-2-1003). Therefore, LORAN-C is not recommended as the sole navigation and positioning system for a capping project, and its use with other systems (e.g., a taut-moored buoy) should be thoroughly scrutinized. Some of the earlier less than fully successful capping projects conducted by the New England Division, where the initial cap did not fully cover the contaminated sediments, were due in part to problems with LORAN-C (SAIC 1995a). High-frequency systems (particularly UHF and microwave) are more commonly used for positioning offshore vessels. In general, operating distances are limited to radio line of sight, which allows use in riverine, harbor, and coastal locations (USACE EM 1110-2-1003).

The most accurate positioning system and rapidly becoming the standard for horizontal positioning is the satellite-based global positioning system (GPS). The NAVSTAR GPS is a real-time, passive satellite-based navigation system operated by the U.S. Department of Defense. The 24 GPS satellites orbit the earth such that from any place on earth at any time, at least four (the minimum required by the GPS receiver for positioning) are visible above the horizon. Standard GPS accuracies (50 to 100 m with DoD selective availability) are not ideal for capping operations. Increased accuracies can be obtained with differential GPS (DGPS). DGPS uses the same NAVSTAR GPS satellite system but requires two receivers with precise coordinates of one of the receivers known (usually a fixed land-based receiver). Accuracies of DGPS range from 0.1 to 1.0 m (USACE EM 1110-2-1003) (Hales 1995).

Kinematic DGPS is an additional refinement of DGPS that can provide accuracies of a few centimeters (USACE EM 1110-2-1003) and thus can eliminate the vertical datum problem that often occurs in the open ocean.

Kinematic DGPS is not yet routinely available, but the rapidly advancing EPS market may soon make its use commonplace. One of the more severe limitations of kinematic DGPS is the need to have the fixed shore station within 12 to 20 km of the surveying platform. However, industry advances will likely extend this distance.

An additional factor that should be considered in barge positioning is the placement of receiving/transmitting equipment on the barge or vessel. For instance, when a barge is being towed to the disposal site by a tug, there may be significant offsets between actual material disposal location and positioning antennae. If the positioning antennae is located on the tug, then the recorded placement location may differ by as much as 200 m from the actual placement due to offsets from the positioning antenna on the tug to the center of the barge. In addition, there may also be lateral offsets from the vessel track line that are on the order of a barge width. Therefore, for most capping projects where placement location is critical and will be recorded, it is recommended that the antennae be located on the barge. To be most effective, the EPS requires a visual display in the vessel's pilot house to accurately navigate and position the vessel.

Placement Options, Restrictions, and Tolerances

Several options are possible for placement of materiel using hopper dredges, barges, or pipeline dredges, depending on the particular needs for the project. These include stationary placement, placement at multiple points or along multiple lanes, or options aimed at spreading materials over large areas.

Stationary placement

Stationary placement is where the tug/barge or hopper dredge comes to essentially a complete stop for disposal. This method is ideal for concentrating the material to minimize mound spread. Dredged material will settle to the bottom without the imparted vessel velocity and associated turbulence and thus reduce total mound coverage. On its capping projects, the New England District has specified that the dredged material be placed while the barge is stationary or moving at less than 2 knots. The disadvantage of this method is the loss of vessel control by the operator during placement. Most operators prefer some forward movement of the vessel, particularly if waves, winds, and/or currents are strong enough to affect positioning. Vessel speeds up to 2 to 3 knots are preferred in the open ocean. However this scenario will increase the mound spread as the material is released over a greater area. In some cases this greater spread may be desirable to prevent creation of too much relief or to spread material evenly over a larger disposal area.

The time required for material to exit a barge or hopper should also be considered when specifying stationary or moving placement. Material exit time depends on the barge opening width, time to open, and type of material being placed. In general, barges open in 20 to 60 sec to a width of approximately the bin width. Barge modifications (including installation of false sides) can be made to effectively increase the opening width/bin width ratio thus facilitating material exit, though this is an extreme (and costly) modification. Typically, sandy material will exit the barge in 30 sec to 2 min, and fine-grained material will take 10 to 30 sec to exit. For split-hull hopper dredges, exit time can take from 3 to 5 min for sandy material, with fine-grained material exiting in roughly 30 sec, with silty sand mixtures exiting in about 2 to 5 min. Hopper dredges with doors and pocket barges require longer times for the material to exit. For example, the STUYVESANT (industry hopper) has 20 hopper doors, and sandy material takes approximately 5 min to exit (Sanderson and McKnight 1986).

An often encountered problem during the disposal phase is that as the hull is opened and material begins to exit the barge, some material will form a bridge across the hull opening and thereby reduce the rate of discharge. Additionally, the material may bridge to the extent that it will not fall until the hull has opened beyond the angle of repose of the material. When this occurs, this bridged material can discharge quickly and exit the barge with a large initial velocity. The net effect can be an increased impact velocity on the bottom, which may displace previously placed material (Parry 1994). Additional discussion of this phenomena is provided later in this section. Bridging of sand over the hull opening is typically much less of a problem in modern hopper dredges that have water cannons in the hoppers to help fluidize the sand.

Barge towing and positioning are generally a factor of weather conditions. In good weather, barges may be transported and positioned with a tug directly alongside. This allows for more precise dump positioning. Also, if the barge is under tow, the line length may be as short as 30 or 45 m with lateral offsets on the order of one barge width. In poor weather, the tow length may be increased to 175 to 300 m where lateral offsets may be several barge widths.

For even placement of material around a point, vessel approach headings should be varied. Vessel operators generally prefer to approach the disposal site from the direction of travel to the site because that direction affords the shortest time to travel and dispose. However, continuous dumping along one transect may concentrate material in a manner or location that is less than ideal for the capping project. When weather permits, approach direction should be specified so that the most even coverage of dredged material can be accomplished. But, for poorer weather conditions, operators should be afforded the flexibility to approach the placement area from the safest direction based on the prevailing winds and waves at that time.

Use of multiple disposal points or lanes

For large projects (say 100,000 to 200,000 m^3 or more) in shallow water (say 20 m and less), point dumping of contaminated material at a single location may create a mound unacceptably tall. To avoid this, placement can be divided among multiple buoy locations to create a larger (footprint) but less thick mound. This was done for the 1993 New Haven Harbor Project (Fredette 1994). The other option is to place material along a line or in lanes. For example, the 1993 Port Newark/Elizabeth project had an EPA Region II restriction not to have the capped mound extend above the 23-m (75-ft) depth contour. Because the existing depth averaged about 25 m (83 ft), point dumping the 448,000 m^3 (586,000 yd^3) of contaminated dredged material would have created a mound extending well above the 23-m depth restriction. To keep the mound elevation below the limit, a triangular mound was designed, with three lanes with a width of 150 m (500 ft) wide by 350 to 450 m (1,150 to 1,480 ft) long (see additional discussion in Chapters 6 and 10). To assist the contractor in siting the placements, each apex of the triangle had taut-moored buoys. To reduce the chance of placing material outside the lanes, the contractor was directed to dispose of all material within 60 m (200 ft) of an imaginary line connecting the apex buoys. Additional details on this project can be found in Chapter 10.

For capping projects, both point dumping and spreading material over specific lanes have been used, sometimes both on the same project. For small projects (say 25,000 m^3 or less) where the contaminated sediment mound was created by point dumping at a taut-moored buoy, the New England District will place the majority (say 65 to 70 percent) of the capping material in similar fashion. However, the capping material is placed within 50 to 75 m of the buoy as opposed to the 25-m limit used for the contaminated material. The remaining 30 to 35 percent of the material is spread around the outer edge of the mound, say 100 to 150 m from the buoy.

Spreading over large areas

For larger projects, a series of specific lanes can be defined to spread the capping material. This technique is generally used when the sand is sprinkled. The sprinkling can be accomplished by cracking the hull of the barge or split-hull hopper dredge or by direct pumpout from a hopper through over-the-side pipes. The most straight-forward method to determine lane spacing for the cracked-hull technique is to compute the footprint from an individual load using either the Multiple Dump Fate of Dredged Material (MDFATE) or Short-Term Fate (STFATE) model (see Chapter 6 and Appendixes D and E). Of interest will be the footprint's maximum thickness, maximum width, and width at 0.5 the maximum thickness. Table 5 shows the results of MDFATE runs used to design the capping operation for the Port Newark/Elizabeth project. Based on this information, disposal lanes 30 m (100 ft) wide, or approximately equal to the maximum width of the footprint predicted by the model lanes, were

Table 5
Summary of Modeling Results for Capping Contaminated Sediments Using the Split-Hull Hopper Dredge Dodge Island and Hopper Barge Long Island

Disposal Type	Dredge Speed m/s	Disposal Time min	Maximum Thickness, cm	Maximum Width m	Width at 0.5 Max Thickness, m
Split-Hull Hopper Dredge Dodge Island					
Cracked hull	1.54	20	4.3	32.0	18.3
Cracked hull	1.54	30	2.7	32.0	18.3
Cracked hull	1.03	20	6.4	41.0	18.8
Cracked hull	1.03	30	4.3	32.0	18.3
Hopper Barge Long Island					
Counterflow	0.51	120	7.3	155.4	64.0
Counterflow	1.03	120	3.0	155.4	82.2
Counterflow	0.51	180	4.9	137.2	64.0
Counterflow	1.03	180	2.0	137.2	82.2
Counterflow	0.51	180	4.9	137.2	64.0
Counterflow	1.03	180	2.0	137.2	82.2

selected for the split-hull hopper dredge Dodge Island, which started the capping operation with the goal of quickly covering the contaminated mound with 15 cm (6 in.) of sand cap. Variations in the vessel's track line down the lane were expected to spread the material evenly over the area. Sediment profile image (SPI) profiles (see Chapter 9) at a spacing of a 5-m run perpendicular to the lanes conducted after a few passes had been made showed no area without sand and most areas to have a 15-cm (6-in.)-thick cover, apparently confirming the model predictions. Lanes 75 m (250 ft) wide were selected for the hopper barge Long Island. This value is about equal to the width at 0.5 of the maximum thickness. The majority of the cap was placed with the Long Island. See Chapter 10 for additional details on this project.

Several factors have to be considered when using disposal lanes for cap placement. Hopper dredges have superior seakeeping abilities compared with towed barges and thus will be better suited to open-ocean placement. Towed barges for lane disposal probably should be restricted to protected areas. When the cracked-hull technique is used, once the hull is cracked it cannot be closed until the vessel is empty. Thus, when the vessel reaches the end of a line, it continues to discharge cap material while turning. So, to reduce the spread of cap material beyond the contaminated footprint, the vessel should turn before reaching the edge of the contaminated material. It is likely more effective to cap the outer edge of a contaminated mound using a series of straight segments around the perimeter of the footprint. Also, while a vessel that is using direct pump-out to discharge material can stop the pump during turns, the dredge operators would much prefer to keeping pumping. Thus, similar considerations will have to be made regarding where the turn is conducted.

Turning radius is another factor that needs to be considered for cap placement using disposal lanes. Modern hopper dredges have bow thrusters and can turn in less than their own length; therefore, they can often proceed down adjacent disposal lanes. Older hopper barges and less maneuverable hopper dredges have larger turning radii and therefore may only be able to cap every 2nd or 3rd disposal lane. This is not a problem, but requires more accurate record keeping to confirm no lanes are missed. The decision on how the dredge or barge is operated, i.e., adjacent lanes, or every 2nd, 3rd, 4th lane, etc., should be made in consultation with the operator. Keeping a record of track plots is highly recommended. In protected waters, a 1,000-m^3 towed hopper barge needs about 120 m to turn while maintaining speed and control (Parry 1994). Because of individual variations between vessels, it is prudent to consult with the vessel operators early on in the process to obtain the best estimates of sea-keeping abilities turning radii, etc.

How long it takes to discharge the capped material is another factor to be considered for cap "sprinkling." When the Dodge Island cracked its hull 0.3 m (1 ft) during the Port Newark/Elizabeth project, the 2,000-m^3 (2,600-yd^3) load of sand exited in 20 to 30 min, translating to a rate of 65 to 100 m^3/min. During direct pump-out, the Long Island emptied its roughly 9,600-m^3 load in 2 to 3 hr, translating to a discharge rate of 53 to 89 m^3/min. Hopper dredges can use their water cannons to produce reasonably continuous discharge rates. In fact, they can turn off their water cannons to reduce the discharge rate during turns.

Conversely, it is much more difficult to control the rate sand is discharged from a split-hull barge. Based on the Seattle District's experience using split-hull barges to place caps, Parry (1994) recommends discharge rates of 30 to 42 m^3/min to reduce the size of the end pulse caused by bridging to about 5 percent of the load. At higher discharge rates, say 600 m^3/min, Parry (1994) notes that the size of the pulse can be up to 33 percent of the total load. Nelson, Vanderheiden, and Schuldt (1994) report discharge rates of 41 to 70 m^3/min using a split-hull barge at the Eagle Harbor in situ capping project.

Controlling and monitoring extended discharge from a split-hull barge is a nontrivial matter. The small barges, typically about 1,000 m^3 used by the Seattle District, are opened 6 to 8 deg to start sand flowing. Discharge rate can be monitored by change in draft measured by pressure sensors radio linked to a display on the tug, and with experience it can be done visually. As the load is lightened, the barge has to be opened more to continue a constant flow of sand.

Inspection and Compliance

Proper tracking of dredged material placement prior to capping includes adequate records of barge position, environmental conditions, vessel headings and velocities, start/end times of discharge, and load/draft of barge. In most cases, dredging contractors keep records detailing much of this information in their dredge logs.

The information from the inspector's or contractor's logs can be useful in identifying volumes of material placed, locations of placement, and correlation of material placement with hydrographic survey results. Dredge logs can also be the primary source of information for locating material that is short-dumped. Short-dumping can result for various reasons including human error, inadequate positioning information, malfunction of electronic positioning instruments, and safety. When material is short-dumped, it usually ends up outside of the specified disposal site, and postdisposal survey information may be limited or nonexistent. However, the dredged material must still be capped, and the more information that is available (from dredge logs), the better the capping job that can be done. In one instance on the Port Newark/Elizabeth project, a short dump of one barge load of material (2,300 m^3) was covered with 31,000 m^3 of cap material because of a substandard positioning system (LORAN-C), lack of knowledge of the tug/barge offset (the antenna was on the barge not the tug), and incomplete records.

Dredged material placement inspection can be conducted by onboard personnel provided by either the USACE District or dredging contractor. Many USACE dredging projects already require onboard inspectors to document proper dredging location, volumes dredged, and appropriate depths attained. For capping projects, both the New England Division and the New York District use inspectors. New England Division inspectors are contractors (but not employees of the dredging company). The New York District uses Corps employees as inspectors.

A new technology for dredging inspection that is being implemented is the Silent Inspector (SI). The SI uses state-of-the-art computer hardware and software to measure multiple dredge state parameters and provide output to automatically create USACE dredging reports. At this time, the SI is most readily applied to hopper dredges. Future work involves developing similar automatic inspection systems for hydraulic pipeline and mechanical dredge types. Many types of information are recorded by the SI including vessel speed, heading and position, hopper door status, vessel draft, and water depth. For capping projects that use hopper dredges, the SI can provide much of the needed information from dredging throughout placement (Cox, Maresca, and Jarvela 1995).

SI technology has also been applied to dredged material placed from a barge. A data logger on the barge records position and draft (from a pressure sensor). When the barge doors or hull are opened, the change in draft and location are recorded. The data can be downloaded to a computer at a later time or broadcast via radio link to a shore station for real-time monitoring. Commercial systems are available, and the New England Division has also provided some custom systems to the Districts. Both the Seattle and San Francisco Districts have used this type of system to monitor placement of dredged material.

During the placement of dredged material, periodic hydrographic surveys may be desirable to track mound growth. These surveys can allow the project manager to make midcourse adjustments in placement operations to effect changes in mound heights (either greater or less). Track plots from dredge logs or placement positions provide good information for long-term project placement locations.

Weather plays an important role in placement of dredged material not only for barge positioning but also in exposing the dredged material mound to unwanted erosion. As with most dredging projects, capping projects should be conducted in the less energetic summer months. During this time of year, storms are usually less frequent, thereby reducing the near-bottom currents that tend to move bottom sediments. For capping projects, this is particularly important to prevent the spread of contaminated material. Therefore, capping projects should afford adequate time for contaminated material placement and cap material placement to be conducted prior to the onset of fall/winter storms. Contingency plans that include phased capping or staging cap material for easier postconstruction placement should be considered for areas that are susceptible to hurricanes or other summer storms.

6 Sediment Dispersion and Mound Development and Site Geometry During Placement

The physical behavior of a dredged material discharge depends on the type of dredging and disposal operation used, nature of the material (physical characteristics), and hydrodynamics of the disposal site. For capping operations, it is essential to determine beforehand the nature of the discharge for both contaminated and capping material. The degree of dispersion and associated water column contaminant release dictates whether a given discharge is acceptable from the standpoint of water column impacts. The geometry of the subaqueous deposit or mound dictates the required area to be capped and cap configuration.

Sediment Dispersion During Placement

A knowledge of the short-term physical fate of both the contaminated material and capping material is necessary to determine the acceptability of the equipment and placement operation under consideration. Short-term fate is defined as the behavior exhibited by the material during and immediately following discharge. The dispersion of material released into the water column and the deposition of the material on the bottom are also of interest. These processes occur over a time period of a few minutes to several hours for a single release from a barge or hopper dredge.

In addition to physical dispersion of suspended material, an evaluation of water column mixing of released contaminants or suspended dredged material is necessary whenever potential water column contaminant effects are of concern. Such an evaluation may involve comparison of predicted water column contaminant concentrations with water quality criteria (or standards) or predicted suspended dredged material concentrations with bioassay test results. Water column effects measured in the field on actual projects may be valuable in quantifying water quality effects. For capping operations, such evaluations are normally required for the contaminated material to determine if water column control measures (i.e., submerged discharge) are necessary during placement. In addition, the prediction indicates what portion of the contaminated material is dispersed during placement and is not capped.

Methods for evaluation of potential water-column contaminant release are available ((USACE/EPA 1992). The contaminant release is predicted by an elutriate test, and results are compared with applicable water-quality criteria or standards as appropriate. In addition, acute water-column toxicity bioassays considering initial mixing may be needed. The procedures to be used in elutriate or water-column bioassays are provided in the MPRSA and CWA testing manuals (EPA/USACE 1991; EPA/USACE 1998). For disposal operations under the MPRSA, specific criteria for water quality and water-column toxicity must be met, and specific allowances are specified for initial mixing (EPA/USACE 1991). For disposal operations under CWA, water quality and water-column toxicity standards and allowances for initial mixing are specified by the States as a part of the Section 401 water-quality certification requirements.

The physical development of a mound or deposit on the bottom due to a number of barge or hopper releases or prolonged discharge from a pipeline is also of interest. Such information can be used to define the areal extent of the mound or deposit for the contaminated material. This dictates the required volume of capping material.

A computer model is available for evaluating the short-term fate of dredged material discharges in open water from hoppers or barges. The model is called the Short-Term FATE (STFATE) model (Johnson et al. 1993; Johnson and Fong 1995) and can be run on a personal computer (PC). This model is available as a part of the Automated Dredging and Disposal Alternatives Management System (ADDAMS) (Schroeder and Palermo 1990). Versions of the model are also included in the Ocean and Inland testing manuals (EPA/USACE 1991; EPA/USACE 1998). Appendix D describes the STFATE model in greater detail.

Input data required to run the model include (a) description of the disposal operation, (b) description of the disposal site, (c) description of the dredged material, (d) model coefficients, and (e) controls for input, execution, and output. More detailed descriptions and guidance for selection of values for many of the parameters are provided directly on-line in the system software or default values may be used.

Model output includes a time history of the descent and collapse phases of the discharge and suspended sediment concentrations for various particle size ranges as a function of depth and time. At the conclusion of the model simulation, the thickness of the deposited material on the bottom is given. Examples of model output are given in Figures 12 and 13. This allows an estimate of the areal extent or "footprint" of contaminated material as deposited on the bottom for a single disposal operation (i.e., a single barge or hopper load of material).

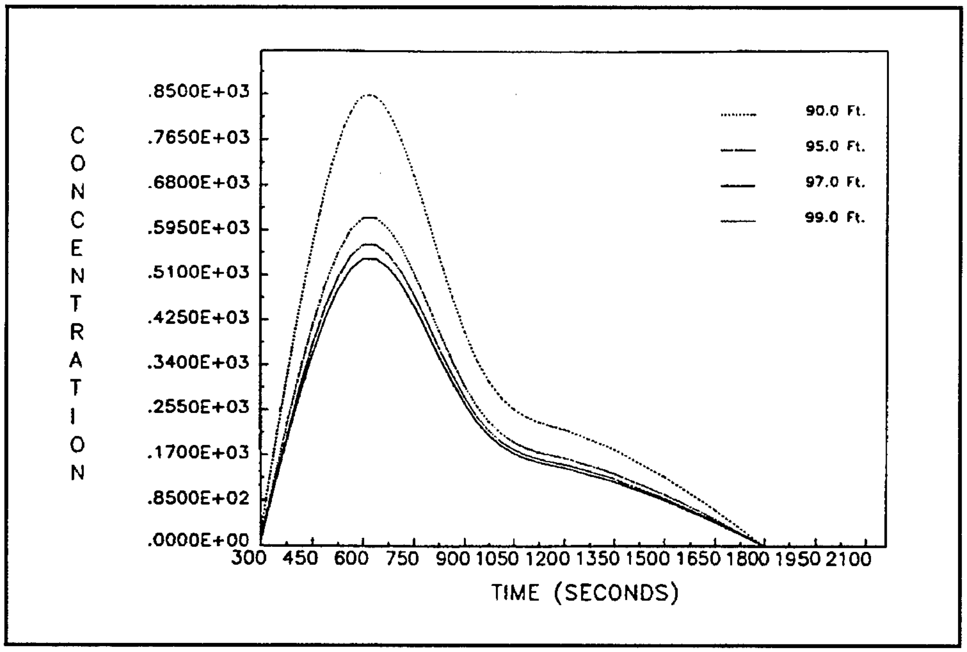


Figure 12. Typical STFATE model results showing concentration above background of clay (mg/l) (from Johnson 1992)

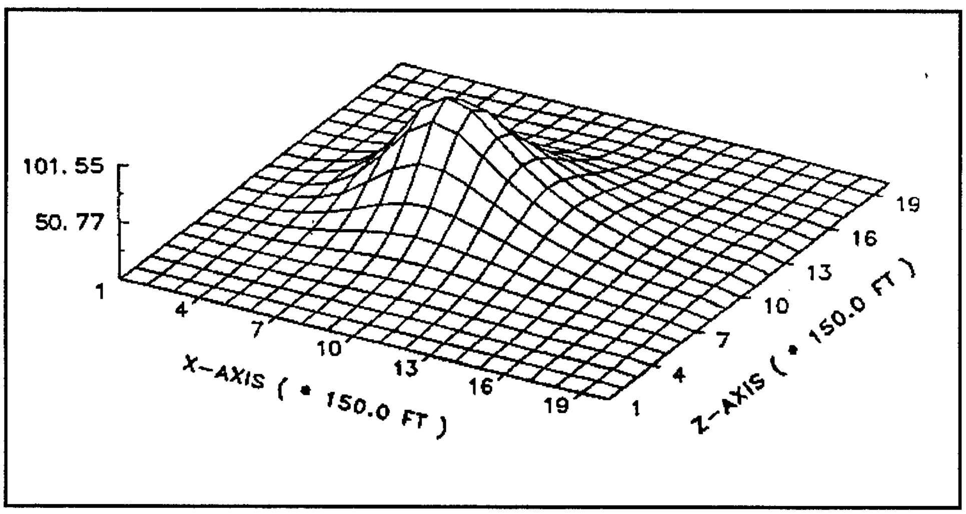


Figure 13. Typical STFATE model results showing total volume (ft^3/grid square) of new material (from Johnson 1992)

Evaluation of Spread and Mounding

The mound or deposit geometry, including contaminated material and cap, will influence the design of the cap and volume of capping material required. The smaller the footprint is of the contaminated material as placed, the less volume of capping material will be required to achieve a given cap thickness.

For LBC sites, the geometry of the contaminated material mound depends on the physical characteristics of the material (grain size and cohesion) and the placement technique used (hydraulic placement will result in greater spread than mechanical placement). Assuming that the material from multiple barge loads or pipeline can be accurately placed at a single point, the angle of repose taken by the material and the total volume placed will dictate the mound spread.

However, few data are available on the volume changes resulting from entrainment of water during open-water placement or the shear strengths of dredged material initially deposited in open-water sites. For these reasons, a priori estimates of mound spread made to date have been made based on the observed characteristics of previous mounds created with similar placement techniques and similar sediments (Palermo et al. 1989).

Models have been developed that will account for the development of mounds due to a number of barge or hopper discharges (Moritz and Randall 1995; SAIC 1994). The Corps' mound building model that models Multiple Disposals from barges and hopper dredges and their FATE (MDFATE) is a modification of the STFATE model. In the MDFATE model, a streamlined version of the STFATE model is run for each barge disposal. Thus, the input requirements for MDFATE are similar to those for STFATE. In MDFATE, the program keeps track of the mound thickness in each grid cell, then algebraically adds the thickness from subsequent disposals with avalanching when mound steepness exceeds critical values. MDFATE allows a number of typical disposal patterns to be automated; it allows moving barges and can import actual site bathymetry in real-world coordinates. MDFATE also allows interaction with the LTFATE model (Scheffner et al. 1995). This allows the mound created in MDFATE to be eroded by waves and currents during mound creations that may last months. A more detailed description of MDFATE can be found in Appendix E, and a more detailed description of LTFATE can be found in Appendix F.

Similar to the output from STFATE, output from the MDFATE model includes the volume of material on the bottom and contour and cross-section plots of mound bathymetry. Figures 14 and 15 show typical MDFATE output. One limitation of MDFATE is that it has been verified on only one actual project to date (Moritz and Randall 1995).

A model developed for the New England Division Disposal Area Monitoring System, the DAMOS capping model (Wiley 1994), is also based on the STFATE model. While it does not consider moving vessels or erosion by waves and currents, it has the advantage of having been verified for a number of mounds constructed by the New England Division in Long Island Sound.

Typical Contaminated Mound Geometry

As noted in the previous chapter, for LBC projects, virtually all of the mounds created have been constructed using mechanical dredging with transportation and placement by bottom-dump barges. The resulting

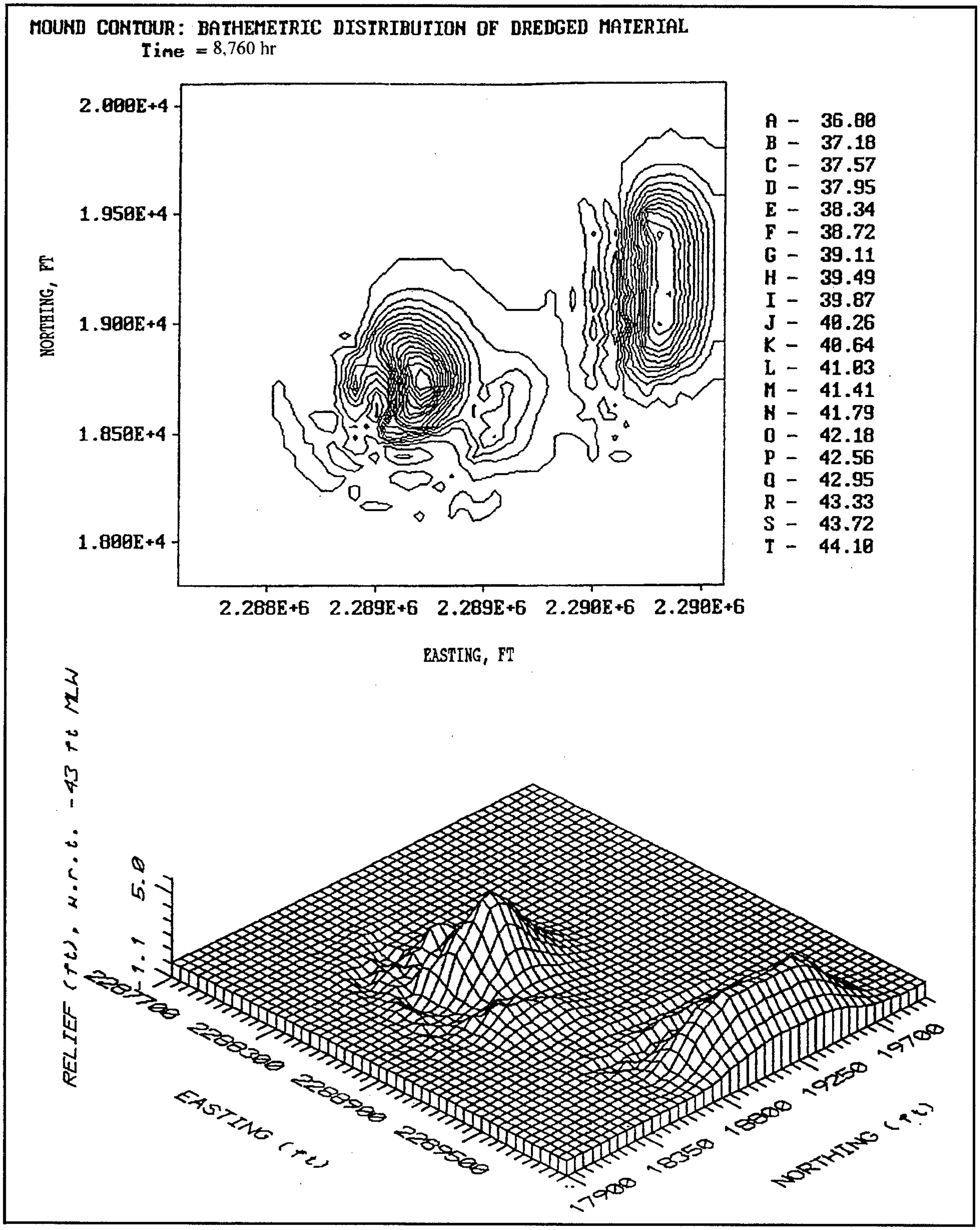


Figure 14. Typical MDFATE model output showing differences between predisposal and post-disposal bathymetry

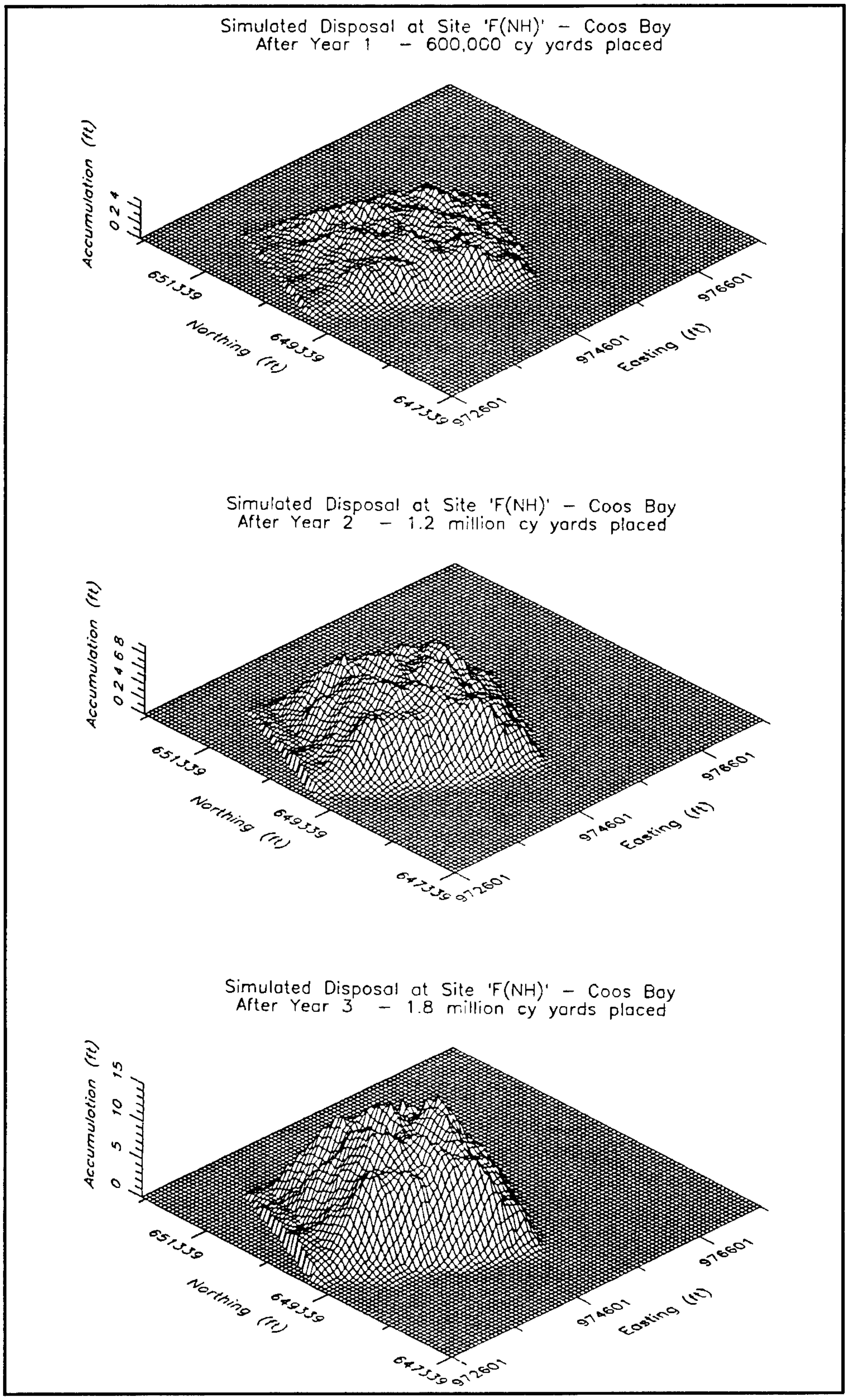


Figure 15. Typical MDFATE model output showing mound formation 1 to 3 years of disposal at Coos Bay

mounds created have had reasonably consistent geometries. Most mounds have been round or elliptical in shape, with a defined crest that is relatively flat, a main mound side slope (also termed the inner flank), sometimes an outer flank, and a thin outer apron. Figure 16 shows a generic contaminated mound. The dimensions for the side slopes and apron widths are based on those seen at the Port Newark/Elizabeth mound created in the Mud Dump site in 1993. The following paragraphs describe each of the mound features in more detail.

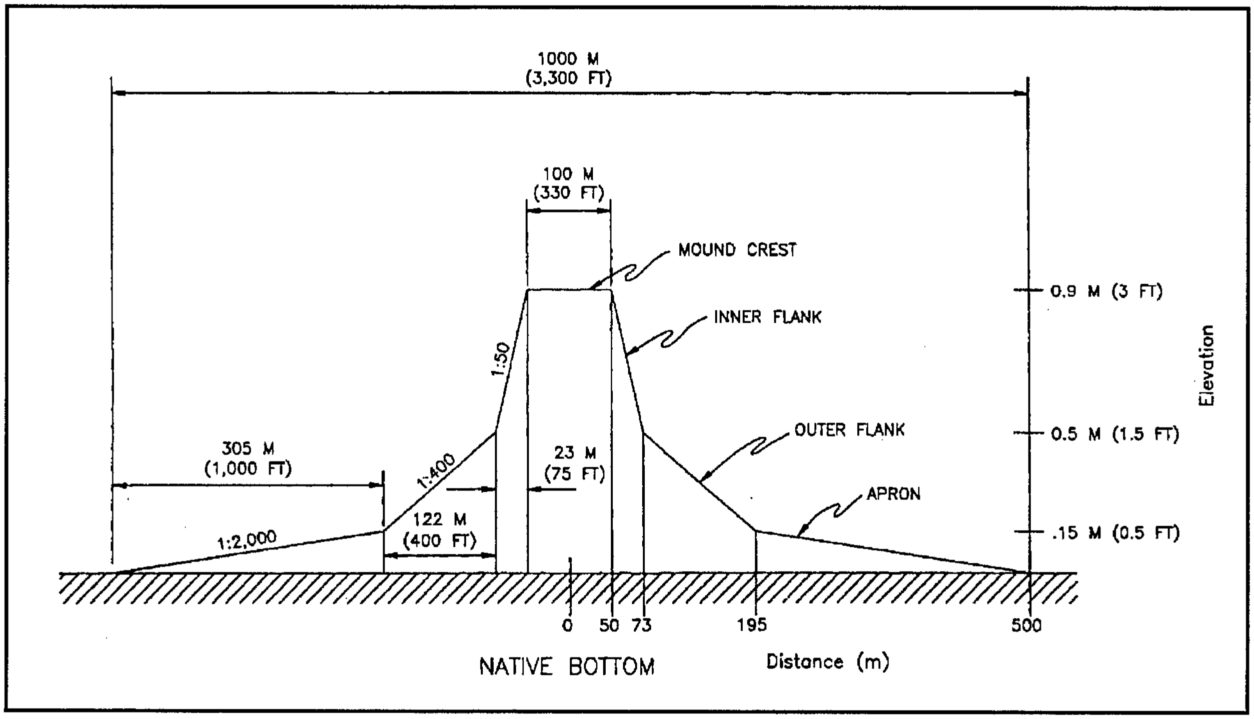


Figure 16. Typical mound geometry

Mound crest

Most contaminated mounds to date have had main mound crest elevations of 1 to 2 m, though some contaminated mounds with elevations of 3+ m have been constructed. Higher mounds have been constructed from noncontaminated material. For point-dumped projects in the New England Division, mound crests have generally been circles or ellipses approximately 100 to 200 m in diameter, reflecting good control of the disposal process around a taut-moored buoy (disposal within about 25 m of the buoy), for moderate-sized projects, generally 20,000 to 100,000 yd^3. The 1993 Port Newark/Elizabeth project used disposal lanes, 150 m in width and 300 to 420 m long, to create a triangular-shaped mound, approximately 630 by 645 m, with peak elevations of 1.5 to 2.4 m.

Inner flank

At the edge of the main mound, the inner flank of the mounds slope downward at a slope of approximately 1:35 to 1:70 with most of the mound slopes between 1:35 and 1:50. For the Port Newark/Elizabeth mound, the inner flank extended from the mound crest down to an elevation of about 1.0 m above the preplacement bottom.

Outer flank

For the Port Newark project, a break in slope generally occurred at the 1.0-m elevation; the outerflank then sloped down to an elevation of about 0.30 to 0.15 m at a slope of about 1:115. Data from the New England Division projects have not been examined in sufficient detail to determine if a similar feature exists for those mounds.

Apron

During the dynamic collapse phase (when the energy of the vertically descending jet of material disposed from a barge or hopper dredge is converted to horizontal velocity), some portion of the low shear strength, fine-grained material with high water contents may be transported a considerable distance from the disposal point. At the completion of the contaminated material placement, an apron of fine-grained material, typically 1 to 15 cm in thickness but extending up to several hundreds of meters beyond the main mound flanks, has occurred on almost all LBC projects. The apron has been defined as that portion of the material less than about 15 to 30 cm in thickness, because 20 to 30 cm is the resolution limit for high-quality bathymetry in water depths of 25 m or less.

A sediment profiling camera (SPC) can reliably measure apron thickness from 1 to 2 cm up to 20 cm. Thus, the outer limit of the apron should be defined as the point at which the apron can no longer be conclusively distinguished by the SPC, a thickness of 1 to 2 cm. Some contaminated material extends beyond the apron edge as defined by the 1- to 2-cm SPC limit; however, the percentage of the total volume is likely extremely small.

The apron typically exhibits an overall slope of 1v:1000+h at the Port Newark/Elizabeth project, and overall apron slope of about 1:2,000 was observed on downward sloping bottoms. If the inner edge of the apron is assumed to be 15 cm in thickness, the width of the apron for the Port Newark/Elizabeth project was about 300 m. The STFATE model and MDFATE model and the DAMOS capping model can be used to predict the apron dimensions.

Recent experience with a New York District 1997 capping project placed in the Mud Dump site illustrated the potential for slope adjustments when fine-grained mounds are created with heights exceeding about 10 ft. In one case, a portion of a contaminated mound with a height of 12 ft had a slope adjustment resulting in an after adjustment height of 6 to

8 ft and a movement of material outward of about 1,000 ft. This section of mound was placed on an ambient slope of up to 1.45 deg, which likely contributed to the adjustment and the outward movement. In a second case, a portion of the same mound with an elevation exceeding 10 ft experienced an apparent slope adjustment after capping began. Losses in elevation of 3 to 4 ft occurred as a result of the adjustment, though the significant outward movement seen on the upcapped section did not occur. This section of the mound was placed on a nearly flat slope. The above illustrates the need to consider the potential for slope adjustments in mounds over 6 to 8 ft tall. Analysis of slope stability for taller mounds, particularly those placed on slopes, is recommended (Moritz 1997).

Mound Geometry for Level-Bottom Capping

Evaluation of contaminated material mound geometry for an LBC project requires a series of steps:

a. **Determine volume of material to be disposed**. The first step in a capping project is to compute the volume of contaminated material to be dredged. An accurate estimate of the volume of contaminated material to be dredged should be a fairly straightforward process. Normally computer programs that compare authorized channel dimensions with existing bathymetry determine the volume of material to be dredged, with a combination of core, subbottom profiler, and sediment chemistry and bioassay/bioaccumulation testing done to determine the volume of contaminated sediments. The designer should consider including possible overdepth in the volume calculation. Normal clamshell allowed overdepth is about 2 ft. Some of the "environmental" clamshells claim lower overdepths 6 in. to 1 ft. Very high-quality instrumentation in addition to a special bucket is needed to achieve the lower overdepth values.

b. **Bulking**. Some bulking of the sediments during the dredging process may be factored into computing the volume required for capping. For mechanically dredged sediments, bulking of 10 to 20 percent (Herbich 1992) is reasonable. For materials dredged by hopper, a large volume of excess water is initially stored in the hopper, but the volume of water may be reduced prior to material placement by overflow. Following placement by hopper, a large portion of the excess water is almost immediately expelled from the material as it settles to the bottom.

In most instances capping will involve mechanical dredging of maintenance material with relatively low densities. These materials can experience fairly rapid consolidation. Most contaminated dredged projects will require several weeks or longer to conduct dredging. Thus, by the time capping is ready to begin, some consolidation will have taken place such that the volume to be capped may be nearly the in situ volume. Without site-specific data, a net bulking volume (including the apron) of 10 to 20 percent is reasonable.

c. **Predict contaminated mound geometry**. An accurate prediction of contaminated mound geometry is one of the most critical steps in LBC project design. There are two primary methods to determine mound geometry ranging from fairly simple to complex. The simple method is to assume a basic shape (e.g., a truncated cone or rectangular prism with sloping sides), then estimate side slopes and an apron width. A spreadsheet is an effective method to test a range of expected heights and crest dimensions on footprint dimensions and the corresponding cap volume required. A more rigorous method is to use a numerical model such as the MDFATE model (Moritz 1994; Moritz and Randall 1995) to predict mound geometry. Use of a numerical model allows the user to investigate the impact of changing operations (disposal pattern, barge size, barge velocity, etc.) on mound geometry.

d. **Is the calculated contaminated mound geometry suitable?** After the contaminated mound footprint and elevation have been calculated, the project manager/designer must decide if the predicted contaminated mound geometry meets project needs. The two basic concerns are as follows: Will all the contaminated material (and cap material) stay within any surface area constraints? Is the elevation of the capped mound sufficiently low so as not to interfere with navigation and not experience excessive erosion? A reasonable buffer distance between the edge of the contaminated mound and the site boundary is 100 to 200 m. If the answer to both questions is yes, then the designer can proceed to the next step, computing cap volume required (described in more detail in Chapter 7 and Appendix H). If the contaminated mound is predicted to spread too near or over the site boundary or is too high, then the following options should be investigated.

e. **Calculated contaminated mound footprint is too large.** If the contaminated mound footprint extends beyond the site boundary or is so large that the cost or volume of cap material required is a problem, several options are possible. Once again the simplest solution (but probably unattractive from the project perspective) is to reduce the volume of material being placed. One option to reduce spread is to make the mound taller by reducing the size of the area over which disposal takes place. The mound shape can be changed to make better use of available space; e.g., for the 1993 Port Newark/Elizabeth project conducted in New York District, a triangular-shaped mound was used. Figure 17 shows the rectangular mound dimensions in the original design and Figure 18 shows the triangular mound design modification. Other options include dredging pits and/or placing confining berms around the area (essentially creating a CAD) or using a diffuser to reduce spread. A operational change such as reducing the barge velocity, changing approach direction of the disposal vessels, or disposing only when the currents are in a favorable direction are other possible options. To evaluate such options will require using a numerical model.

Long-term planning can help to create a de facto CAD site. Over a period of several years, the New England Division made a series of small mounds around a portion of their Central Long Island

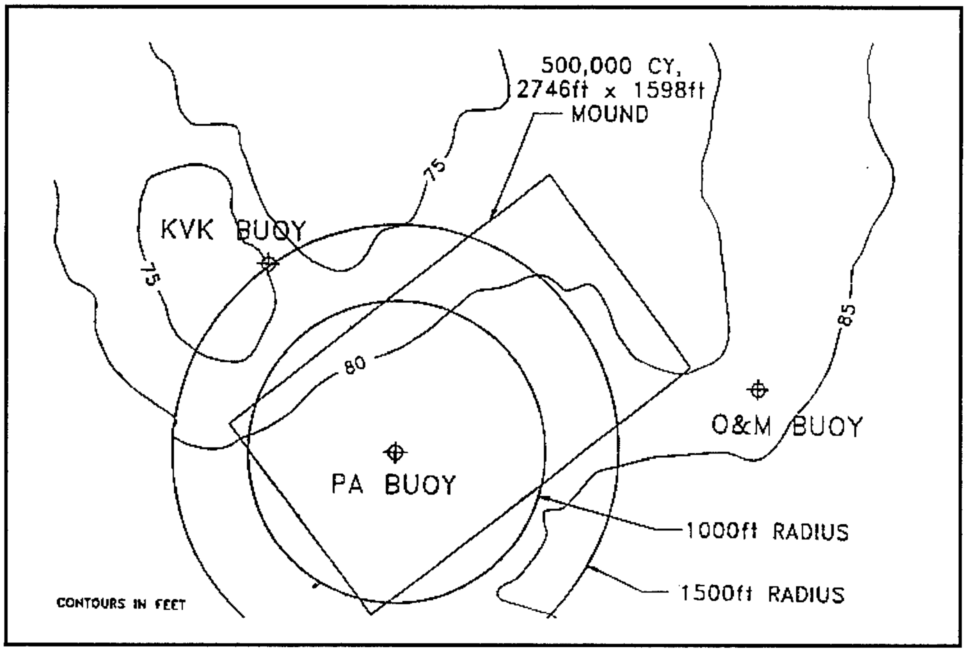


Figure 17. Original contaminated mound design for Port Newark/Elizabeth project

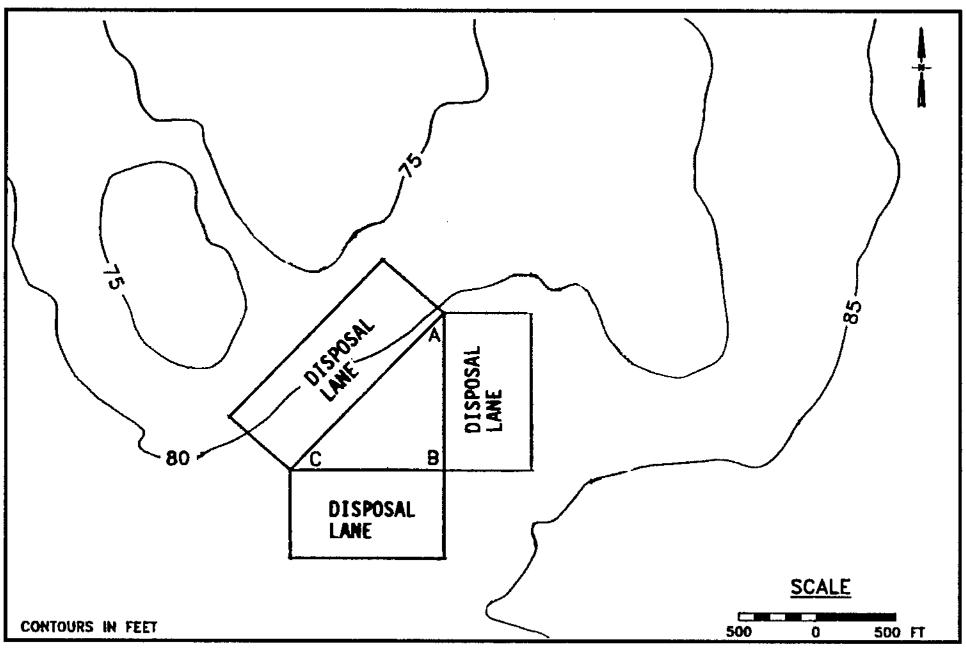


Figure 18. Disposal lanes used for triangular mound placement of contaminated material in Port Newark/Elizabeth project

Sound (CLIS) disposal site. This depression was then filled with over 500,000 m^3 of contaminated sediments in 1993/94 from the dredging of New Haven Harbor. By confining the contaminated material within the series of mounds from the smaller projects, the spread of the contaminated material was greatly reduced, requiring a relatively small volume of material to cap the contaminated sediments. Fredette (1994) describes the project in more detail.

f. **Calculated contaminated mound is too high.** If the calculated mound peaks exceed the maximum depth limit, it may be possible to increase barge velocity to make a mound of more constant elevation without substantially increasing the footprint. If much of the mound exceeds the minimum depth restriction, two obvious solutions are to (a) find a deeper portion of the site or another site (if available), or (b) reduce the volume of contaminated material. Perhaps a more feasible solution is to spread out the area of placement to reduce mound height. This will increase the surface area of the mound and thus the amount of cap required. It may also create problems with contaminated material coming too close to the site boundary. Another option is to consider a dredging method that increases the density of the contaminated material, a difficult proposition for mechanically dredged sediments.

g. **Cap geometry**. The same tools and approaches used for evaluation of contaminated mound geometry can be used to evaluate geometries for LBC caps. However, the major consideration for cap geometry is the placement of a layer of the required cap thickness over the central portion of the mound and over the apron as appropriate.

Geometry for CAD Projects

The geometry of the deposit for CAD sites is largely controlled by the geometry of the depression or subaqueous berms that form the lateral containment. If hydraulic methods are used to dredge the contaminated materials going into the CAD site, and if the site has a relatively small surface area, the materials will tend to spread in a layer of even thickness over the entire area. If the site has a large surface area, or if the contaminated material is mechanically dredged and placed by barges, the material may tend to form a mound within the site not covering the entire surface area. If this is the case, methods for intentionally spreading the contaminated material within the CAD site boundaries may be appropriate. Contaminated materials should be placed in CAD sites as a layer of uniform thickness, so that the required thickness of cap material can be placed using a minimum volume of cap material.

Cap geometry for CAD sites should be developed as the design cap thickness placed uniformly over the entire contaminated deposit. Assuming the contaminated material has been placed as a fairly uniform layer, the cap would essentially be placed from bank to bank within a depression, pit, or contained area formed by subaqueous berms.

The same tools as described above for LBC projects can be used for evaluation of deposit geometry for CAD sites. The major consideration for CAD geometry is the placement of both contaminated and cap layers in a uniform and level configuration.

Bulking is an important consideration for CAD geometry. The volume of contaminated material and cap and associated bulking must be closely estimated to ensure that all the material and cap can be placed within the available contained volume. For mechanically dredged sediments, bulking of 10 to 40 percent (Bray, Bates, and Land 1997) is reasonable. For hydraulically dredged sediments, dredged and placed by hopper or pipeline, much of the excess water will be expelled as the material is placed within the CAD site, but the volume occupied during the placement operation must be closely estimated. A project-specific investigation of the expected increase in volume for a particular dredging/placement method and sediment is warranted. Sedimentation analysis to determine a volume occupied by hydraulic pipeline placement to a CAD site has been conducted using procedures developed for diked confined disposal facilities (Averett et al. 1989). Procedures for such an analysis are outlined in detail in the USACE Engineer Manual 1110-2-5027, Confined Disposal of Dredged Material (USACE 1987).

7 Dredged Material Cap Design

This chapter presents procedures for designing subaqueous dredged material caps and a sequence for determining the design cap thickness components to account for bioturbation, erosion, consolidation, operational considerations, and chemical isolation. Methods for determining the required volume of cap material and design considerations for intermediate caps are also discussed.

General Considerations

The composition and dimensions (thickness) of the components of a cap can be referred to as the cap design. This design must physically isolate the contaminated sediments from the benthic environment and achieve the intended cap functions. The design must also be compatible with available equipment and placement techniques.

The composition of caps for dredged material projects is typically a single layer of clean sediments because relatively large volumes of cap material are involved; clean sediments from other dredging projects are often available as cap materials; and dredged material capping sites with low potential for erosion can be selected. Guidance on dredged material cap design in this chapter therefore focuses on the thickness of the cap as the major design criterion.

In contrast, in situ capping projects usually involve smaller volumes or areas; clean sediments are not always readily available as capping material; and site conditions are a given. For these reasons, caps composed of multiple layers of granular materials as well as other materials such as armor stone or geotextiles are often considered, and the in situ cap design cannot always be developed in terms of cap material thickness alone. Procedures for design of caps composed of nonsediment components are available in the EPA guidance document for in situ capping projects (Palermo et al. 1996).

Required Cap Thickness

Determining the minimum required cap thickness depends on the physical and chemical properties of the contaminated and capping sediments, hydrodynamic conditions such as currents and waves, potential for bioturbation of the cap by aquatic organisms, potential for consolidation of the cap and underlying sediments, and operational considerations. Total thickness can be composed of components for bioturbation, consolidation, erosion, operational considerations, and chemical isolation. Schematics of the cap thickness components and potential physical changes of the cap thickness due to erosion, consolidation, etc., are shown in Figure 19.

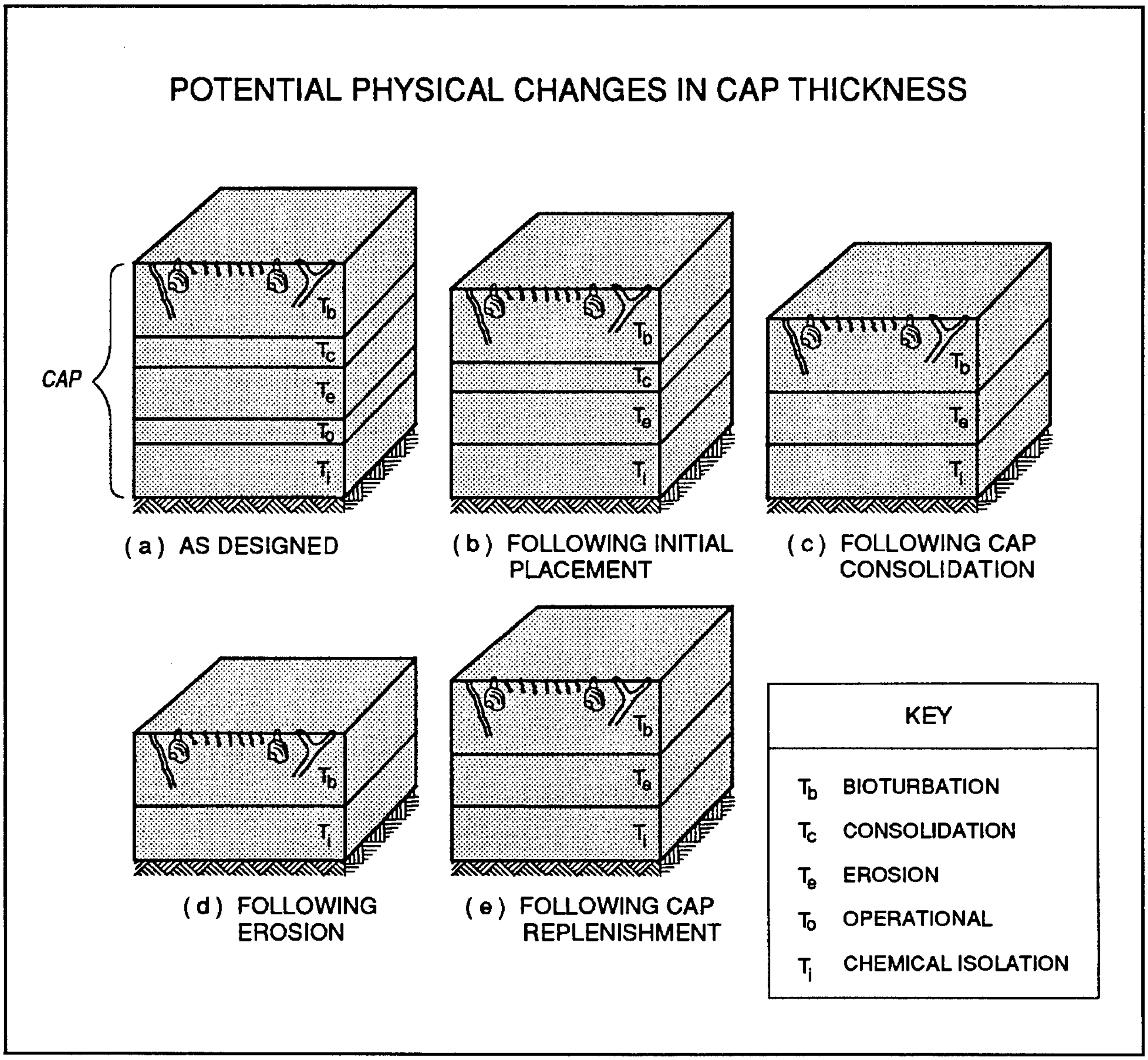


Figure 19. Schematics of cap thickness components and potential physical changes in cap thickness

The thickness for chemical isolation (if required) and/or the thickness for bioturbation must be maintained to ensure long-term integrity of the cap. The integrity of the cap from the standpoint of physical changes in cap thickness and potential for a physical reduction in cap thickness due to the effects of consolidation and erosion can be evaluated once the overall size and configuration of the capped mound or deposit and resulting water depth over the cap are determined. The design cap thickness for the various components can then be adjusted by iterative calculations if needed.

At present, the design of caps composed of clean sediments is based on a combination of laboratory tests and models of the various processes involved (contaminant flux, bioturbation, consolidation, and erosion), field experience, and monitoring data. Since the number of carefully designed, constructed, and monitored capping projects is limited, the design approach is presently based on the conservative premise that the cap thickness components are additive. No dual function performed by cap components is considered. As more data become available on the interaction of the processes affecting cap effectiveness, this additive design approach can be refined.

Before the design cap thickness can be determined, the following must be resolved: (a) the intended functions and design objectives of the cap must be defined (see Chapter 1); (b) suitable capping material must be identified (see Chapter 3); (c) a specific site must be identified and characterized (see Chapter 4); (d) equipment and placement techniques must be selected (see Chapter 5); and (e) overall geometry of the contaminated mound or deposit must be evaluated (see Chapter 6). The recommended sequence for determining the design cap thickness is as follows:

a. Assess the bioturbation potential of indigenous benthos and determine an appropriate cap thickness component for bioturbation.

b. Determine if the capping material is compressible, and if so, evaluate potential consolidation of the cap material after placement. If contaminated sediments or native underlying sediments are compressible, evaluate potential consolidation of those materials. If required, add a thickness component to offset consolidation of the cap.

c. Considering the mound or deposit geometry and site conditions, conduct a screening evaluation of potential erosion. If there is potential for erosion, conduct a detailed evaluation, considering both ambient currents and episodic events such as storms. If required, add a thickness component to offset potential erosion.

d. Evaluate operational considerations and determine restrictions or additional protective measures (e.g., institutional controls) needed to ensure cap integrity. If needed, add a thickness component to offset operational considerations.

e. If a design function of the cap is to control contaminant flux, evaluate the potential for short-term and long-term flux of contaminants through the cap as necessary. Determine any necessary additional cap thickness component for chemical isolation based on modeling and/or testing.

A flowchart illustrating the sequence of cap thickness evaluations and the interdependence of the components is shown in Figure 20. More detailed discussions of these design steps are given in the following paragraphs.

Bioturbation

A design objective of a dredged material cap is to physically isolate the contaminated material from benthic organisms. In the context of capping, bioturbation may be defined as the disturbance and mixing of sediments by benthic organisms. The importance of bioturbation by burrowing aquatic organisms to the mobility of contaminants cannot be overestimated. In addition to the disruption (breaching) of a thin cap that can result when organisms actively rework the surface sediments, there is the problem of direct exposure of infaunal organisms to the underlying contaminated sediment. The best available knowledge on local infauna must supplement generic assumptions concerning the bioturbation process.

Aquatic organisms that live on or in bottom sediments can greatly increase the movement of contaminants (solid and dissolved) through the direct movement of sediment particles or irrigation of pore water, increasing the surface area of sediments exposed to the water column, and as a food for epibenthic or pelagic organisms grazing on the benthos. The specific assemblage of benthic species that recolonizes the site, the bioturbation depth profile, and the abundances of dominant organisms are key factors in determining the degree to which bioturbation will influence cap performance. The depth to which organisms will bioturbate is dependent on behaviors of specific organisms and the characteristics of the substrate (i.e., grain size, compaction, organic content, pore water geochemistry, etc.). In general, the depth of recolonization by marine benthos is greater than that of freshwater benthos. Recolonization by benthic infauna at marine dredged material caps is primarily by suspension feeders as opposed to burrowing organisms (Morton 1989; Myers 1979). The intensity of bioturbation is greatest at the sediment surface and generally decreases with depth. Three zones of bioturbation are of importance (see Figure 21). A surficial layer thickness of sediment will be effectively overturned by shallow bioturbating organisms and can be assumed to be a continually and completely mixed sediment layer for purposes of cap design. This layer is generally a few centimeters in thickness. Depending on the site characteristics, a number of middepth burrowing organisms over time recolonize the site. The level of bioturbating activity for these organisms will decrease with depth as shown in Figure 21. The species and associated behaviors of organisms that occupy these surface, and middepth zones are generally well known on a regional basis. There may also be potential for colonization by deep-burrowing organisms (such as certain species of mud shrimp), which may burrow to depths of 1 m or more. However, knowledge of these organisms is very limited. These cap design criteria assume that deep bioturbators are not present in significant numbers.

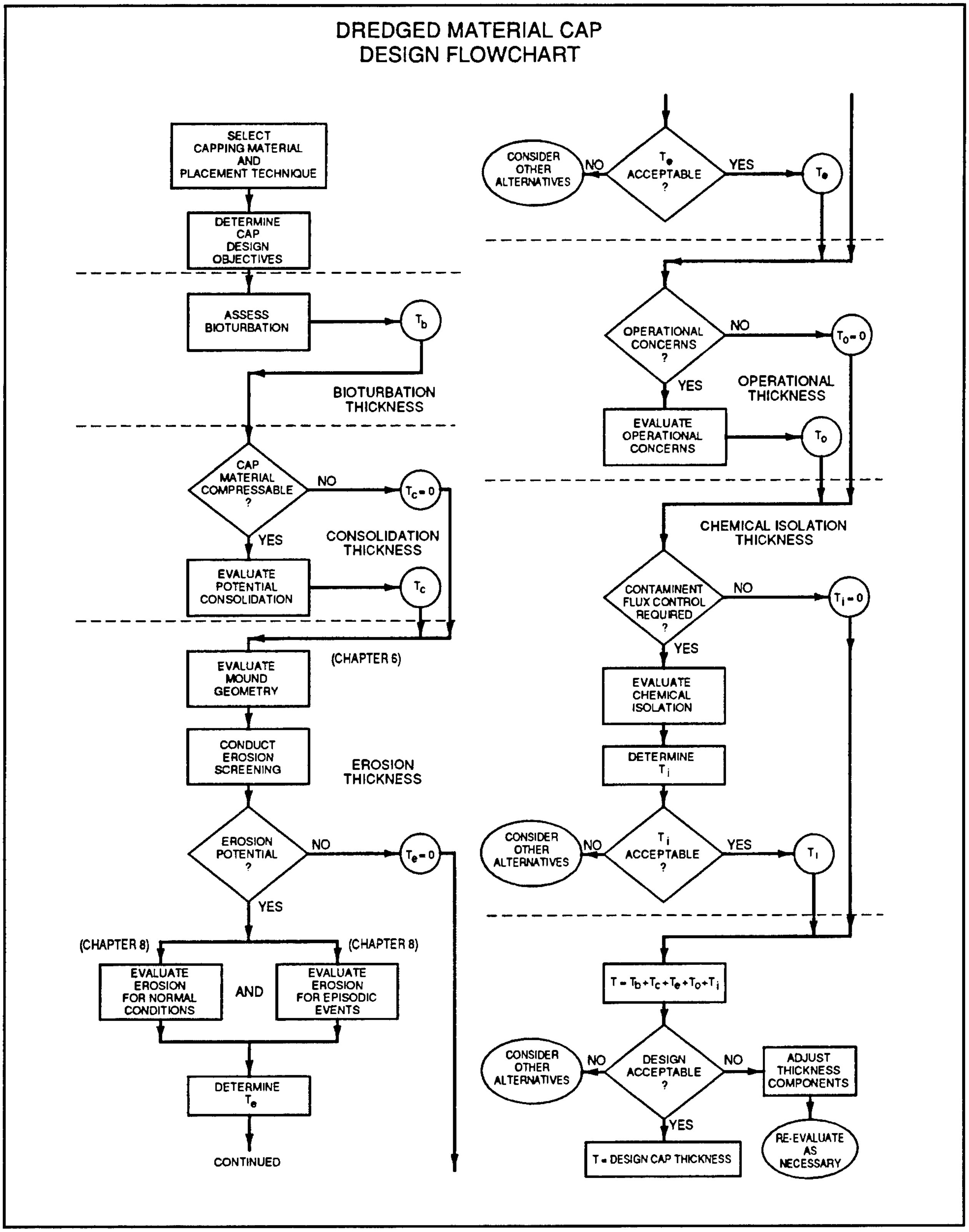


Figure 20. Flowchart illustrating sequence of evaluations for determining cap thickness

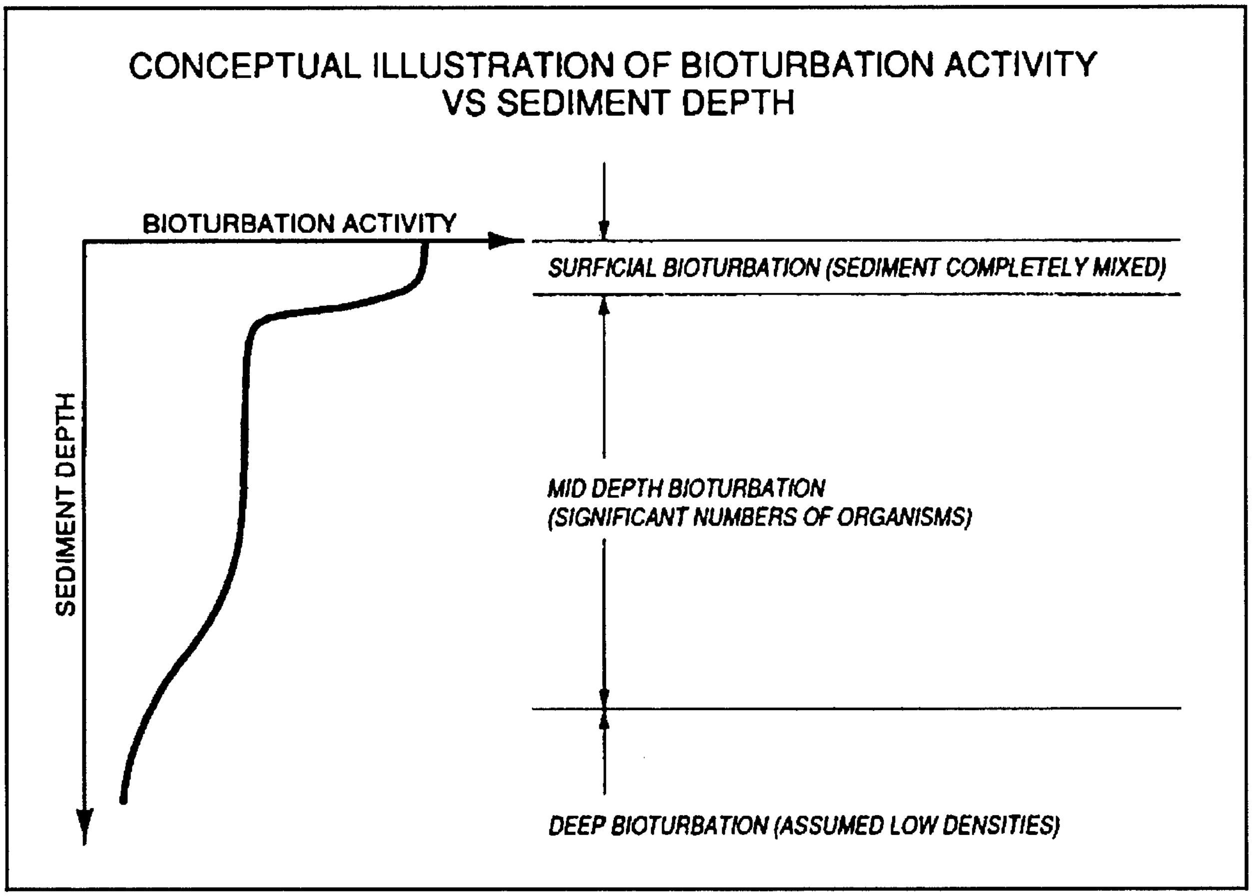


Figure 21. Conceptual illustration of bioturbation activity versus sediment depth

Cap thickness required for bioturbation, T_b, should be determined based on the known behavior and depth distribution of infaunal organisms likely to colonize the site in significant numbers. Bioturbation depths are highly variable, but have been on the order of 30 to 60 cm (1 to 2 ft) for most infaunal organisms that populate a site in great numbers. Consulting with experts on bioturbation in the region of the disposal site location is desirable. The thickness needed to prevent breaching of cap integrity through bioturbation can be determined indirectly from other information sources. For example, the benthic biota of U.S. coastal and freshwater areas have been fairly well examined, and estimates of the depth to which benthic animals burrow should be available from regional authorities.

Consolidation

Consolidation of the cap, contaminated material, or underlying native sediments may occur over a period of time following cap placement, but does not occur repeatedly. If a fine-grained cap material will be used, consolidation of the cap may require an added cap thickness component in the design such that the consolidated cap will remain at the required thickness. If any of the sediments (cap, contaminated, or native sediment) are compressible, a prediction of consolidation is important in interpreting monitoring data to differentiate between changes in surface elevation due to consolidation as opposed to those potentially due to erosion. It is important to note that the total mound height for an LBC project or fill height for a CAD project can decrease (due to consolidation of the contaminated layer or underlying native sediment) without the need to nourish the cap.

The consolidation analysis also holds importance for any required assessment of potential long-term flux of contaminants through the cap. The magnitude of consolidation of underlying sediments will determine the amount of water potentially moving (advecting) upward into the cap. Changes in the void ratio of the cap must also be considered in determining the distance to which this water is expressed upward into the cap.

If the selected material for the cap is fine-grained material (defined as material with more than 50 percent by weight passing a #200 sieve), the change in thickness of the material due to its own self-weight or due to other cap components should be considered in the overall design of the cap thickness. An evaluation of cap consolidation should be made in this case, and an additional cap thickness component for consolidation, T_c, should be added so that the appropriate cap thickness is maintained. Such consolidation occurs over a period of time following cap placement, but does not occur more than once.

If the cap material is not a fine-grained material, no consolidation of the cap may be assumed, and no additional increase in the isolation thickness is necessary. However, consolidation of the underlying contaminated sediments may occur, and a consolidation analysis may be necessary to properly interpret monitoring data. Procedures for evaluation of consolidation are given in Chapter 8 and Appendix I.

Erosion

If there is potential for erosion, the total cap thickness should include a thickness component for erosion, T_e, which may occur primarily due to long-term continuous processes (i.e., tidal currents and normal wave activity) or episodic events such as storms. This portion of the total thickness can be lost after many years of normal levels of wave and current activity, after an abnormally severe storm season, or in a few days during extreme events. Monitoring activities should result in detecting the loss of cap followed by a management decision to place additional material to bring the cap back to its design thickness.

A screening level assessment of erosion potential should first be conducted. This assessment may be conducted as a part of the site screening process described in Chapter 4. This assessment can be based on simple analytical or empirical methods. If the screening assessment indicates little or no potential for erosion, no detailed assessment need be conducted, and no erosion cap thickness component is needed. If the screening assessment indicates a potential for erosion, a more detailed assessment should be conducted. If the contaminated material is to be hydraulically placed (as for a CAD site) or a site with higher energy potential is being considered, a thorough analysis of the potential for resuspension and erosion must be performed, to include frequency considerations.

Based on the detailed assessment, a value of T_e should be added as the erosion cap thickness component. The criteria used to calculate the thickness to be added are equivalent to that used for the site screening discussed in Chapter 4. For projects in which no subsequent capping is anticipated for a long time period (several decades or longer) or for which materials for cap nourishment are not easily obtained, the recommended cap thickness component to be added, T_e, should be equivalent to the calculated net cap erosion over the major portion of the mound over a period of 20 years of normal current/wave energies or for a 100-year extreme event. The 20-year ambient time interval and 100-year return interval for storms are based on field experience gained to date. Twenty and one hundred years as time periods are in the range of design periods for many engineering structures. Note that calculated erosion at localized portions of the mound or feature may be somewhat greater than the value of T_e selected. The corners of a mound would normally have an overlap of capping material, and the crest of a mound would normally have a greater cap thickness; therefore, somewhat larger erosion could be tolerated over these portions of a mound.

Selection of other values of ambient time periods, return intervals, etc., for calculating erosion thickness should be based on site-specific factors (e.g., the degree of contamination, distance to other resources), the level of confidence in the calculations, and the acceptable level of risk. For projects in which subsequent capping is planned or for which materials for cap nourishment can be easily obtained, higher erosion rates may be considered. In areas where available capping materials and current and wave conditions are severe, a coarse-grained layer of material may be incorporated into the cap design to provide protection against erosive currents at the site.

Selecting a cap thickness component for erosion is a function of the acceptable level of risk. Definitive guidance is difficult because the level of risk acceptable will likely vary from project to project. Detailed guidance on erosion thickness evaluation is found in Chapter 8, along with additional discussion of the risk-related aspects associated with design cap thickness.

Operational concerns

At some locations, other considerations, termed operational, may have to be considered when determining the final cap thickness. These include ice gouging, anchoring, ability to place thin layers, unevenness of material placement, etc. If these are serious considerations, then locations that have significant potential for these types of operational considerations would be poor choices for capping projects.

For most open-water disposal sites, the sites will be located sufficiently far from shore and in sufficiently deep water that ice gouging should not be a concern. Ice gouging is obviously only a problem in areas that receive significant amounts of ice in the winter (e.g., the Great Lakes). Ice gouging occurs as ice thickness builds up, usually nearshore or adjacent to structures, to such a thickness that the lower portion of the ice gouges and displaces the bottom sediments. The thickness of the ice buildup decreases as distance from shore increases. Also as water depth increases, ice gouging will be less of a concern. For those locations where ice gouging may be problem, e.g., in situ capping sites nearshore, local experts should be consulted as to the locations where ice gouging occurs and the depth of the sediments disturbed.

Another operational concern is anchoring. Vessel anchors have the potential to disturb bottom sediments (as do trawlers). While most any location in shallow water (say 30 m or less) is subject to potential anchoring, for most locations where open-water dredged material placement sites are located, anchoring to such a degree that cap integrity is impacted will be extremely rare. The anchors used by recreational vessels typically only penetrate the bottom 1 to 2 ft. The relative area impacted by anchors compared with the size of a cap is very small. Also, when the anchors are removed, the area disturbed by the anchor is quickly filled. This is not true for anchors from large ships, which can penetrate up to 5 to 10 ft. Thus an area where ships routinely anchor would be a very poor choice for a capping project.

Another operational concern is the ability to place a relatively thin cap layer. Until recently, open-ocean capping operations made the controlled placing of small thicknesses (less than 30 cm) difficult. For many of those projects, the minimum cap thickness for most projects has been on the order of 75 to 120 cm (2.5 to 4 ft). Recent experience from the Port Newark/Elizabeth project at the Mud Dump (Randall, Clausner, and Johnson 1994) and Puget Sound capping projects (Nelson, Vanderheiden, and Schuldt 1994; Sumeri 1995) has shown that the sprinkling techniques developed were successful and that layers about 15 to 20 cm (0.5 to 0.75 ft) thick can be placed with reasonable assurance (though at increased cost due to increased operational controls).

The placement process will likely result in some unevenness of the cap thickness. This unevenness should be considered in calculation of the volume of capping material required.

If any of the above factors are significant for the site under consideration, an additional cap thickness component for operational concerns, T_o, should be added to the design cap thickness.

Chemical isolation

If a design function of the cap is to control contaminant flux, the potential for short-term and long-term flux through the cap should be evaluated. The need for such an evaluation is dependent on the types of contaminants, the potential for contaminant impacts, site and operational conditions, and other factors. For example, if the reason for capping is to isolate a sediment that is nontoxic to benthic organisms and exhibits bioaccumulation only marginally above that for a reference sediment, the isolation provided by the bioturbation thickness component will likely provide sufficient control, and there is little reason to conduct a detailed assessment. Conversely, if the sediment to be capped has exhibited toxicity to benthic organisms, a detailed assessment of long-term effectiveness would be advisable.

The additional cap thickness component for chemical isolation may be defined as T_i and should be determined based on modeling and/or testing as described in this section. The basis of design of a contaminant flux thickness component will be project specific. The flux rates (mass of contaminant per unit area per unit time) pore water concentrations in the cap and long-term accumulation of contaminants in cap sediments may be evaluated and used in the design. For example, flux and the resulting impact on overlying water quality may be compared with a water quality standard or criterion in much the same way as water column contaminant releases during the placement process. Compliance of the flux concentrations at the boundary of the site or edge of an established mixing zone would be appropriate. In this way, the cap thickness component for isolation required to meet the water quality standards can be determined.

Chemical flux processes

Properly placed capping material acts as a filter layer against any migration of contaminated sediment particulates. There is essentially no driving force that would cause any long-term migration of sediment particles upward into a cap layer. Most contaminants of concern also tend to remain tightly bound to sediment particles. However, the movement of contaminants by advection (movement of pore water) upward into the cap is possible. Molecular diffusion over extremely long time periods will always occur. Advection refers to the movement of pore water. Such movement could occur as an essentially continuous process if there is upward groundwater gradient acting below the capped deposit. Advection could also occur as a result of compression or consolidation of the contaminated sediment layer or other layers of underlying sediment. Movement of pore water due to consolidation would be a finite, short-term phenomena, in that the consolidation process slows as time progresses and the magnitude of consolidation is a function of the loading placed on the compressible layer. The weight of the cap will "squeeze" the sediments, and as the pore water from the sediments moves upward, it displaces pore water in the cap. The result is that contaminants can move part or all the way through the cap in a short period of time. This advective movement can cause a short-term loss, or it can reduce the breakthrough time for long-term advective/diffusive loss.

Diffusion is a molecular process in which chemical movement occurs from material with higher chemical concentration to material with lower concentration. Diffusion results in extremely slow but steady movement of contaminants. The effect of long-term diffusion on the design cap thickness is normally negligible, because long-term diffusion of contaminants through a cap is an extremely slow process and contaminants are likely to adsorb to the clean cap material particles.

Properly designed caps act as both a filter and buffer during advection and diffusion. As pore waters move up into the relatively uncontaminated cap, the cap sediments can be expected to scavenge contaminants so that any pore water that traveled completely through the cap theoretically would carry a relatively small contaminant load to the water column. Furthermore, through-cap transport can be minimized by using a cap that has sufficient thickness to contain the entire volume of pore water that leaves the contaminated deposit during consolidation. For example, Bokuniewicz (1989) has estimated that the pore water front emanating from a consolidating 2-m-thick mud layer would only advance 24 cm into an overlying sand cap (Sumeri et al. 1991). Contaminant flux processes are very much dependent upon the nature of the cap materials. For example, a cap composed of pure sand would not be as effective in containing contaminants as a naturally occuring sand with an associated fraction of fines and organic content.

Some components for cap thickness should not be considered in evaluating long-term flux. For example, the depth of overturning due to bioturbation can be assumed a totally mixed layer and will offer no resistance to long-term flux. The component for erosion may be assumed to be absent for short periods of time (assuming the eroded layer would be replenished). Components for operational considerations, such as an added thickness to ensure uniform placement would provide long-term resistance to flux. The void ratio or density of the cap layer after consolidation should be used in the flux assessment.

Any detailed assessment of flux must be based on modeling since the processes involved are potentially very long term. Laboratory testing to more precisely determine parameters for the available models may also be conducted.

Modeling applications for cap effectiveness

A model has been developed by EPA to predict long-term movement of contaminants into or through caps due to advection and diffusion processes. This model has been developed based on accepted scientific principles and observed diffusion behavior in laboratory studies (Bosworth and Thibodeaux 1990; Thoma et al. 1993; Myers et al. 1996). The model considers both diffusive and advective fluxes, the thickness of sediment layers, physical properties of the sediments, concentrations of contaminants in the sediments, and other parameters. This model is described along with example calculations in Appendix B.

The results generated by the model include flux rates, breakthrough times, and pore water concentrations at breakthrough. Such results can be compared with applicable water quality criteria or interpreted in terms of a mass loss of contaminants as a function of time, which could be compared with similar calculations for other remediation alternatives. The model in Appendix B is applicable to the case of a single contaminated material layer and a single cap material layer, each with a homogenous distribution of material properties. The diffusion relationships used in the model have been verified against laboratory data. However, no field verification studies for the model have been conducted.

There is a need for a comprehensive and field-verified predictive tool for capping effectiveness, and additional research on this topic is planned.

The USACE has applied a refined version of an existing sediment flux model (Boyer et al. 1994) for capping evaluations, and more refinements to the model are planned to account for a comprehensive treatment of all pertinent processes. But in absence of such a tool, analytical models such as that in Appendix B should be used in calculating long-term contaminant loss for capped deposits as long as conservative assumptions are used in the calculations.

Laboratory tests for flux evaluation

Several testing approaches have been applied to define cap thicknesses and the sediment parameters necessary to model their effectiveness in chemical isolation. Laboratory tests may be used to define sediment-specific and capping-material-specific values of diffusion coefficients and partitioning coefficients. But no standardized laboratory test or procedure has yet been developed to fully account for advective and diffusive processes and their interaction.

The USACE developed a first-generation capping effectiveness test in the mid-1980s as part of the initial examination of capping as a dredged material disposal alternative. The test was developed based on the work of Brannon et al. (1985, 1986), Gunnison et al. (1987a), and Environmental Laboratory (1987). Louisiana State University has conducted laboratory tests to assess diffusion rates for specific contaminated sediments to be capped and materials proposed for caps (Wang et al. 1991). Diffusion coefficients for long-term modeling of diffusive transport of contaminants from contaminated sediment into cap material have also been measured using diffusion tubes (DiToro, Jeris, and Clarcia 1985). Environment Canada has performed tank tests on sediments to investigate the interaction of capping sand and compressible sediments, and additional tests are planned in which migration of contaminants due to consolidation-induced advective flow will be evaluated (Zeman 1993). The USACE has also developed leach tests to assess the quality of water moving through a contaminated sediment layer into groundwater in a confined disposal facility environment (Myers and Brannon 1991). This test is being applied to similarly assess the quality of water potentially moving upward into a cap due to advective forces.[1]

Results of laboratory tests conducted with samples of the contaminated sediments to be capped and the proposed capping sediments should yield sediment-specific and capping-material-specific values of diffusion coefficients, partitioning coefficients, and other parameters needed to model long-term cap effectiveness. Model predictions of long-term effectiveness using the laboratory-derived parameters should be more reliable than predictions based on so-called default parameters. More detailed descriptions of test procedures for evaluation of capping effectiveness are presented in Appendix C.

---

[1] Personal Communication, 1995, Tommy E. Myers, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Field data on long-term effectiveness

Some field studies have been conducted on long-term effectiveness of caps. Sequences of cores have been taken at capped dredged material sites in which contaminant concentrations were measured over time periods of up to 15 years (Fredette et al. 1992; Brannon and Poindexter-Rollings 1990; Sumeri et al. 1994). Core samples taken from capped sites in Long Island Sound, the New York Bight, and Puget Sound exhibit sharp concentration shifts at the cap/contaminated layer interface. For the Puget Sound sites, these results showed no change in vertical contaminant distribution in 5 years of monitoring with 18-month and 5-year vibracore samples taken in close proximity to each other. In the New York Bight and Long Island Sound sites, respectively, cores were taken from capped disposal mounds created approximately 3 and 11 years prior to sampling. Visual observations of the transition from cap to contaminated sediment closely correlated with the sharp changes in the sediment chemistry profiles. The lack of diminishing concentration gradients away from the contaminated sediments strongly suggests that there has been minimal long-term transport of contaminants up into the caps. Additional sampling for longer time intervals is planned.

These results confirm that no gross movement of contaminated sediments or contaminants occurs with a properly placed cap, that only pore water advection and molecular diffusion would act to move contaminants into a cap over the long term, that such processes move contaminants at extremely slow rates, and therefore contaminants are effectively isolated from the aquatic environment for extremely long periods (Brannon and Poindexter-Rollings 1990).

Acceptability of flux component design

If the flux evaluation indicates the design objectives are not met, additional cap thickness can be added or cap materials with differing properties (grain size and TOC) can be considered to further decrease the contaminant flux. The evaluation process could then be run in an iterative fashion if necessary to determine the chemical isolation component needed to meet the design objectives. Of course, if no reasonable combination of cap thickness and cap material properties can meet the objectives, other alternatives or control measures must be considered.

Required Design Cap Thickness and Area and Volume of Capping Material

Calculation of design cap thickness

The total design cap thickness, as initially placed, is determined as follows:

$$T_t = T_b + T_e + T_c + T_o + T_i$$

where

T_t = total cap thickness, cm

T_b = thickness for bioturbation, cm

Te = thickness for erosion, cm

T_c = thickness for consolidation, cm

T_o = thickness for operational considerations, cm

T_i = thickness for physical/chemical isolation, cm

Areal coverage of the full cap versus apron cap

For a capping operation to be successful, the required cap thickness must be placed over the deposit of contaminated material. Typically, the edge of the contaminated mound will be detected with an SPC, which can reliably detect contaminated layers of thickness of 1-2 cm. Within this context, the contaminated material deposit is considered that which can be detected. However, it is not possible or necessary to cap every particle of contaminated material with the full design cap thickness.

For LBC projects, capping operations should be aimed at placing the full design cap thickness over the central portion of the mound and inner and outer flanks of the mound as defined in Chapter 6. As contaminated material is placed to form the mound, material settles to the bottom as the apron in ever-decreasing thicknesses with increasing distance from the point of discharge. The capping material is similarly dispersed, especially if the grain size and placement methods are similar. Therefore, operations aimed at placing the design thickness over the geometry of the mound that can be defined by bathymetric surveys will result in somewhat thinner layers of capping material being placed over the apron, as defined in Chapter 6.

Monitoring techniques are discussed in Chapter 9. Differential bathymetric surveys can determine the extent of a deposit down to a thickness of approximately 15 to 30 cm, while an SPC can detect sediment thicknesses from 2 to 20 cm. A combination of these approaches can be used to define the areal extent of the contaminated material mound and subsequently the required areal extent of the full capping thickness.

For CAD projects in which the contaminated material is placed as a layer of uniform thickness within the contained area, the full design cap thickness should be placed over the entire surface area.

Volume calculations

Once the design cap thickness and required areal extent of the cap are determined, the required volume of capping material can be estimated. There is no minimum acceptable ratio of capping to contaminated sediment volumes for capping. The requirement is to cap the deposit of contaminated material with the required thickness of capping material. The areal extent of the contaminated material deposit and required cap thickness are the key factors in calculating the volume of cap material. For example, if a large volume of contaminated material were placed in a subaqueous depression or pit (a CAD project), the deposit could be satisfactorily capped with a relatively small volume of capping material. Additional considerations on cap areas and volumes are provided in Appendix H.

Acceptability of design

Once the total cap thickness is determined, the calculations used to arrive at each of the components should be reexamined and the acceptability of the design evaluated. Some recalculations using an iterative process may be necessary because total cap thickness influences the water depth above the cap, which influences erosion potential, and total cap thickness as placed influences the magnitude of consolidation of the cap. However, in most cases, the calculations will not be overly sensitive to the overall cap thickness, and recalculation of specific thickness components should not be required.

The overall design of the cap should also be examined with respect to acceptability from the operational, logistical, and economic perspectives. If the total cap thickness is too large for effective placement, or the needed volume of cap material is not available, or the anticipated cost of capping too great, alternate sites or other disposal alternatives should be considered.

Considerations for Intermediate Caps

Some capping projects could be designed in the context of anticipated multiuse or multiuser applications. In such a case, one site (e.g., a subaqueous borrow pit) could be selected for placement of contaminated sediments from several projects. If several placements of contaminated sediments are to be placed with such frequency that the site could not effectively recolonize, there would be no pathway for bioaccumulation or benthic toxicity. Also, if the site is located in a sheltered area, or the energy from low-frequency events would not cause significant erosion, no placement of cap material or placement of a intermediate cap with a lesser thickness. That is, one that has a shorter return period level of erosion protection or less capabilities for chemical or biological isolation than the full design cap could be considered. Determining an appropriate thickness for an intermediate cap would require an evaluation of the same processes as described above, but the design parameters (especially those for long-term flux, return periods for storms, etc.) should be selected to represent the time periods anticipated between dredged material and intermediate cap placement and final cap placement.

8 Long-Term Cap Stability

Considerations in Long-Term Stability

When contaminated material is isolated from the environment through a dredged material capping operation, it is essential that not only the precision and thoroughness of initial cap placement be considered but also the long-term integrity, or stability, of the capped deposit be evaluated on a regular basis. A critical element in successful performance of a cap is preservation of an adequate thickness of this clean material to control flux of contaminants and isolate the contaminated sediments from benthic organisms. In evaluating long-term cap stability, factors that must be addressed include the following:

a. Possible consolidation (of capping material, contaminated sediment, and foundation material) for effect on long-term site capacity, differentiation from erosion, and quantification of contaminated pore water volume expelled.

b. Potential for erosion (considering the wave and current conditions at the disposal site and dredged material particle size and cohesion).

If erosion or consolidation causes the cap to be too thin to effectively isolate the contaminated material from the surrounding environment, then remedial actions will be required to reestablish cap integrity. This chapter presents detailed procedures to evaluate long-term physical stability of subaqueous dredged material caps, considering consolidation and erosion processes. These processes are discussed in the following paragraphs, along with recommended techniques and computer models available for analysis.

A critical step in cap design is to use the information from Chapter 7 in determining a design cap thickness (or a trial thickness for detailed evaluations such as decribed in this chapter). Selecting a design cap thickness is a function of an acceptable level of risk. Assessment of consolidation is mathematically straightforward, while the very stochastic nature of erosion makes it much more complicated to predict. Definitive guidance on cap stability is difficult because the level of acceptable risk will likely vary from location to location. Further discussion of risk-related cap design topics are found at the end of this chapter.

Evaluation of Consolidation

For LBC projects, dredged material typically forms a mound of material on the bottom of the water body. If a clean sediment is placed to isolate the contaminated material from the surrounding environment, the capping material increases the size of the existing mound and also places a surcharge load on the underlying dredged material and further increases the surcharge load on the foundation soil. Because the contaminated sediments are usually fine grained and have a relatively high moisture content, they are often susceptible to large amounts of consolidation. For CAD projects, the materials are layered but are subject to the same consolidation processes.

Assessing consolidation potential of capped dredged material mounds or deposits requires consideration of the consolidation potential of three elements: the cap, the contaminated dredged material, and the native or substrate sediments (foundation soils). The contaminated dredged material (which is usually fine-grained, cohesive material) likely will undergo consolidation resulting both from its own self-weight and from the surcharge load of the capping material. If the capping material is fine grained (e.g., silt or clay), it will also be susceptible to consolidation. Coarse-grained capping material (e.g., sand or gravel) would not normally be expected to consolidate. The final element to be considered is consolidation potential of the foundation soils. If these soils are fine-grained materials susceptible to consolidation, the loading applied by the contaminated and capping material will probably be sufficient to cause consolidation.

Quantifying consolidation is necessary for three reasons. First, changes in elevation due to consolidation must be delineated from those due to erosion. Decreases in the elevation of the mound or deposit surface caused by erosion of the cap may require remedial actions to replenish and restore the cap to its required thickness. If consolidation of constituent materials accounts for the change in elevation, then no cap replenishment is necessary, particularly if cap thickness design accounted for, a priori, potential cap consolidation. Thus it is imperative that consolidation be distinguished from erosion. Second, consolidation should be considered when determining long-term site capacity. As a mound consolidates and decreases in elevation, additional volume becomes available between the mound surface and the plane of maximum acceptable mound elevation; this volume can be used for storage of additional dredged material. The increases in the storage capacity of subaqueous disposal sites due to consolidation are especially important when these sites will be used to store large quantities of material from several dredging operations occurring over a number of years. Thus the ultimate holding capacity of repeated-use sites will be significantly increased if consolidation is considered. Third, a consolidation analysis will provide data needed to evaluate the potential movement of pore water from the contaminated sediment upwared into the cap, and this is necessary in evaluating the potential for long-term flux of contaminants.

Many soft fine-grained materials may undergo on the order of 50-percent vertical strain during the consolidation process. Therefore, the objective of consolidation analysis is to determine the amount and rate of consolidation that the mound and/or foundation soils will undergo as a result of self-weight consolidation and/or surcharge loading. One-dimensional (1-D) consolidation analysis is normally used in geotechnical engineering. In a 1-D analysis, pore water is expelled vertically (upward and/or downward) from soil layers; no horizontal flow or strain is allowed. Few 2-D or 3-D analyses are ever performed, and these are usually conducted on research projects. Because of the configuration of subaqueous sediment mounds (relatively flat slopes and thin lifts), a 1-D analysis of mound consolidation should provide adequate results for either design or analysis of these mounds. However, in the future, development and use of 2-D or 3-D consolidation models would permit more accurate prediction of the actual direction and magnitude of flows and movements.

Fine-grained dredged sediments, especially those placed by pipeline or hopper dredge, are initially soft and have a high water content, with an associated high compressibility. Potential changes in height (strains) due to consolidation are large; therefore, a finite strain approach that accounts for the large strains should be used to evaluate consolidation (Rollings 1994; Poindexter 1989).

Consolidation testing

Laboratory consolidation test data are necessary for an evaluation of consolidation; however, standard procedures for consolidation tests (USACE 1970) may not be applicable for testing of soft sediment samples. A modified version of the standard oedometer consolidation test (USACE 1987) and a self-weight consolidation test (Cargill 1985) have been developed that provide data for the wide range of void ratios that may be encountered in the context of dredged material placement operations. Additional details on consolidation testing are given in Appendix I.

Consolidation models

The complexity and number of calculations required to predict consolidation of deposits using large strain consolidation theory require use of a computerized solution technique. The theory of finite strain consolidation (Gibson, England, and Hussey 1967) has been incorporated into several generations of computer models for analyzing consolidation of capped sediment mounds (Cargill 1985; Poindexter-Rollings 1990; Stark, in preparation). To run any of these models, consolidation test data from self-weight consolidation tests and/or standard oedometer tests (USACE 1970; USACE 1987) are required (See Appendix I).

Initial work on consolidation of dredged material was done with the computer model PCDDF (Primary Consolidation and Desiccation of Dredged Fill) (Cargill 1985), which was later modified and released as PCDDF89 (Stark 1991); these programs were developed specifically for analysis of confined upland disposal sites. Subsequent work on consolidation of subaqueous capped mounds was done with MOUND (Poindexter 1989; Poindexter-Rollings 1990). This program incorporated capabilities for analyzing deposits that were subjected to surcharge (cap) loads and included an empirical relationship between shear strength and void ratio, plasticity index, and activity of the sediment particles. Most recently, PCDDF89 has been updated to include secondary compression; this version is known as PSDDF (Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill) and is likely the most user-friendly version (Stark, in preparation). Each of these computer programs is based on the same 1-D theory of consolidation and is capable of predicting the consolidation of multiple compressible layers. Computational details and processing speeds vary among the programs, but similar consolidation estimates should be obtained from each.

In evaluating consolidation, both the rate and the magnitude of consolidation should be determined separately for the contaminated sediment, the capping material, and the foundation layers, as appropriate. Then for any given time of interest, the individual settlement values for the foundation, contaminated sediment, and capping sediment should be summed to provide an estimate of the total amount of settlement to be expected at that particular time. This information can be used in conjunction with field-monitoring data in the ongoing assessment of cap integrity. The change in thickness of the capping layer is of primary concern from an environmental containment perspective. However, the total amount of consolidation settlement, or decrease in elevation, of the cap surface over time is necessary to delineate between mound height changes caused by erosion and those accounted for by consolidation of constituent materials.

Because consolidation settlement of capped mounds can be mistaken for erosion of the cap, estimates of consolidation of capped mounds should be made when mound geometry is established and should be routinely compared with field-monitoring data thereafter. Estimating consolidation of capped mounds requires collection of appropriate samples, conducting necessary geotechnical testing (as described in Chapter 3), and conducting a consolidation analysis for each compressible material (foundation, contaminated sediment, and/or capping material).

The MOUND model and another consolidation model, CONSOL (Gibson, Schiffman, and Cargill 1981; Wong and Duncan 1984), were used to predict consolidation of three capped dredged material mounds in Long Island Sound (Silva et al. 1994). Bathymetry of these sites showed reductions in mound elevations of up to 3.5 m over time periods of 10 to 13 years after cap placement. Comparisons between consolidation and bathymetry estimates were made to show that the reductions in mound elevation could be attributed to consolidation rather than cap erosion. These results compare favorably with earlier analyses of the same capped mounds in which the predictions were also validated by field measurements (Poindexter 1989). Results showed the two models used in the recent study were reasonably accurate in predicting consolidation, that consolidation of the base (native) sediments can constitute a majority of the observed consolidation, and that the caps had not experienced erosion losses. The work also pointed out the need to obtain more accurate geotechnical information on the void ratios and initial effective stress of the contaminated materials.

Typical consolidation results

As in all consolidation analyses in geotechnical engineering, the profile of the deposit (including thickness and extent of each material) must be determined. An idealized mound geometry for an LBC project is shown in Figure 22. The consolidation of the mound is then predicted using an appropriate finite strain consolidation model, and the results should then be plotted.

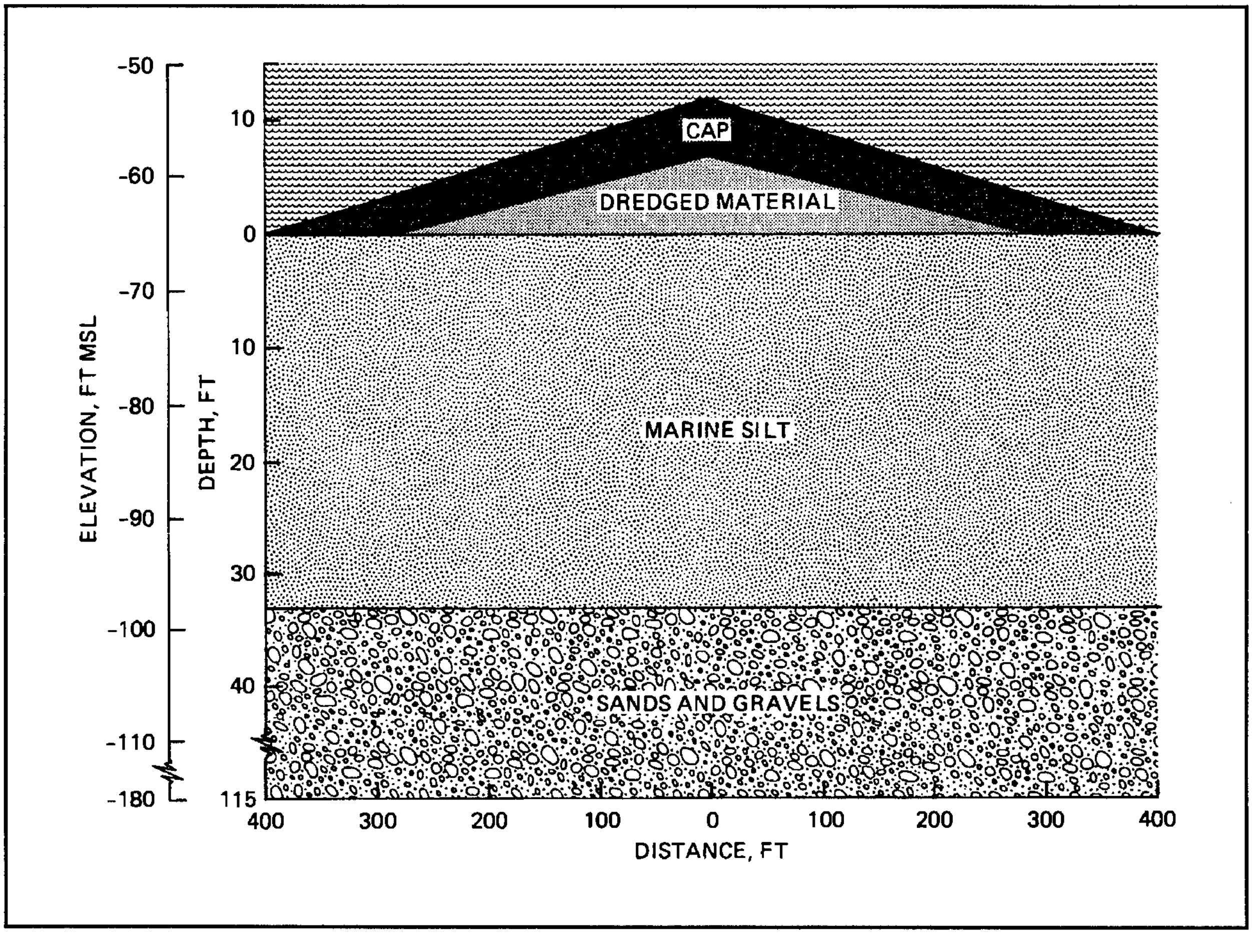


Figure 22. Idealized soil profile of mound and foundation soils

Two types of plots are often used to show the amount of consolidation that is expected to occur in a dredged material mound. The ultimate change in elevation of the mound surface is often plotted to show the change in configuration that can be expected following consolidation. Figure 23 shows the original and final mound height when consolidation only (i.e., no erosion) is considered. Secondly, a plot is usually constructed of settlement over time at a particular point or points in the mound. This plot can show the individual quantities of consolidation settlement predicted for the capping material, the contaminated dredged material, and the foundation soil; it will normally also show the total settlement expected. This type of plot is very useful for comparing predicted settlement (or surface elevation) with field-monitoring data. Figure 24 shows

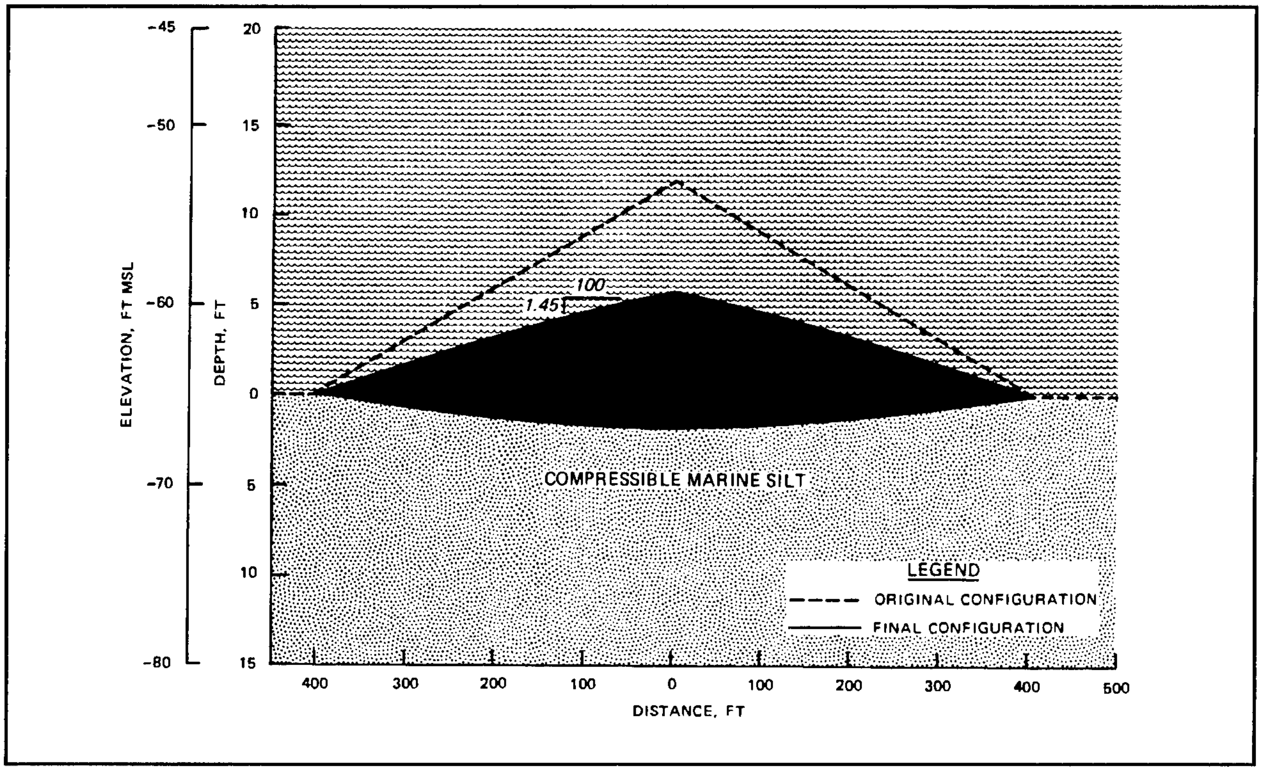


Figure 23. Predicted final mound configuration at completion of consolidation

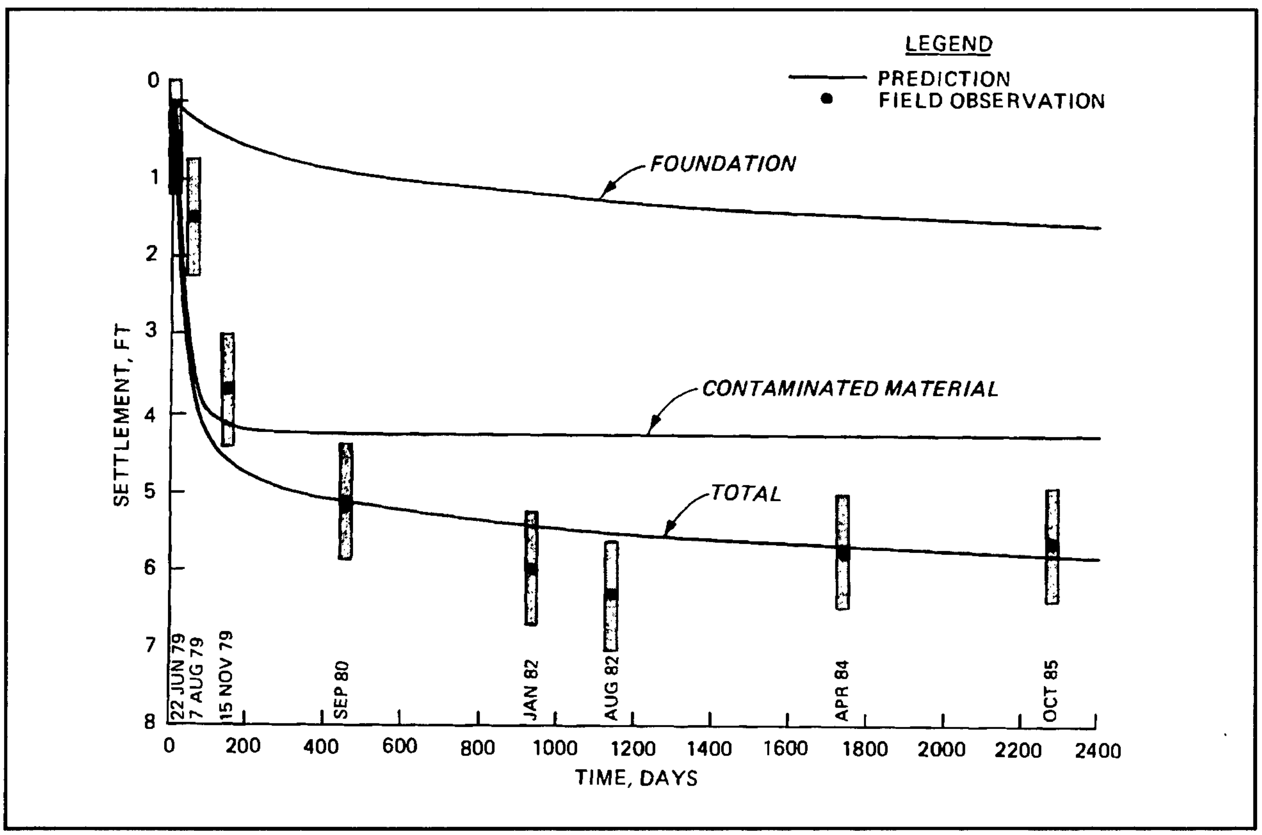


Figure 24. Time rate of consolidation at center of mound

the predicted time rate of consolidation as compared with actual field data.

Evaluation of Erosion Potential

If practical, capping should normally be conducted predominantly at sites that are classified as nondispersive, i.e., sites with relatively little potential for erosion. However, existing sites with more frequent potential for erosion can be used for capping projects after completing studies of the frequency of erosion of a specific capping material (considering grain size, mound geometry and sediment cohesion) for expected wave and current conditions (to include storms) over time predicted in the area. The results from such a study will provide data that can be used to predict the expected cumulative amount of erosion over time along with confidence intervals on the answers. The estimated erosion amounts can then be used to define the design cap thickness component for erosion protection required for a given length of time (say 20 to 100 years). Cap thickness should be monitored periodically as well as after large storm events to verify cap stability and measure cap erosion rates. In addition, minimum thicknesses for contaminant isolation should be predetermined. If monitoring indicates that cap thickness has been reduced below the minimum values, contingency plans should be enacted to place additional capping sediments.

The deposit of contaminated dredged material must also be stable against excessive erosion and resuspension of sediment before placement of the cap. The potential for resuspension and erosion depends on bottom-current velocity, potential for wave-induced currents, sediment particle size, and sediment cohesion. Site selection criteria as described above would normally result in a site with low bottom-current velocity and little potential for erosion during the window for placement of the contaminated sediments and cap. However, if the contaminated sediment is hydraulically dredged, erosion potential is greatly increased due to the high water content of the slurry (eventually this water content decreases, thus reducing erosion potential). In this case, a thorough analysis of the potential for resuspension and erosion should be performed to estimate the short- and long-term effects on resuspension potential. Conventional methods for analysis of sediment transport are available to evaluate erosion potential (Teeter 1988; Dortch et al. 1990; Resio and Hands 1994; Scheffner 1991a,b). The first level of investigation of cap stability against erosion involves examination of the normal wave and current regime to determine if these cause measurable amounts of erosion. However, sites where day-to-day waves and currents cause measurable amounts of erosion would be poor sites for capping projects.

Estimating critical conditions for initiation of motion in wave or current environment

For most sediment bed compositions, a critical stress value exists below which no or negligible sediment movement occurs. Stress is the force per unit area applied to the sediment bed surface by water movement. This critical value is usually called the critical shear stress for initiation of motion. Estimating the shear stress for given conditions is not a simple calculation and may depend on a multitude of variables. However, under many conditions, given a few basic parameters, an estimate can be made for the shear stress that can tell the engineer if sediment deposits are in the range where sediment movement may occur (i.e., above the critical value). This can be done for a wave environment or a current environment. This section contains graphs that, if a few basic parameters are known (such as median grain size, wave height, wave period, water depth, and current), a reasonable estimate of stress can be developed. The calculations for combined current/wave environments cannot be plotted easily. Under these conditions, the relationships become much more complex, and a detailed study is required to determine the bottom stresses and ultimate dispersive/nondispersive classification of the site.

The dashed lines in Figure 25 plot the critical value of the vertically averaged current velocity (u_{cr}) versus the median grain size (d_{50}) for various water depths. The expression for u_{cr}, as described by van Rijn (1993), is defined as a function of the water depth h and grain size distribution. This simplified equation, based on Shields curve for initiation of motion and assuming effective bed roughness can be estimated as $3d_{90}$ (where d_{90} is the 90th percentile grain size, i.e., 90 percent of the material is finer) and $d_{90} = 2d_{50}$ can be expressed as:

$$\bar{u}_{cr} = 0.19(d_{50})^{0.1} \log\left(\frac{12h}{3d_{90}}\right) \qquad \text{for } 0.0001 \le d_{50} \le 0.0005\, m$$

$$\bar{u}_{cr} = 8.50(d_{50})^{0.6} \log\left(\frac{12h}{3d_{90}}\right) \qquad \text{for } 0.0005 \le d_{50} \le 0.002\, m$$

As stated previously, the above equations calculate the approximate critical vertically averaged velocity value for the initiation of sediment movement. At these values, the particles will start to roll or move across the bottom in fairly regular jumps (saltation). There are also higher stress levels at which the particles will leave the turbulent bottom boundary layer and be brought into suspension. These values are called the critical velocities for initiation of suspension and are indicated by the solid lines in Figure 25. These values can be approximated, using the same assumptions as for u_{cr}, by:

$$\bar{u}_{cr,s} = 5.75\left[(s-1)gd_{50}\right]^{0.5} \left(\Theta_{cr,s}\right)^{0.5} \log\left(\frac{12h}{3d_{90}}\right)$$

where s is the sediment specific gravity; g is acceleration of gravity; and $\Theta_{cr,s}$, the critical Shields parameter for suspension, is defined by:

$$\Theta_{cr,s} = \frac{16}{D^{*2}} \frac{w_s^2}{(s-1)gd_{50}} \qquad \text{for } 1 < D^* \le 10$$

$$\Theta_{cr,s} = 0.16 \frac{w_s^2}{(s-1) g d_{50}} \qquad for\ D^* > 10$$

w_s is the sediment settling speed (which can be estimated for a given grain size from charts or by Stokes law) and the dimensionless particle parameter, D^*, is defined by:

$$D^* = \left[\frac{(s-1)g}{v^2}\right]^{1/3} d_{50}$$

The value for the kinematic viscosity, n, is approximately 1×10^{-6} m^2/s.

For determining the stability of a specific site, Figure 25 can be used to indicate potential for site erosion when a distribution of the vertically averaged velocities, bed grain-size distribution, and water depth are known. If the velocities are frequently above u_{cr}, then there is a potential for some site erosion. There is a strong likelihood for severe erosion if the velocities frequently exceed $u_{cr,s}$. It should be emphasized that if there is any question concerning site stability, i.e., Figure 25 does not clearly indicate that erosion will not occur, more detailed data collection and modeling efforts should be undertaken to determine erosion potential.

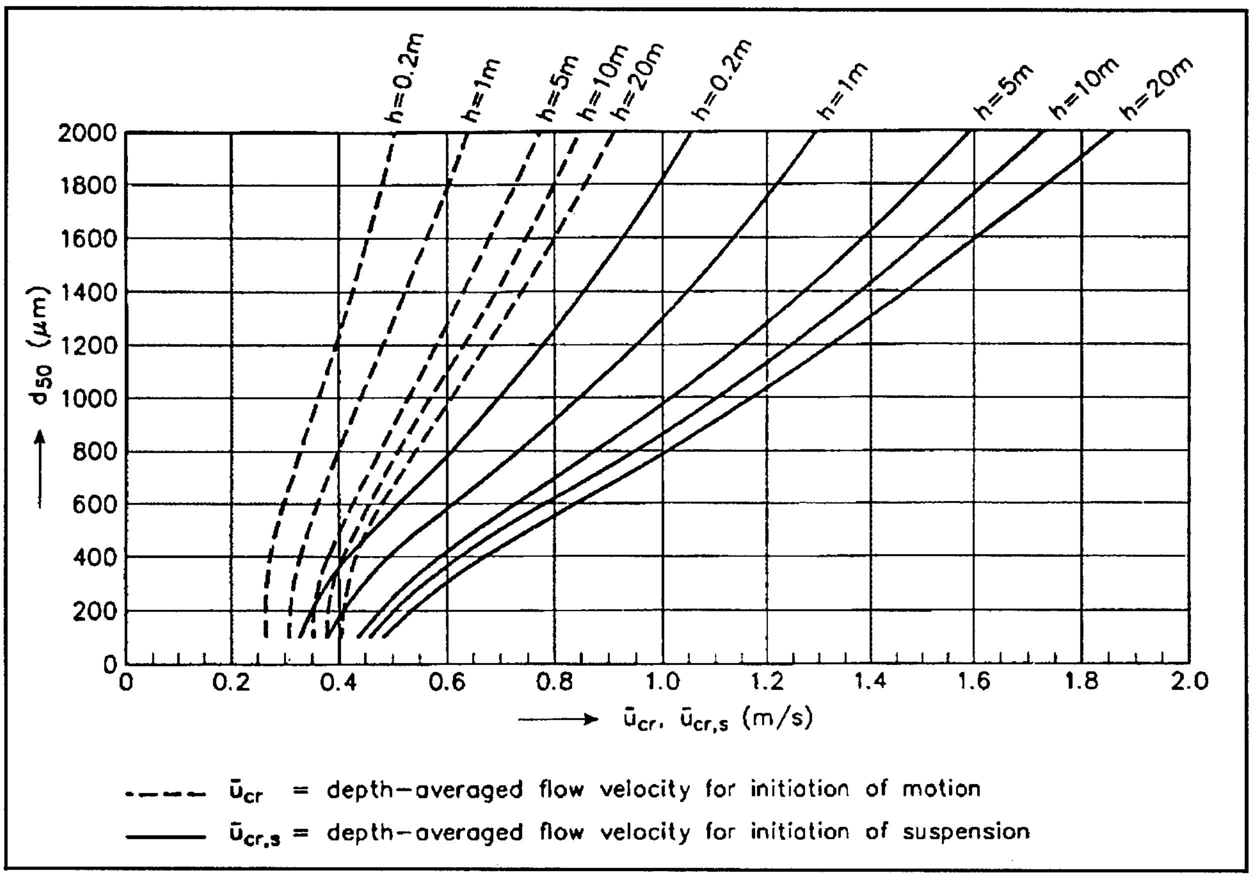


Figure 25. Critical vertically averaged velocities for a plane bed (from van Rijn 1993)

Under wave-dominated conditions, the orbital velocities produced by waves will be the primary force agitating the sediment bed surface and producing erosion. Because of the unsteady nature of the orbital velocities (compared with the relatively steady currents), a peak orbital velocity of similar magnitude to a current velocity will not result in similar shear stresses at the sediment-water interface. The current boundary layer is fully developed and much thicker than that for continually changing orbital velocities. Therefore, bottom shear stresses created by a similar magnitude orbital velocity will be much greater than that for current velocity and Figure 25 will not apply. Due to the complexity of wave/bottom stress complexities, there is no general agreement amongst researchers on a proper method for estimating bottom effects. However, it is possible, without a detailed analysis, to develop a first order magnitude estimate that will assist the engineer in determining site stability for a plane bed. The method described here was developed by van Rijn (1989), and a brief overview is presented in van Rijn (1993). Figure 26 plots wave period, T, versus the critical peak orbital velocity at the bed, $u_{\delta,cr}$. The solid lines are the experimentally determined values of the critical value for the initiation of motion. The average inaccuracy of the curves is 25 percent. The value of U_δ for conditions at a specific site can be evaluated by:

$$U_\delta = \frac{\pi H}{T \sinh(kh)}$$

where

H = significant wave height

T = wave period

k = wave number

The wave number k can be determined from the wave length L by the equation $k = 2p/L$. The wave length in turn is determined by iteration of the equation:

$$L = \frac{gT^2}{2\pi} \tanh(2\pi h/L)$$

The user can then compare the value of U_δ to the critical value, $U_{\delta,cr}$, for a known median grain size and wave period using Figure 26. If the values of U_δ is greater than $U_{\delta,cr}$, then the potential for erosion is significant. Even if the value is only slightly less than critical, given the margin of error in the estimates presented in Figure 26, the engineer should seek further detailed analysis to determine site stability. However, if the value is significantly less than critical, the site can be assumed stable.

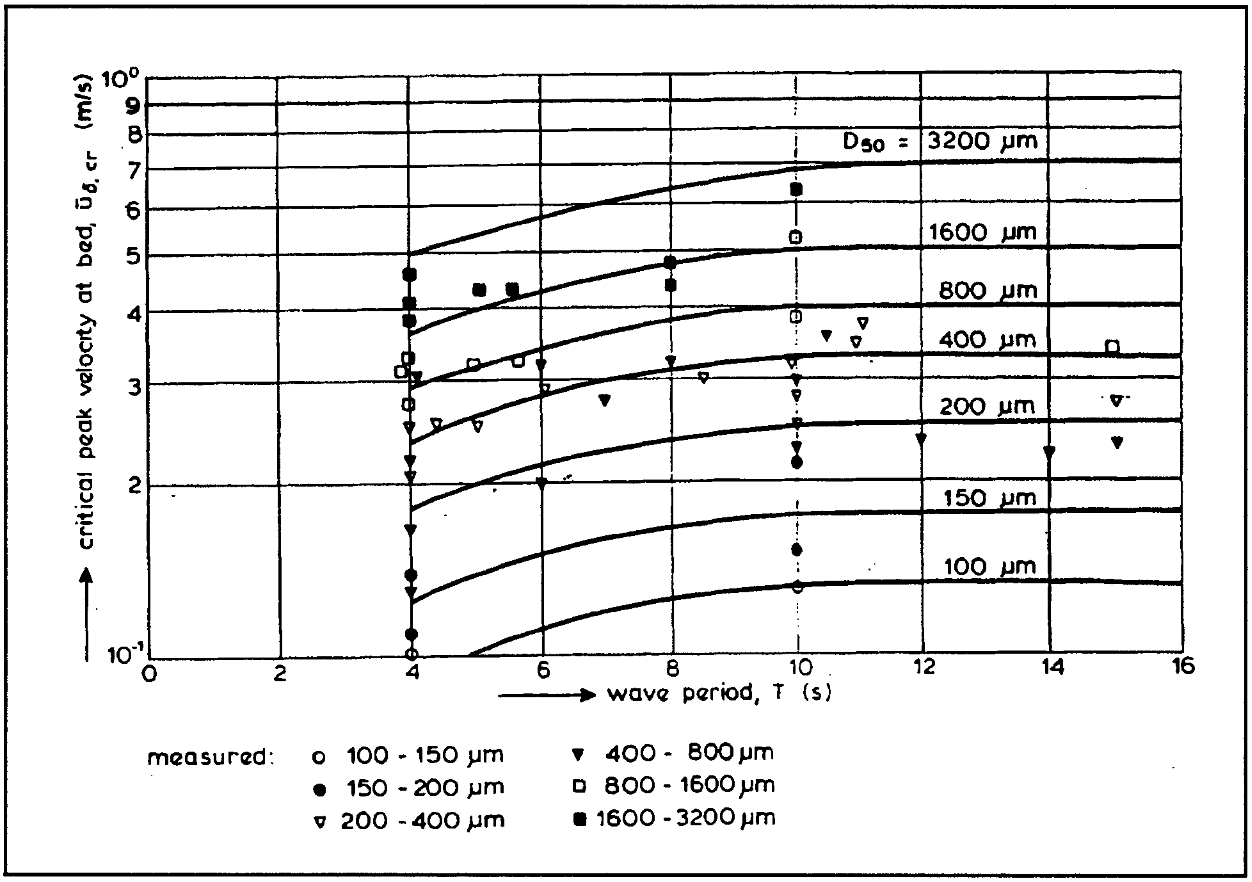


Figure 26. Initiation of motion for waves over a plane bed based on critical velocity (from van Rijn 1993)

***Example* 1, Current-dominated environment**: If the region of interest is in 10 m of water, the median grain size (d_{50}) is 500 mm, then the critical velocity for initiation of motion from Figure 25 is approximately 44 cm/s, and the critical velocity for initiation of suspension is 70 cm/s (these values can also be calculated from the equations in this section). If the vertically averaged velocity for a particular storm frequently exceeds 50 cm/s with peak velocities around 65 cm/s, then it can be assumed that the sediment bed will experience some erosion during the storm.

***Example* 2, Wave-dominated environment**: The water depth is 5 m, wave period is 7 s, wave height is 0.5 m, and d_{50} is 200 µm.

For these conditions, it is determined that L = 46 m and k = 0.14 m^{-1}. Using the supplied equation, U_δ = 0.30 m. From Figure 26, for a d_{50} of 200 mm and wave period of 7 s, $U_{\delta,cr}$ is approximately 0.24 m/s. Therefore, the bottom shear stresses generated by these conditions, represented by U_δ = 0.30 m, are greater than the critical value of 0.24 m/s, and erosion will occur under these conditions.

Predicting erosion magnitude and rate

Predicting erosion thicknesses, which consists of computing a resuspension rate (the volume or mass of material put into movement by the currents per unit of time and area), net transportation rate (how fast is the sediment mass or volume moved horizontally), net transportation gradient (is more sediment moving out of a given area than moving in), and the duration of the erosion, is a difficult task that requires a sophisticated numerical model to obtain reasonable results at an open-water site.

Erosion of fine-grained cohesive sediments is even more complicated than for cohesionless particles because of interparticle forces (i.e., cohesion), the fact that cohesive forces can vary with depth (i.e., become more erosion resistant), cohesive forces are time dependant (density and cohesion increase with time), and other factors (e.g., salinity). In contrast, cohesionless sediments are considerably simpler because the erosion resistance does not change with depth, time, or sediment chemistry. Thus, modeling erosion of cohesive sediments is much more difficult than for cohesionless sediments.

A model was developed as a part of the USACE Dredging Research Program (DRP) to evaluate the long-term fate of a mound, i.e., mound stability over periods ranging from months to years (Scheffner 1991a,b). This model is called the Long-Term FATE of dredge material (LTFATE) model (Scheffner et al. 1995). In LTFATE, hydrodynamic conditions at a site are considered using simulated databases of wave and current time series or actual wave and current data as driving forces. These boundary conditions are used to drive coupled hydrodynamic, sediment transport, and bathymetry change models that predict erosion of dredged material mounds (of specific dimensions, grain size, and water depth) over time. LTFATE uses empirically derived methods to estimate either noncohesive (Ackers and White 1973) or cohesive (Lavelle, Mofjeld, and Baker 1984) sediment resuspension, transport, and deposition. Results from this model indicate whether a given site is predominantly dispersive or nondispersive and predict potential erosion and migration of a mound for the given current and wave conditions, mound geometry, and sediment characteristics. Typical results from the model are shown in Figure 27. Appendix F describes the model in more detail by providing background, major assumptions and limitations, input requirements, and sample output.

The LTFATE model has recently been applied in hindcasting the stability of a capped mound located in the Mud Dump site, a designated ocean-disposal site in the New York Bight, during a severe storm that occurred in December 1992 (Richardson et al. 1993). In this application, wind and wave data from a directional wave buoy operated by the National Data Buoy Center of the National Weather Service, data on current and tidal fluctuation from a verified Bightwide numerical hydrodynamic model, and data on historical storm and surge effects in the area were used to develop bottom currents for a range of storm-induced conditions at the proposed capped mound location. The model was used to predict the magnitude of resulting cap material erosion. Long-term stability of the mound was also evaluated using empirical criteria from nearshore berms to determine the potential for significant movement of the overall capped feature using criteria from other monitored sites. This study provides a model for

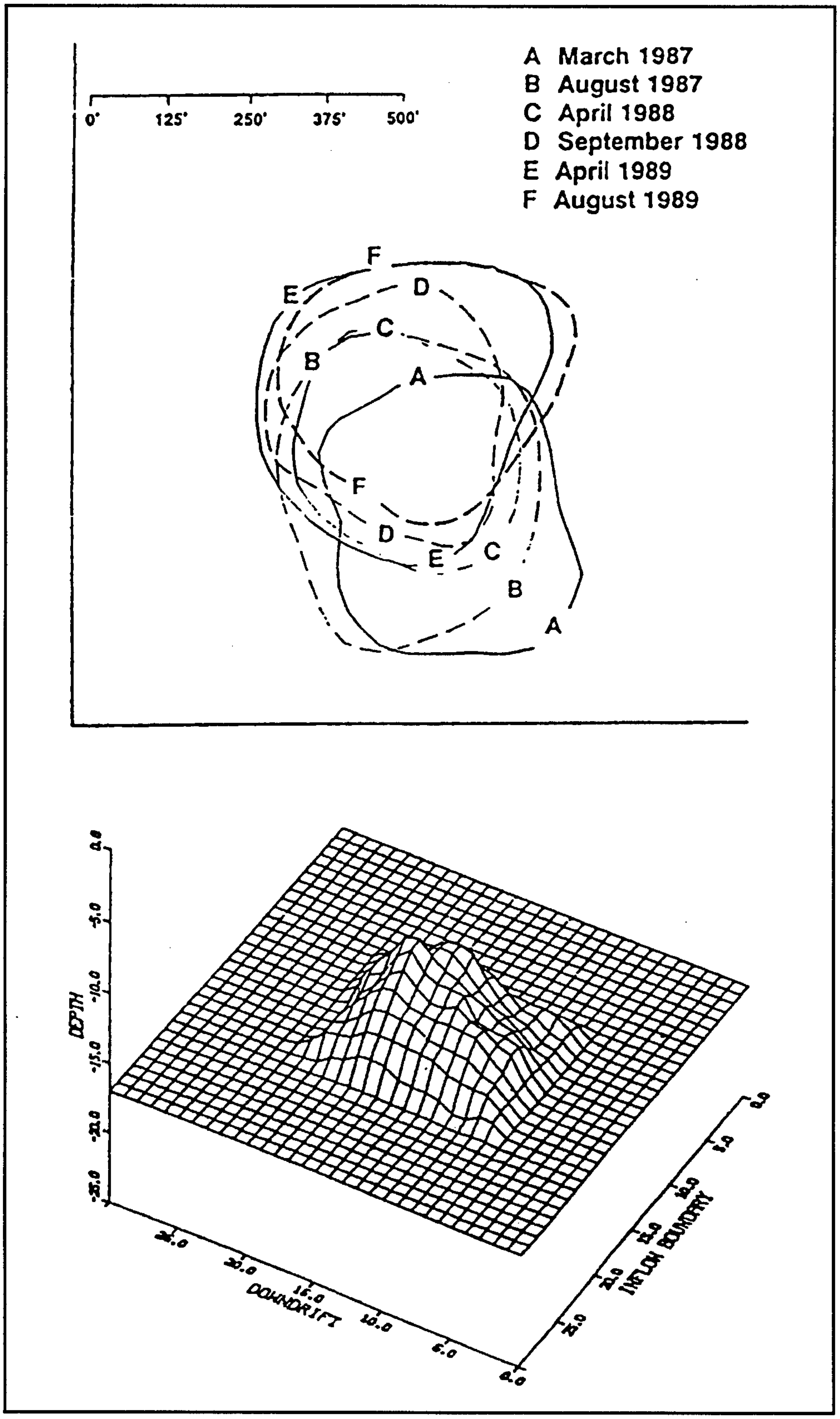


Figure 27. Typical LTFATE model results showing long-term changes to mound geometry

comprehensive evaluation of the potential mound stability from a single storm. A more comprehensive approach, however, is to evaluate the long-term physical stability by computing the frequency of occurrence of erosion over much longer periods. This procedure is described in the following section.

Frequency of erosion studies

While it is desirable to site capping projects in low-energy areas with little or no potential for erosion, these sites are not always available. At higher energy sites, the potential for erosion has to be estimated and taken into account when designing the cap. Stated simply, an additional layer is added to the overall cap thickness to account for expected erosion over a finite time period. Knowledge of the frequency of occurrence of vertical erosion (i.e., how often a given amount of vertical erosion will occur) is a critical component of a probabilistic cap design. Too thin an erosion layer may compromise the cap, potentially allowing the contaminants to be dispersed over the site and surrounding area. Conversely, too thick cap will have an unnecessarily high cost and also reduce the capacity of the site to contain additional dredged material. This section describes a rational method to determine the erosion layer thickness for sites where erosion is expected to be a problem. A detailed explanation of the frequency of erosion procedure and background information is provided in Appendix G.

The amount of expected erosion will be a function of the depth of the capped mound, mound geometry, the material used for the cap, and environmental forcing functions at the site, waves and currents, and their duration. The designer/project manager can influence the depth of the capped mound and the type of cap material. Therefore, most frequency of erosion studies of capped mounds require an investigation of a range of mound elevations (and thus water depths) and several different types of cap material, e.g., sand of various grain sizes and typical fine-grained (silt and clay) maintenance material.

Among existing procedures for computing frequency of erosion due to tropical and extratropical storms (e.g., worst case "design storms" or the joint probability method(JPM)), the empirical simulation technique (EST) is the best. EST is a statistical procedure for simulating nondeterministic multiparameter systems such as tropical and extratropical storms. The EST, which is an extension of the "bootstrap" statistical procedure (Efron 1982; Efron 1990), overcomes the JPM limitations by automatically incorporating the joint probability of the historical record. The bootstrap method on which EST is based incorporates resampling with replacement, interpolation based on a random walk nearest neighbor techniques with subsequent smoothing. More detailed descriptions of EST can be found in Scheffner, Borgman, and Mark (1993) and Borgman et al. (1992).

In EST, the various geometric and intensity parameters from storms are used to create a large artificial population (several centuries) of future storm activity (Borgman et al. 1992). The only assumption required for EST is that future storms will be statistically similar to past storms. Thus, the future storms generated during EST simulations resemble the past storms but possess sufficient variability to fill in the gaps in the historical data.

To perform the EST, historical storms impacting a site are broken down into the parameters that impact the engineering aspect of interest: storm track, maximum winds, radius to maximum, pressure deficit, etc. These variables are termed input vectors. The storm response of interest, in this case vertical erosion of the capped mound, is also calculated for each historical storm using an appropriate model (in this case LTFATE is used). The response of interest is referred to as a response vector. During EST simulations, N-repetitions (say 100 or more) of T-year responses (say 100 to 200 years) of the response vector of interest (vertical erosion for capping projects) are produced providing mean value frequency relationships with accompanying confidence limits such that probability of occurrence can be defined with error band estimates. In other words, the mean vertical erosion for a range of return intervals with confidence limits (based on the number of standard deviations) are produced by the EST procedure.

Application of the EST to a capping project involves a series of sequential steps to calculate the cap erosion thickness. A description of these specific steps are provided in Appendix G, using the Mud Dump study mentioned above as an example. The remainder of this section summarizes the required steps and concludes with specific recommendations on how to translate frequency of erosion values into a cap erosion layer thickness.

To define the required cap erosion layer thickness as a function of depth at a specific site, the following procedure was developed. It consists of a site-specific quantitative analysis approach. First, an appropriate set of storms, both tropical and extratropical for east coast sites, and tropical for Gulf coast sites, have to be selected. Next, the hydrodynamic inputs (the time series of storm surge levels and tide elevations, their resulting currents, and wave heights and periods) for the selected storms have to be developed for input to an erosion model such as the LTFATE model. These inputs are often developed using a 3-D ocean circulation model such as ADCIRC (Luettich, Westerink, and Scheffner 1992) or CH3D (Scheffner et al. 1994).

After the water level, current, and wave data for specific storms are available and in the proper format, LTFATE can be run to calculate the thickness of the layer eroded by each storm for a range of capped mound configurations (elevations and cap materials). These data are then input into the EST program, which makes 100 or more simulations of mound erosion over a long time period (100-200 years). The results can then be analyzed with standard statistical techniques to produce frequency of erosion estimates for the various mound configurations tested. Finally, the frequency of erosion estimates, including expected annual erosion and the longer return period erosion estimates, are converted into a design erosion layer thickness.

The following paragraphs discuss the results of such a study and how these can be used to compute erosion layer thickness.

Recommended procedure for computing erosion layer thickness and selecting a design cap erosion thickness

This section describes a recommended procedure for computing the erosion layer thickness for open-water capping sites. Also provided is a discussion on how the erosion thicknesses can be used to select the design erosion thickness for the cap.

One of the primary outputs of a frequency of erosion study will be a series of curves similar to the one shown in Figure 28. This figure shows the return period frequency of a given amount of vertical erosion for a year of extratropical storms acting on a mound in the Mud Dump site with a base depth of 73 ft and an 8-ft-high mound for a crest depth of 65 ft. The solid curve is the mean erosion predicted based on 100 simulations; error bars define plus or minus one standard deviation. Values from the curve can be translated into a tabular form. For northeast coast sites that experience both tropical and extratropical storms, the values from both types of storm are combined into a single return frequency table, such as the one as shown in Table 6 generated for the Mud Dump site.

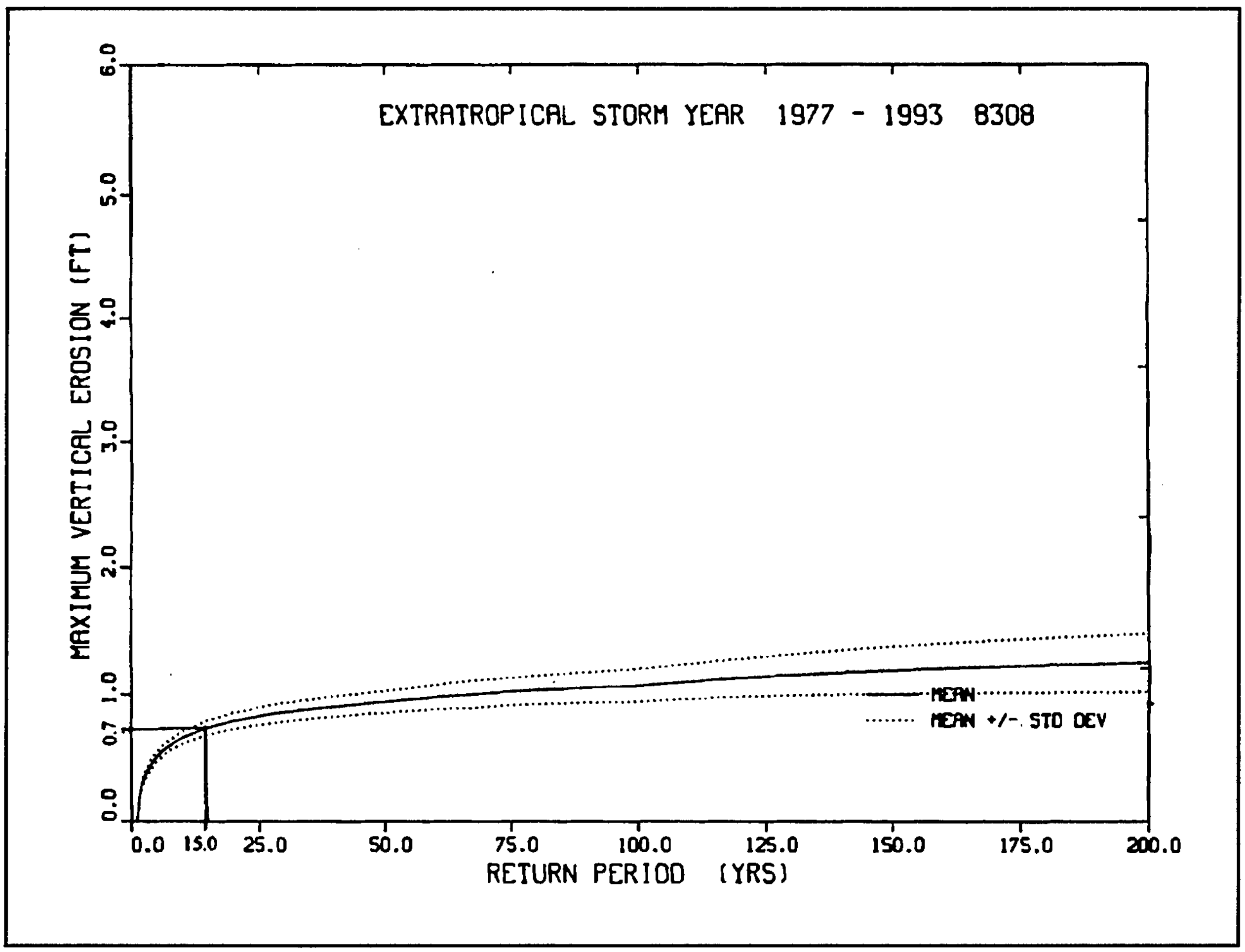


Figure 28. Frequency of vertical erosion from extratropical storms acting on a mound in Mud Dump site with a base depth of 73 ft and an 8-ft-high mound for a crest depth 65 ft

Table 6
Episodic Erosion Thickness Estimates for Mud Dump Site for 0.4-mm Sand Caps

Combined Hurrican/Northeaster Single-Year Erosion Frequency, ft				
Base Depth/ Mound Height/ Crest Depth, ft	**10 years**	**25 years**	**50 years**	**100 years**
63/13/50	2.4	3.0	3.4	3.9
63/08/55	1.6	2.1	2.3	2.6
73/13/60	1.5	1.8	2.0	2.3
73/08/65	1.0	1.3	1.5	1.7
83/13/70	0.9	1.2	1.3	1.6
83/08/75	0.7	0.8	0.9	1.1

It is very important to note that the erosion values predicted by this curve and reported in the table are the maximum erosion experienced anywhere on the mound. Qualitatively, the maximum erosion is present over a very small portion of the mound, typically one corner on the seaward side (see Figure 29). Average erosion over the entire mound is expected to be much less, perhaps two-thirds of the maximum value, though this value will be a function of mound geometry, water depth, wave climate, and cap material and grain size.

In addition to maximum erosion expected from a severe storm year, the average-year cumulative erosion should be computed. To accurately compute average cumulative erosion, a time series of mound erosion resulting from typical storms (and nonstorm conditions if they are expected to produce erosion) over periods of between 5 and 10 years should be computed. During these model runs, the initial mound geometry would be impacted by a series of storms (or day-to-day conditions if warranted), with the resulting mound geometry from the previous storm becoming the input mound geometry for the following storm. Statistics on average and maximum erosion over the mound should be computed for time periods of say 1, 2, 5, and 10 years.

Using the above information on maximum episodic erosion thickness and cumulative annual erosion, the cap designers can then choose the return period erosion that provides the desired level of comfort or degree of risk. Factors that may influence the decision include the amount of uncertainty in the erosion prediction, the relative levels of annual versus episodic erosion, the level of contamination of the sediments being capped, whether or not additional material is expected to be placed on top of the project in the next few years, the difference in thickness required between a short and long return period, nearness of valuable resources/predicted consequences of the cap breeching, relative portion of the cap required for erosion compared with chemical isolation, bioturbation and consolidation, the unit/total cost of capping, difficulty in finding capping material and

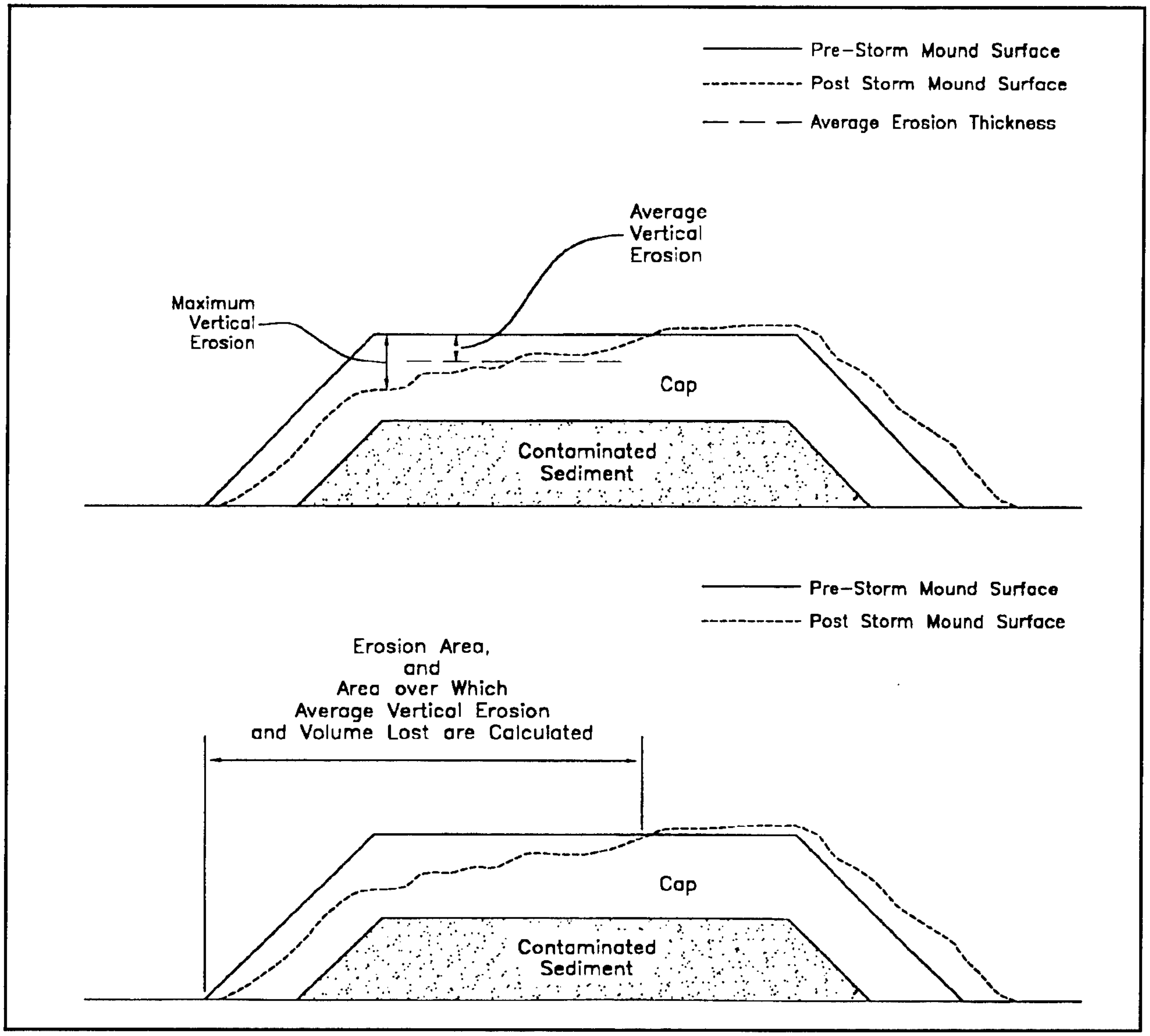


Figure 29. Idealized mound cross sections showing maximum and average vertical erosion and areas over which erosion volume is computed

gaining approval to cap, and other factors including political/social issues. Thicker erosion layers will reduce risk with a corresponding increase in cost.

The decision on the appropriate erosion layer thickness then will be site or region specific. For projects with minimally contaminated material where additional projects are expected in the next few years, a relatively short return period erosion thickness could be selected, say 10-20 years. Note that in Table 6, the erosion thickness for the 75-ft mound crest is 0.7 ft at a 10-year return period while the 100-year return period thickness in only 1.1 ft. For a mound at this depth, the designers may decide the extra protection provided by the additional 0.4 ft of cap is a good investment. However, for the 50-ft mound crest, the difference between the 10-year erosion thickness and 100-year erosion thickness is 1.5 ft (2.4 versus 3.9 ft), almost four times greater than at 75 ft. Therefore, if a short-term cap is needed for a 50-ft mound, the designers might find a 25-year erosion thickness; 3.0 ft provides a reasonable tradeoff between risk and cost.

Another critical factor in selecting a design erosion thickness may be the cost and difficulty in finding capping material. For example, assume the project is one where the desire is to place a cap that would ideally never have to be repaired, or one for which the renourishment interval would be on the order of decades because of the difficulty and cost in obtaining additional cap material. For such a project, a fairly long period erosion thickness, say 100 years, might be selected (perhaps adding some additional thickness for annual erosion if it is significant). However, if the cost of such a project becomes too high and capping sand is relatively available, then a shorter return period thickness, say 30 to 50 years (without adding annual erosion rates), might be more acceptable.

As a starting point, past practice in engineering structure design provides some guidance. Many Corps projects are designed with 50-year lives. However, because a capped project is, at least for now, assumed to require maintenance for a considerably longer time, a 100-year erosion thickness seems to be a reasonable starting point. First, because of our limited knowledge of historical storm data, it is difficult to predict with confidence storm conditions for return periods much greater than 100 to 200 years. Second, providing a cap thickness sufficient to resist storms with intervals greater than 100 to 200 years would probably be much too expensive. For projects where additional material is likely to be added in the near future, a 20-year return erosion thickness seems to be reasonable. The thickness of the erosion layer should also be capable of withstanding multiple years of annual erosion; a minimum of 10 years is suggested for caps designed for a long-term cap.

Additional cap should be placed when the average thickness of the cap has been reduced such that the design year return period erosion thickness would also remove some to all of the cap thickness that accounts for bioturbation. This is suggested because it is expected that a major storm that causes significant amounts of erosion will also remove any established biological community that is able to bioturbate a significant thickness of material (typically 10 to 20 cm). It is also assumed that the thickness of cap lost in a major storm will be repaired prior to recolonization by significant numbers of organisms that bioturbate to a substantial depth (greater than 1 year).

Potential control measures for erosion

If cap erosion is considered to be a problem, armoring with larger diameter material (coarse sand, gravel, riprap) or geotextiles may be considered as engineering approaches to overcome or protect against this problem. Procedures for design of caps composed of nonsediment components is available in the EPA guidance document for in situ capping projects (Palermo et al. 1996).

9 Monitoring Considerations for Capping

Need for Monitoring

Monitoring of capped disposal projects is required to ensure that capping acts as an effective control measure (Palermo, Fredette, and Randall 1992). Monitoring is therefore required before, during, and following placement of the contaminated and capping material to ensure that an effective cap has been constructed. (This activity also may be defined as construction monitoring.) Monitoring should also be required to ensure that the cap as constructed will be effective in isolating the contaminants and that long-term integrity of the cap is maintained (This activity also may be defined as long-term monitoring).

Since capping is a control measure for potential benthic effects, the monitoring discussed here does not focus on water column processes or the water column contaminant pathway during the placement of contaminated material prior to capping. Also, this chapter does not focus on those aspects of open-water site monitoring pertaining to site designation or on the direct physical effects of disposal. Any such monitoring would be considered in the context of the overall site selection process (Palermo 1991b).

Design of Monitoring Programs and Plans

The design of monitoring programs for any project should follow a logical sequence of steps. Several excellent publications containing general guidance for monitoring in marine environments and specific guidance on physical and biological monitoring at aquatic sites for purposes of site designation/specification and for permit compliance are available (Marine Board, National Research Council 1990; Fredette et al. 1990a; Fredette et al. 1990b; Pequegnat, Gallaway, and Wright 1990). These basic references should be consulted in developing appropriate monitoring plans for capping projects that suit the particular site and material conditions. A capping-specific monitoring plan has been developed for the DAMOS program in the New England Division (SAIC 1995a); it has been successful in evaluating capping success on over 20 capping projects to date (SAIC 1995a).

Fredette et al. (1990a) outlines five steps for developing a physical/biological monitoring program for open-water dredged material disposal. These steps as shown below should also be followed in developing a monitoring program for capping projects:

a. Designating site-specific monitoring objectives.

b. Identifying components of the monitoring plan.

c. Predicting responses and developing testable hypotheses.

d. Designating sampling design and methods (to include selection of equipment and techniques).

e. Designating management options.

Fredette et al. (1990a) recommend prospective monitoring that consists of observations or measurements that determine if site conditions conform to a predetermined standard. In addition, unacceptable adverse effects or unreasonable degradation are defined before sampling is begun. This is in contrast to retrospective programs in which the magnitudes, types, and areal extent of adverse impacts are not defined until after sampling is underway and data are interpreted. The physical and chemical thresholds that result in undesirable biological responses or effects must be determined and the potential impacts of the disposal predicted.

The monitoring program should be multitiered, as suggested by Fredette et al. (1986), Zeller and Wastler (1986), and Pearson (1987). Each tier has its own unacceptable environmental thresholds, null hypotheses, sampling design, and management options should the thresholds be exceeded. These are best determined by a multidisciplinary advisory group whose technical advice is sought in organizing and conducting the monitoring program. A sample tiered monitoring program pertaining to capping projects is outlined in Table 7. Each of the steps in developing a capping monitoring program is discussed in more detail in the following paragraphs. Note that not all the monitoring techniques would necessarily be used at every site.

Monitoring Objectives

Setting attainable and meaningful objectives is a necessary first step in the design of any monitoring program/plan. Appropriate objectives for a capping-monitoring program/plan may include the following:

a. Determine bathymetry, organisms, and sediment type at capping site.

b. Determine currents for evaluating erosion and dispersion potential.

c. Define areal extent and thickness of contaminated-material deposit to guide cap placement.

d. Define areal extent and thickness of the cap.

e. Determine that desired capping thickness is maintained.

f. Determine cap effectiveness in isolating contaminated material from benthic environment.

g. Determine extent of recolonization of biology and bioturbation potential.

Table 7
Sample Tiered Monitoring Program for a Capping Project

Monitoring Program	Monitoring Frequency	Threshold	Management (Threshold Not Exceeded)	Options (Threshold Exceeded)
Consult site designation surveys, technical advisory committee, and EIS for physical and chemical baseline conditions.				
TIER I *Bathymetry *Subbottom profiles *Side-scan sonar *Surface grab samples *Cores *Water samples	Pre, Post Placement, Annually	*Mound within 5 ft of nav. hazard. *Cap thickness decreased 0.5 ft. *Contaminant exceeds limit in sediment or water sample.	*Continued to monitor at same level. *Reduce monitoring level. *Stop monitoring.	*Go to next tier. *Stop use of site. *Increase cap thickness.
TIER II *Bathymetry *Subbottom profiles *Side-scan sonar *Sediment profile cam. *Cores *Water samples *Consolidation instru.	Quarterly to Semi-annually	*Cap thickness decreases 1 ft. *Contaminant exceeds limit in sediment or water sample.	*Continued to monitor at same level. *Reduce monitoring level.	*Go to next tier. *Replace cap material. *Increase cap thickness. *Stop use of site.
TIER III *Bathymetry *Subbottom profiles *Side-scan sonar *Sediment profile cam. *Surface grab samples *Cores *Water samples *Tissue samples	Monthly to Semi-annually	*Cap thickness decreases 1 ft. *Contaminant exceeds limit in sediment or water sample. *Contaminant exceeds limit in tissue.	*Continued to monitor at same level. *Reduce monitoring level.	*Replace cap material. *Increase cap thickness. *Stop use of site. *Change cap sediment. *Redredge and remove.

Components of the Monitoring Plan

The components of the monitoring plan must be directly tied to the objectives and should include physical, chemical, and biological components to address the processes of concern. In identification of components and processes, it should be noted that biological responses are a direct result of physical and chemical alterations due to the disposal operation. This fact provides a logical basis for establishing an appropriate tiered monitoring program that emphasizes physical monitoring in the lower tiers.

Physical processes of interest include the spreading and mounding behavior of the contaminated and capping layers during disposal operations, the potential erosion of these deposits due to currents and wave action, and the consolidation of the deposits and underlying sediment layers. Erosion and consolidation processes dictate the long-term thickness of the cap. The components of a monitoring plan needed to address these processes include periodic precision bathymetry, perhaps supplemented with SPC surveys, settlement plates, or other instrumentation.

Chemical processes of interest include potential mixing of contaminated material with the clean capping material during the construction phase, and perhaps in the long term due to bioturbation, and the potential migration of contaminants upward through the cap due to advection or diffusion. The components of the monitoring plan addressing these processes include sediment cores for chemical analysis of sediment or interstitial water to define the chemical profile of the contaminated and clean capping layers. Additional cores taken over time at the same stations would detect any upward migration of contaminants.

Biological processes of interest include type/quantity of organisms present and the potential for contaminant effects (i.e., toxicity and/or bioaccumulation) should contaminant migration occur or should the integrity of the cap be compromised. Components of monitoring that address these processes include sampling and analysis of benthic organisms that would colonize the site following completion of capping.

Developing Testable Hypotheses

Testable hypotheses must be established that are tied to critical threshold levels that, when exceeded, trigger a higher monitoring tier or implementation of a management action. Development of reasonable and testable hypotheses requires a prediction of the end result of the various processes that may occur at the site. A null hypothesis is developed (i.e., that there is no significant difference between predicted and observed conditions); if the threshold is exceeded, the null hypothesis is rejected. Tiers must be structured so that early warning of potential problems can be detected. Often physical monitoring may be the best tool in the lowest tier, but biological or chemical tools may have appropriate roles in the lowest tier as well. The key is to get relatively rapid, inexpensive, and interpretable results.

Construction Monitoring

Monitoring to ensure that placement occurs as designed may include baseline, postcontaminated material-placement, interim, and postcap material-placement surveys. Baseline surveys consist of determining the existing bathymetry of the site in order to determine changes in depth resulting from disposal. The postcontaminated material-placement monitoring determines where the contaminated sediments have been placed so that a final plan of cap-placement locations can be developed. Postcontaminated material-placement sampling is also needed as a baseline for cap-thickness determinations based on bathymetry. Interim surveys may be employed in large projects to determine where sufficient cap has been placed and where additional material should be placed. Finally, postcap material-placement monitoring is used to confirm the final cap thickness and to serve as a baseline for future monitoring efforts.

Monitoring for Long-Term Effectiveness

The principal long-term concerns for capped deposits are (a) whether the cap is remaining in place or whether erosion is occurring, and (b) whether the contaminants remaining within the contaminated layer are being transported to the sediment surface layer or to the water column. Erosion can occur either due to daily tidal currents, propeller wash, or as a result of storm-related surges or waves. Potential mechanisms for contaminant movement through the cap include pore water movement, diffusion, and biological mixing of the sediment (bioturbation).

Monitoring approaches for these concerns include sequential bathymetric surveys or diver-inspected settling plates to determine changes in deposit height, surface-sediment chemistry samples, sediment and pore water chemistry profiles from cores, sediment physical structure from cores, benthic community structure, and contaminant tissue concentrations of mound resident benthic species. These and other monitoring techniques discussed below can all be considered within the framework of a tiered monitoring plan and conducted on time intervals ranging from months to years.

After a severe storm, one with a 10- to 20-year return period, a modest monitoring program should be conducted to confirm the cap has not suffered any significant damage. Monitoring required after a severe storm should probably be limited to bathymetry, grab samples, and perhaps SPI and subbottom profiles.

Monitoring Techniques and Equipment

Selection of the types of samples or observations to be made, the equipment to be used, the number of samples or observations, etc., is highly project dependent. Fredette et al. (1990b) contains guidelines on available equipment and techniques. Monitoring programs may only consist of physical measurements that include bathymetry, cap thickness, sediment physical properties (e.g., grain-size distribution and density), wave and current conditions, etc. Depth sounders, side-scan sonar and subbottom profilers, sediment sampling and coring devices, sediment profiling cameras, and instruments for measuring engineering properties of the sediment are required to make these physical measurements.

Navigation and positioning equipment are needed to accurately locate sampling stations or survey tracks in the disposal-site area. The accuracy requirements for monitoring are similar to those for placing the contaminated material and cap. See the discussion on navigation and positioning in Chapter 5.

Precision bathymetric surveys are perhaps the most critical monitoring tool for capping projects. Such surveys allow determination of the location, size, and thickness of the contaminated material mound or deposit and cap. A series of surveys should be taken before placement of contaminated material, immediately following (and perhaps during) placement of the contaminated material, and immediately following placement of the cap. The differences in bathymetry as measured by the consecutive surveys yield the location and thickness of the deposits. Because relatively small changes in mound elevation are of prime interest, highly accurate bathymetric surveys are required. Lillycrop et al. (1991) discuss interdependence of tidal elevations or bathymetry measurements and equipment capabilities and their effect on measurements. Acoustic instruments such as depth sounders (bottom elevations accurate to ± 0.6 ft under favorable conditions), side-scan sonar (mapping of areal extent of sediment and bedforms), and subbottom profilers (measures internal mound and sea-floor structure) are used for these physical measurements. Survey track spacing can be 50 to 200 ft depending on the areal coverage of the mound.

The attainable accuracy of bathymetric surveys limits the area and thickness of the deposit that can be detected. Limits of accuracy are governed by a variety of factors, which include accuracy of positioning systems, water depth, wave climate, etc. Engineer Manual (EM) 1110-2-1003 contains detailed information on hydrographic survey equipment and techniques and should be consulted in estimating the accuracy limitations of surveys. Other monitoring tools such as side-scan sonar, settlement plates, or SPCs must be employed to detect thinner deposits of contaminated and capping material.

Most methods for monitoring ocean-bottom depths from the ocean surface (air/water interface) are not accurate to within 20 cm. Waves bobbing the ship on which measurement equipment is attached, inaccuracy in local tidal elevation, and inaccuracy in latitude/longitude location add to the natural error of the instruments in measuring the bottom depth. In addition, the sediment/water interface is not clearly defined. During relatively quiescent periods, during which most measurements must be made, there is often a nephloid layer that blurs the sediment water interface. This layer can be classified as bottom sediment with a high water content or water with a high sediment content. This layer often creates "noise" on instruments measuring the bottom depths. Therefore, in addition to monitoring the mound from above, periodically, core samples should be extracted from different locations on the sediment mound to determine the thickness of remaining cap material. These cores should be extracted from those locations on the mound from which it is determined (by experience, surface measurements, and models) that most erosion occurs.

Bathymetric monitoring of deposits to determine sediment losses needs to be coupled with an understanding of consolidation processes. Consolidation that occurs in the cap, contaminated sediment, and the original base material within 6 to 12 months of disposal can result in substantial reductions in mound height (Silva et al. 1994; Poindexter-Rollings 1990) that could mistakenly be considered as erosion. Therefore, settlement plates are very useful.

The SPC is a tool that can be used to detect thin layering within sediment profiles. The SPC is an instrument that is lowered to the bottom and is activated to obtain an image of sediment layering and benthic activity by penetrating to a depth of 15 to 20 cm. As with bathymetric surveys, the SPC approach also has limits in its ability to detect the extent and thickness of deposits. The limiting depth of penetration limits the thickness that can be detected. However, SPC can be used in conjunction with bathymetric surveys to define the full range and extent of deposit thicknesses. The SPC is extremely effective for mapping the extent of the flanks of contaminated sediment around the central portion of the mound. Knowing their extent is critical to successful capping since these flanks can account for an area several times larger than that of the central mound and can include 20 to 40 percent of the sediment mass.

Sediment samples can be taken using grab samplers or coring devices to determine both physical and chemical parameters. In general, a core is required to sample the full thickness of a cap layer and the underlying contaminated material. Conventional boring techniques, vibracore samplers, and a variety of gravity coring devices may be suitable. However, site-specific factors such as the layering of the deposit (e.g., sand cap over relatively soft material), the material properties, and the capability of a coring technique to collect samples from such deposits should be considered when selecting a coring technique.

A variety of other instruments and approaches may be considered to gain needed information regarding the physical condition and processes occurring at capping sites. These include settlement plates (which must be monitored by divers), use of remotely operated instruments, or divers with photography and video cameras to obtain data on site conditions.

Biological monitoring may include sampling of fish and benthic organisms. Fish and many shellfish are mobile; therefore, data using these organisms are more difficult to relate to cause and effect. Sampling design using such mobile species needs to carefully consider effects of scale and migration dynamics. Most often, disposal mounds or sites are inconsequential with respect to the ranges of such species, and linking any observed changes in a species to disposal activities may be exceedingly difficult.

Benthic organisms are usually sedentary and often are considered good indicators of the effects of physical and chemical alterations of the environment. Benthic sampling devices include trawls, drags, box corers, and grab samplers. Trawls and drags are qualitative samplers that collect samples at the bottom interface, and therefore are good for collecting epifauna and shallow infauna (top few centimeters). Quantitative samples are usually obtained with box corers and grab samplers. Generally these samplers collect material representing 0.02 to 0.5 m^2 of surface area and sediment depths of 5 to 100 cm.

Detection of chemical gradients or changes in the distribution of contaminants within the mound can be monitored, but requires an understanding of the baseline heterogeneity of contaminants within both the contaminated deposit and the cap. For example, the contaminant concentrations within the contaminated deposit can be expected to range from hot spots to values that are similar to or even below the concentrations within the cap. This is reflective of typical heterogeneity within the original deposit and cleaner underlying layers of the channel or harbor. Thus, while it may be possible to detect large transitions, gradients may be much more difficult to observe, particularly if surface contamination existed within the channel prior to dredging.

Sampling of tissues of marine biota that colonize the mound also needs to be carefully considered. Typically, the chemical analyses require about 15 to 30 g (wet weight) of tissue per replicate. Unless the particular region has large-bodied resident species that are easily collected, it may take a day or more of field collection per station to obtain the necessary sample requirement. Tissue sampling is also complicated by the natural variation of benthic populations in both space and time. In some years, the target species may be very abundant, while in other years the species can be rare. These factors can result in large monitoring costs or produce data that are of limited value.

Designating Management Actions

When any acceptable threshold values are exceeded, some types of management actions are required. The appropriate management actions should be determined/defined early in the disposal planning process; they should not be determined after the threshold values have been exceeded.

Management options in early tiers could include increasing the level of monitoring to the next tier, the addition of more sediment to form a thicker cap, or stopping use of the site. Management options in later tiers could include stopping use of the site, changing the cap material, or the addition of a less porous material in cases where contaminant transport due to biological or physical processes is occurring. For caps that are experiencing erosion, additional cap can also be added, although it may be advisable to choose a coarser material (coarse sand or gravel) to provide armoring. In cases where extreme problems are encountered, removal of the contaminated material and placement at another site could be considered.

10 Case Studies

Subaqueous capping of contaminated dredged material in open-water sites began in the late 1970s, and a number of capping operations under a variety of disposal conditions have been accomplished. The Corps has conducted over 20 capping projects, with the majority conducted by the USACE New England Division (NED). An overview of the field experiences related to capping of contaminated dredged material is found in T able 8. Projects have included sites in Central Long Island Sound, New York Bight area at the mouth of the Hudson River, Puget Sound, and Rotterdam Harbor, the Netherlands. Data on capping projects vary widely in their availability. The projects listed in Table 8 are not intended to be all inclusive, but are representative of a range of site and operational conditions. Brief descriptions of most of these projects and others are given in the following paragraphs.

Long Island Sound

Capping is an alternative frequently used by the NED for disposal of material dredged from numerous industrialized harbors in New England. NED has documented the operations and monitoring programs in the Central Long Island Sound (CLIS) disposal site and other sites as a part of the Disposal Area Monitoring System (DAMOS). The DAMOS program was initiated in 1977, and the experience gained from 15 years (1979-94) of DAMOS capping experience is described in a series of DAMOS technical reports, many of which describe operations involving capping. The capping experience gained by NED in the CLIS disposal area has recently been summarized in a monograph (SAIC 1995) from which some of the information presented here is taken. Other capping experience gained by NED in the New London disposal site can be found in DAMOS reports and SAIC reports.

Over 15 years of disposal site monitoring of capped mounds in New England have provided an important data set of sufficient duration to allow evaluation of the long-term effects of capping contaminated dredged material. The data set includes a broad spectrum of characteristics including physical, chemical, and biological components. Future capping projects can benefit from the lessons learned in these pioneering projects.

Table 8
Summary of Selected Capping Projects

Project		Contaminated Material			Capping Material				
Location (Date)	**Site Name and Characteristics**	**Volume $yd^3 \times 10^3$**	**Dredging Material**	**Placement Method**	**Volume $yd^3 \times 10^3$**	**Cap Thickness ft**	**Placement Method**	**Positioning Method**	**Literature Source**
Duwamish Waterway Seattle (1984)	Existing subaqueous depression 70 ft deep	1.1	Clamshell	Scow (sand)	3.6	1-3	Sprinkling from scow	Surveying instruments	Truitt 1986b Sumeri 1984
Rotterdam Harbor Netherlands (1981-1983)	Phase I Botlek Harbor excav to 98 ft deep	1,200	Trailing suction hopper	Pump-out submerged diffuser	— (clay)	2-3	Scow, then leveled over site	Surveying instruments	d'Angremond, de Jong, and de Waard 1986
	Phase II 1st Petro. Harbor excav to 80 ft deep	620	Matchbox suction	Pipeline submerged diffuser	— (clay	2-3	Scow, then leveled over site	Automated dredge/suction head positioning equipment	d'Angremond, de Jong, and de Waard 1986
Hiroshima Bay, Japan (1979-1980)	Contaminated bottom sediment overlaid in situ with capping material 70 ft deep	N/A	N/A	N/A	— (sand with shell)	1.6	Conveyor to gravity-fed submerged tremie suction pump-out thru submerged spreader bar	Surveyed grid and winch/ anchor wires	Kikegawa 1983 Togashi 1983
New York Bight (1980)	Generally flat bottom 80-90 ft deep	860 (mounded to 6 ft thick)	Clamshell	Scows	1,800 (majority fine sand)	avg: 3-4 max: 5-9	Scow, hopper dredge	Buoy, real-time navigation electronics	Freeland 1983, Mansky 1984, O'Connor and O'Connor 1983, Suszkowski 1983
Central Long Island Sound Disposal Area (CLIS) (1979)	Stamford-New Haven North, flat bottom 65 ft deep	34 (mounded to 3-6 ft thick)	Clamshell	Scows	65.4 (sand)	7-10	Hopper dredge	Buoy, LORAN-C coupled positioning system	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1979)	Stamford-New Haven South, flat bottom 70 ft deep	50 (mounded to 4-6 ft thick	Clamshell	Scows	100 (cohesive)	13	Scow	Buoy, LORAN-C coupled positioning system	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983

(Continued)

Table 8 (Concluded)

Project		Contaminated Material			Capping Material				
Location (Date)	**Site Name and Characteristics**	**Volume $yd^3 \times 10^3$**	**Dredging Material**	**Placement Method**	**Volume $yd^3 \times 10^3$**	**Cap Thickness ft**	**Placement Method**	**Positioning Method**	**Literature Source**
CLIS (1981)	Norwalk, generally flat bottom 65 ft deep	92 (multiple mounds 8-12 ft thick)	Clamshell	Scows	370 (silt and sand)	6-7	Scow	Buoy	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1982-1983)	Mill-Quinnipiac flat bottom 65 ft deep	40	Clamshell	Scows	1,300 (silt)	Multiple broad area placement estimated final avg 6-10	Scow	Buoy	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1983)	Cap Site No. 1 generally flat 60 ft depth	33 (mounded 3 ft thick)	Clamshell	Scows	78 (silt)	Incomplete coverage	Scows	Buoy	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1983)	Cap Site No. 2 generally flat 56 ft deep	40 (low mound 2 ft thick)	Clamshell	Scows	40 (sand)	Irregular maximum 4.5	Scows	Buoy, LORAN-C	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1989-1990)	S-90-1 Harbor Village/Branford River generally flat 60 ft deep	37.6			102.7	Incomplete coverage; several distinct capped mounds 0.6 to 2.0 ft thick	Scows	Buoy	SAIC 1995b
CLIS (1993-1994)	CLIS-NHAV 93 New Haven Harbor generally flat 60 ft deep	561.5	Clamshell		665.2		Scows	Taut-wire buoy	NED files
New London Disposal Site (1988-1989)	Generally flat 54 ft deep	17.4 (2.3 ft thick)		Scows	77.8-scow 28.3—hydro surveys	0.3 to 2.6 ft thick			SAIC 1990
Portland Disposal Site (1991-1992)		17.4			70.3				SAIC 1996

Four LBC projects are the focus of the SAIC (1995a) report, and they all were conducted in the CLIS disposal site. The four NED projects (Stamford-New Haven, Mill-Quinnipiac River, Norwalk, and Cap Sites 1 and 2) are located within the boundaries of the CLIS disposal site, which is an area of 2 nm^2 located approximately 6.2-miles south-southeast of New Haven, CT, in water depths between 56 and 82 ft (Figure 30). Baseline data sets had previously been collected and were available for use in the capping projects as described in SAIC (1995a). Two other recent capping projects not discussed in SAIC (1995a), Harbor Village-Branford River (CS 90-1) and New Haven (CLIS-NHAV 93), have also been conducted in CLIS.

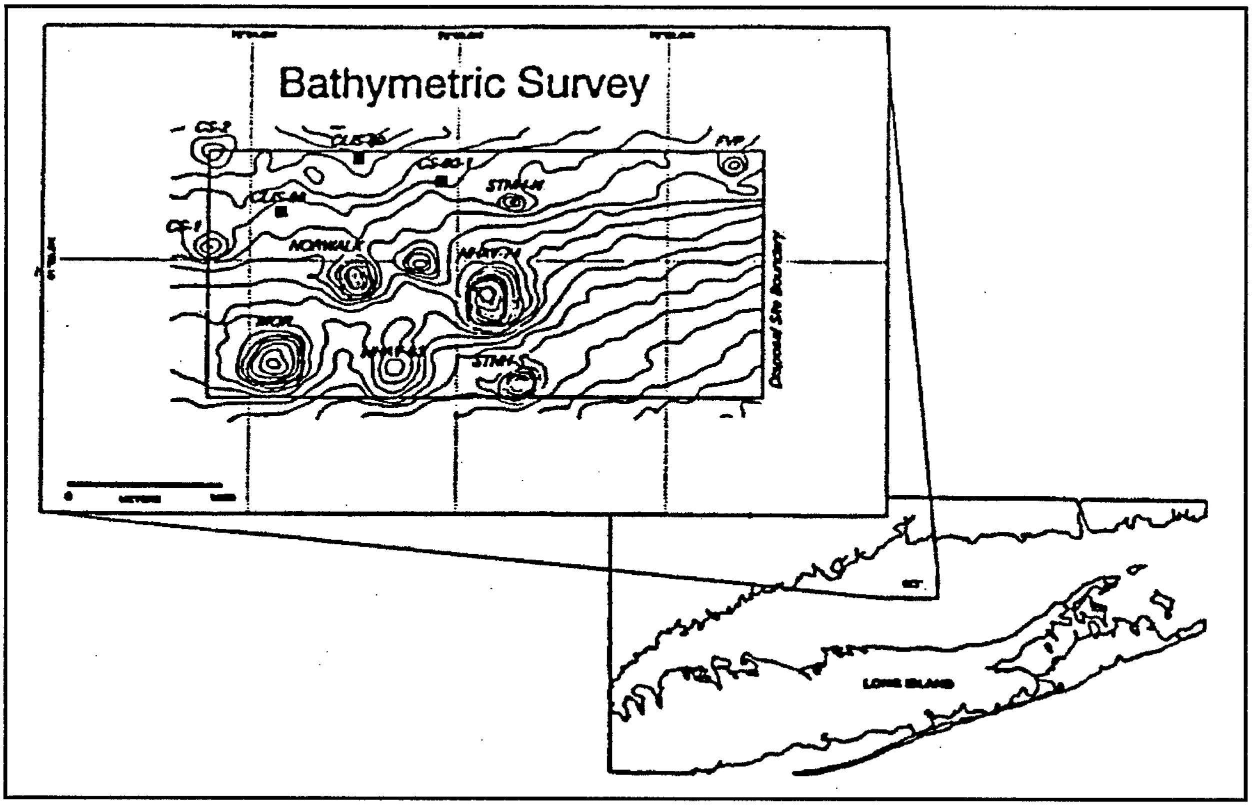


Figure 30. Central Long Island Sound disposal site (SAIC 1995a)

The Stamford-New Haven project was the first planned capping project at a subaqueous site in United States coastal waters. This project involved disposal of contaminated material from Stamford Harbor followed by capping with slightly less contaminated material from New Haven Harbor at two sites within CLIS. The success of the 1979 Stamford-New Haven project led to increased use of capping in New England under the DAMOS program.

The Stamford-New Haven North and South (STNH-N and STNH-S) and the experimental Cap Site 2 (CS-2) were the most successful of the early capped mounds. Bathymetry and SPC data showed that the contaminated material was thickly covered with capping material from the center to the outside radii. Point dumping of mound material and subsequent placement of the cap material over the mound accomplished with the aid of a taut-wired buoy and accurate navigational controls proved to be successful. The stability of these mounds has been tested by 11 years of monitoring and the passage of Hurricane David in 1979, although the hurricane's passage was coincident with the predicted exponential compaction phase of the mound, and Hurricane Gloria (Fredette et al. 1989). It is desirable for the mound/cap formation to occur well before any storm windows in order that natural settlement and compaction has time to occur. All three mounds showed normal biological recolonization rates in subsequent monitoring. Sediment chemistry data show the surface sediment remained at or below background concentrations of the contaminants measured. Coring data show a clear visual and chemical boundary in many of the cores.

The historical record of the successful capping of the STNH mounds and CS-2 provided comparative insight as to why other capping projects were not as successful. For example, accurate placement of dredged sediments is less reliable without the use of both a buoy and an accurate navigation system, and their lack of use was attributed to the offset of the cap and mound at CS-1. The Mill-Quinnipiac River mound (MQR) demonstrated the importance of controlling operational factors and maintaining vigilant monitoring. Biological monitoring at the MQR showed subnormal recolonization rates relative to the other CLIS mounds. The disposal operations that included the Mill-Quinnipiac River and Black Rock and New Haven harbors were not conducted as distinct mound and cap depositional phases. The overlapping cap/mound deposition may have affected the recolonization rate at MQR. Similarly, the Norwalk mound was not formed in distinct cap and mound operations. The contaminant concentrations for both the mound and cap at Norwalk were well below those of Black Rock and MQR, and there was no evidence of adverse effects due to disposal operations at Norwalk in subsequent monitoring. Sediment chemistry results from MQR show that the surface chemistry of the mound was not similar to Black Rock sediments; instead, concentrations were at the high end of the range of most constituents analyzed in New Haven sediments. However, these monitoring results have allowed NED to detect and take corrective management actions.

During a 1993 NED capping project, maintenance sediments from New Haven Harbor and private terminals were placed in the CLIS. A total of approximately 500,000 yd^3 of contaminated material was dredged from New Haven Harbor and private terminals followed by capping with about 660,000 yd^3 of cap materials. Placement of the contaminated sediments was controlled with a taut-wire buoy, while a total of 18 separate placement points (using LORAN-C) were specified for the cap placement. Throughout the cap placement process, continuous monitoring allowed for adjustment of disposal points to optimize cap coverage and avoid point dumping.

The unique aspect of this project was that the mounds created from five previously placed projects were used to make a bowl in which to place the 500,000 yd^3 of New Haven sediments (Fredette 1994). At the center of the bowl, the depth was 62 ft, while the surrounding depths were generally 0.6 to 10 ft shallower. Surveys showed that the planned depression was successful in reducing the spread of the contaminated sediments and thereby significantly reduced the volume of capping sediments required.

The CLIS experience has provided insight on the procedures that historically are recommended for a successful capping project. In the preproject planning, it is recommended to (a) completely characterize the sediments to be disposed including sediment chemistry, bioassay, or bioaccumulation data and classify sediments using most recent information; (b) estimate volumes of material to be disposed; (c) conduct site surveys and choose a disposal area that is not vulnerable to natural or anthropogenic erosion; (d) schedule dredging and disposal operations ideally to complete mound and cap well before a storm season to allow for consolidation and surface stabilization; and (e) dispose the cap materials as soon as possible after contaminated material. For the disposal operations, it is recommended to (a) employ both accurate navigational techniques and a taut-wired buoy to locate the designated disposal mound; (b) point dump mound materials by directing the barge to unload as near to the buoy as possible; (c) dispose approximately one-third of the cap sediments along the radius of the contaminated mound; (d) maintain the preproject plan for mound deposition followed by cap deposition; and (e) keep good records of all disposal operations.

New York Bight

Experimental Mud Dump (EMD) mound

An evaluation of the 1980 LBC project at the Experimental Mud Dump (EMD) site at the New York Bight apex (Figure 31) was reported by O'Connor and O'Connor (1983), and excerpts from their report are used to summarize this capping project. Contaminated dredged material from the Hudson Estuary, Newark Bay, and contiguous waters were capped initially with fine sediments from the Bronx River and Westchester Creek and followed with sand from the Ambrose Channel. The resulting cap was a 1-m-thick layer of sand overlaying contaminated sediment. Biological, chemical, and physical investigations were completed to evaluate the ability of the cap to remain intact and reduce the loss of organic and inorganic toxicants from the contaminated material to the surrounding water.

Results showed the cap was successfully placed at the experimental dump site, and it remained intact after 16 months. Erosion of the cap was minor, and predictions of cap life were in excess of 20 years under normal environmental conditions. However, it was predicted that major storm events were capable of causing cap erosion and exposing the contaminated material. The contaminated material volume decreased by 4 percent over the 16-month study due partly to consolidation and partly to losses during the disposal operation. Contaminant levels in the sand cap as measured by chemical analysis were shown to be lower than those in contaminated sediments. Bioaccumulation investigations indicated that contaminant uptake was less than at uncapped dredged material sites. Therefore, it was concluded that the New York Bight EMD capping project was successful

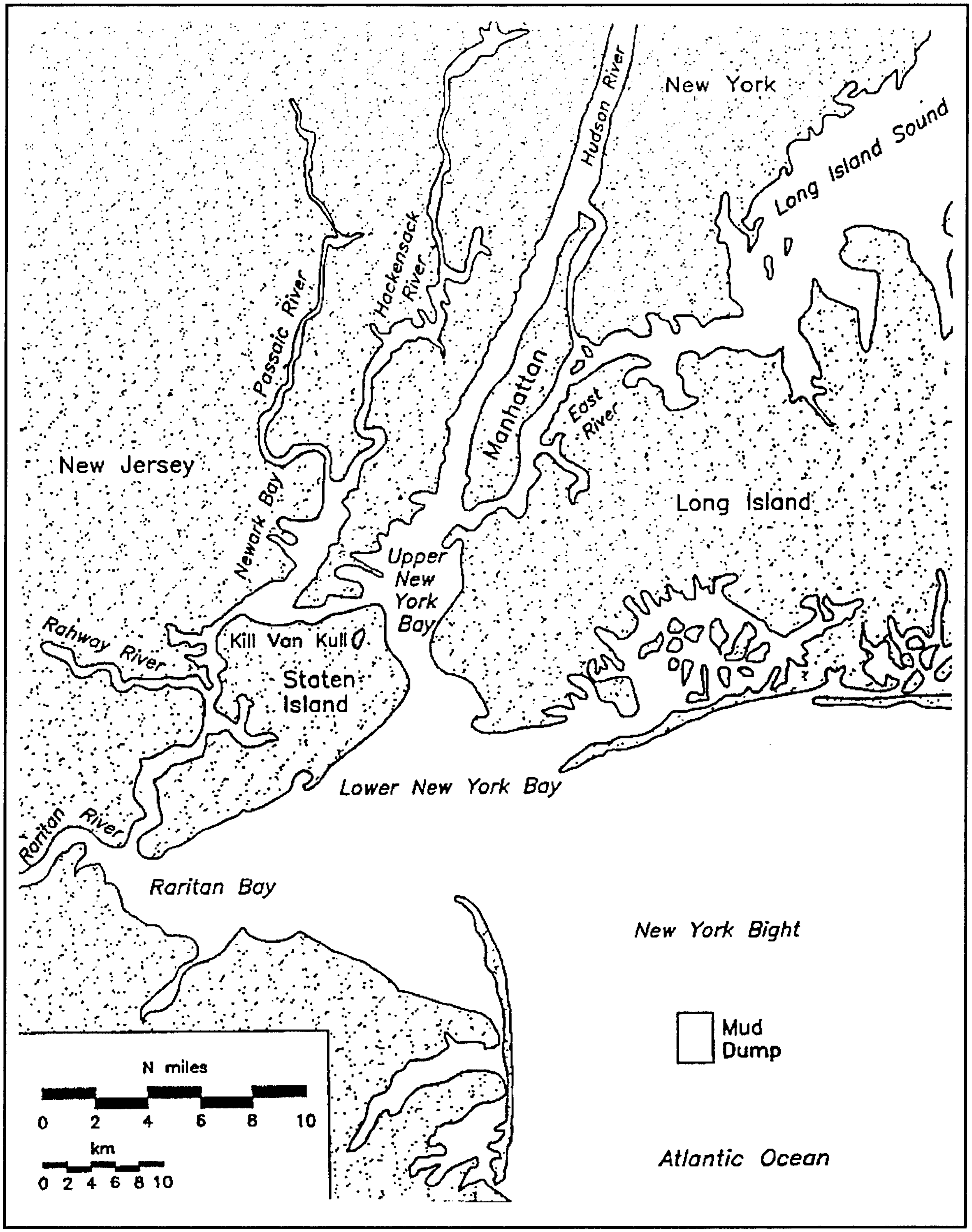


Figure 31. Mud Dump site in New York Bight (O'Connor and O'Connor 1983)

and capping can serve as an alternative to the control of contaminants in dredged material. The thickness and stability of the cap reduced the losses of contaminants to the surrounding water. It was recommended that capping be integrated with routine disposal operations to efficiently cover and isolate contaminated material at designated disposal sites.

In 1986 a detailed survey of the EMD mound was conducted to evaluate long-term stability of the mound (Parker and Valente 1988). Results of the survey, which included precision bathymetry, subbottom profiling, and SPI imagery, indicated the sand cap has not experienced significant erosion.

Port Newark/Elizabeth project

In June and early July 1993, 450,000 m^3 of maintenance sediments contaminated with low levels of dioxin from the Port Newark/Elizabeth complex (part of the larger Port of New York-New Jersey), and last dredged in 1990, were dredged and placed in the Mud Dump site (MDS) (Figure 31). The maintenance material was subsequently capped (July 1993-February 1994) with 1,900,000 m^3 of sand from Ambrose Channel. This project was preceded by several years of controversy due to the dioxin contamination (May, Pabst, and McDowell 1994; McDowell, May, and Pabst 1994; Greges 1994). Concerns about cap stability were based on erosion within the MDS that occurred after a severe northeaster in December 1992 (McDowell, May, and Pabst 1994). Erosion thicknesses greater than 1 m occurred from portions of the flanks of recently placed fine-grained maintenance material. These concerns led to a study (Richardson et al. 1993) that concluded that a mound with a 0.4-mm sand cap with an upper crest limit at a depth of 23 m (75 ft) should be stable (i.e., experience minimal erosion) during a storm comparable with the December 1992 storm.

The upper cap elevation limit of 23 m combined with the large volume of material and limited space available resulted in the design of a triangular-shaped mound as shown in Figure 32. Water depths at the site of the planned disposal ranged from 24 to 25.3 m. A design requirement to provide a 1-m cap over the mound restricted the planned elevation of the contaminated mounds to approximately 1.5 m.

Readily available geotechnical data on the contaminated sediments were limited to percent sand, silt, clay, and percent moisture (average values were 6, 58, 35, and 52 percent, respectively).

The contaminated material was removed using mechanical dredges; no overflow was allowed. Dredged material was placed in bottom-dump scows ranging in capacity from 1,900 to 4,600 m^3 and transported to the MDS. A total of 149 loads were placed over a 5-week period. The permit required the barge operators to place material within the 150-m-wide by 350- to 450-m-long disposal lanes on a rotating basis (Figure 32). To assist the contractor in siting the placements, the apex's of the triangle had taut-moored buoys. To reduce the chance of placing material outside the lanes, the contractor was directed to dispose of all material within 60 m of an imaginary line connecting the apex buoys. Calibrated LORAN-C positions for the tugs with offsets to correct for the location of the center of

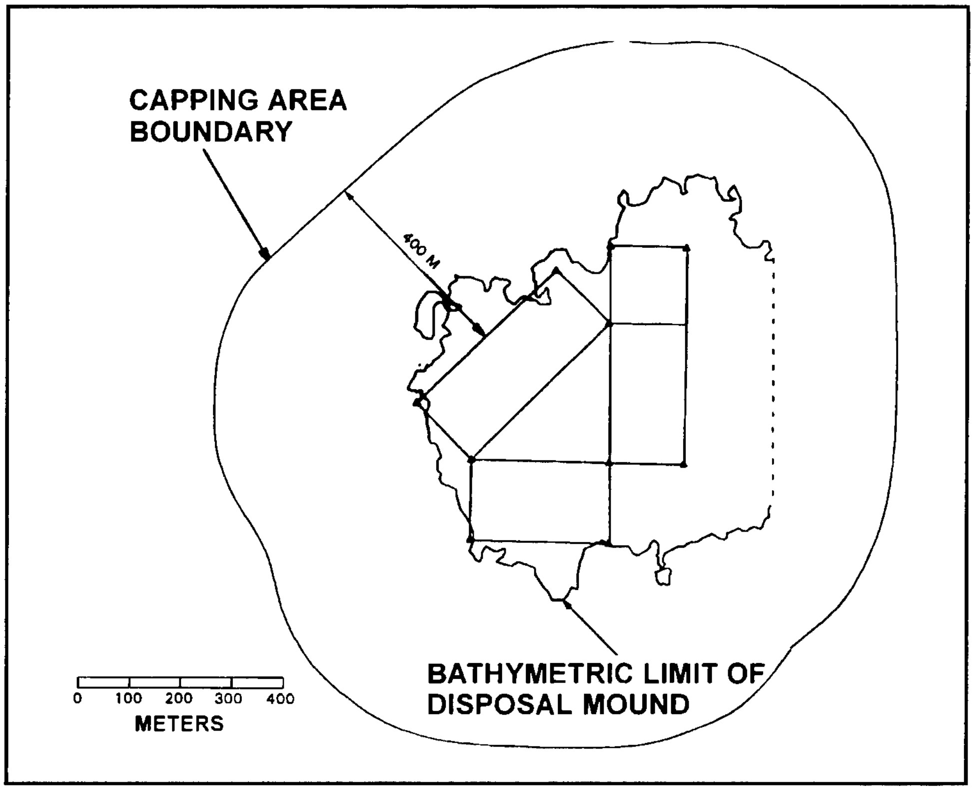


Figure 32. Port Newark/Elizabeth mound limits

the barges were recorded. Barge speed during placement was 0.5 to 1.5 m/sec. To help prevent mounding at the point of release, the barge operators were directed to crack the hull part way resulting in a disposal time of 30 sec to 1 min, and were also directed to enter the disposal lanes from opposite ends on alternate placements.

Apex buoys were installed using calibrated LORAN-C so they could be quickly reset. LORAN-C was calibrated with short-range microwave readings at known points within the harbors.

A bathymetric survey conducted during mound construction indicated the contaminated material mound was exceeding the desired 1.5-m height limitation in some locations. This combined with the Port's request to increase the amount of material dredged altered the disposal lane pattern to include additional placement in the center of the triangle and the addition of a 150- by 150-m square area at the north end of lane AB (Figure 32).

The final postcontaminated mound bathymetry survey showed that a roughly triangular mound had been formed as designed. As might be expected, individual mound peaks were evident (generally located at the ends of the lanes), which projected above the average mound thickness over the area of about 1.3 m. The peaks ranged in elevation from 1.5 to 2.4 m. Average side slopes (from the edge of the mound crest down to the 0.2-m contour) on the outer sides of the mounds were about 1:45.

The final overall dimensions of the contaminated sediment mound, as defined by the 0.3-m contour, were approximately 630 m in the north/south direction and 645 m in the east/west direction. If the 0.15-m contour is defined as the edge of the main mound, then the mound dimensions increase to approximately 745 m in each direction as shown in Figure 32. SPI surveys of the contaminated sediment apron showed the apron extended out approximately 400 m in each direction beyond the outer edge of the disposal lanes, creating a roughly circular area to be capped with an average diameter of 1,370 m (4,500 ft) (Figure 32).

Based on nine SPC transects with three to six stations per transect that contacted the apron, the average thickness was about 3 to 5 cm. On some transects, the thickness decreased regularly out from the mound, while on others the variation was more random. The native bottom was visually distinct, allowing a visual resolution of a minimum thickness of contaminated sediments of 1 to 2 cm. Thus, the edge of the apron was defined as areas with less than 1- to 2-cm thickness of dredged material.

Prior to the start of the capping operation, New York District and EPA Region II staff decided to cap the contaminated mound including the apron with 1 m of sand. This required what was initially estimated as 1,500,000 m^3 of sand to cap the area shown in Figure 32. On 11 July 1994, hopper dredges began placing cap material, 0.4 mm sand from Ambrose Channel, over the contaminated sediments. At least two intermediate surveys and additional capping were required before capping was completed in February 1994, when an estimated total of 1,870,000 m^3 of sand had been placed covering the entire contaminated footprint with close to a meter or more of sand. The additional 370,000 m^3 (480,000 yd^3) over the original estimate (a 25-percent increase) was due to the requirement to provide a 1-m cap everywhere as opposed to an average of 1 m. Capping the contaminated main mound as defined by the 0.15-m contour with 1 m of sand would have required an estimated volume of approximately 450,000 m^3. If instead of the 1-m cap placed over the apron, a 0.30-m cap had been placed over the apron, it would have required an estimated 308,000 m^3, for a total cap volume of 758,000 m^3. Increasing that total by 25 percent to provide a minimum 1-m cap over the main mound and a 30-cm cap over the apron would have brought the total to 940,000 m^3, or approximately half the amount actually placed.

Due to concerns about the possible adverse effects of contaminated sediment resuspension during the cap placement, EPA Region II required that the initial 15 cm of cap placed impact the bottom with as little downward velocity as possible (i.e., sprinkled at the individual particle settling velocity). This required modification of previous capping procedures routinely used where barge or hopper dredges perform conventional bottom dumping operations. Randall, Clausner, and Johnson (1994) discuss modifications made to the STFATE model (and now incorporated into the MDFATE model), based on experiments using planar laser-induced fluorescence (Roberts, Ferrier, and Johnson 1994), used to model cap placement.

The capping procedure consisted of using the spit-hull hopper dredges Dodge Island and Manhattan Island and the hopper barge Long Island discharging over predetermined lanes to cover the contaminated mound. The split-hull dredges "sprinkled" their average 2,000-m^3 loads over a period of 25 to 30 min while moving at an average speed of 3.0 to 3.7 km/hr with the hull cracked open 0.3 m. The Long Island pumped out its average 9,200-m^3 load through over-the-side pipes with the slurry directed forward over a period of 2 to 3 hr while moving at 1.9 to 5.6 km/hr.

To uniformly place the material, the dredges followed a series of lanes 30 m wide that covered the contaminated sediment mound and apron. Turning requirements typically caused the hopper barge to move over four lanes after reaching the end of a lane. A series of straight-lane segments around the perimeter were also used to cover the outer edges of the project. Disposal-lane orientation varied over the duration of the project. Initially, the lanes started north-south; at later stages they were a series of straight sections around the roughly octagon-shaped perimeter of the project (Figure 33). Microwave positioning (with three shore stations) with an estimated accuracy of 3 m or better was used for navigation and positioning of the hopper dredges.

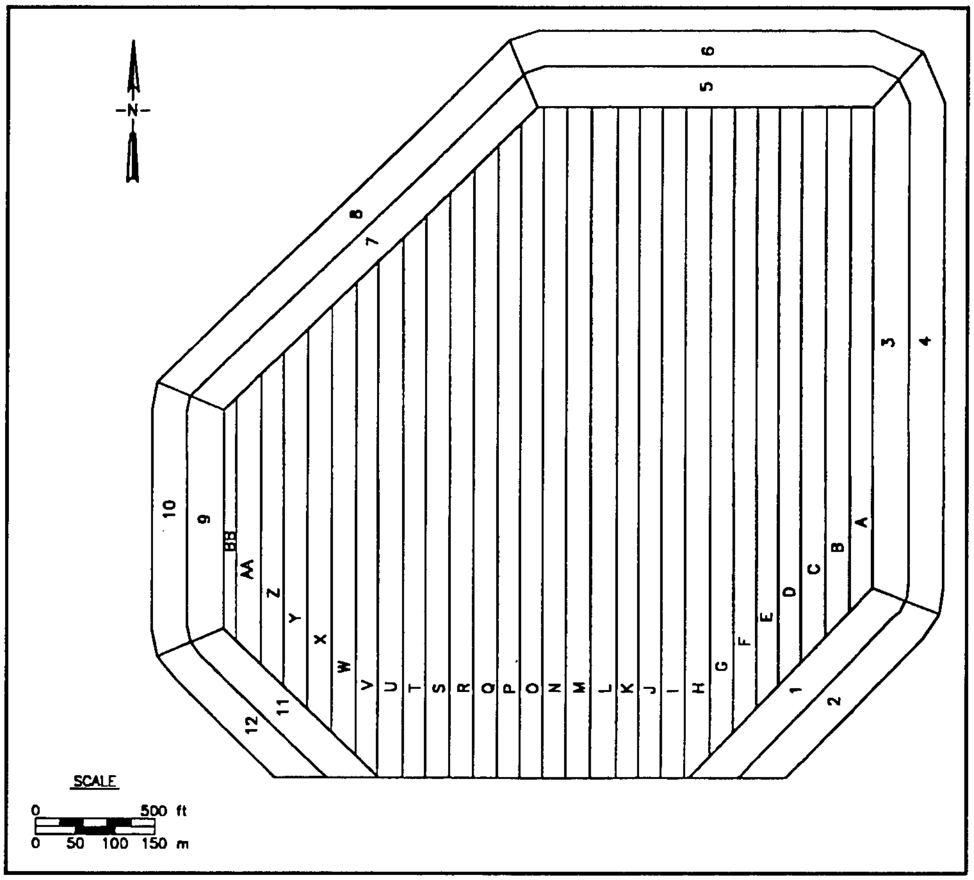


Figure 33. Disposal lanes used for placing cap material in Port Newark/ Elizabeth project

Initial cap placement involved sailing long straight lines, 600 to 900 m long (with a turn at the end of each line). Cleanup operations, i.e., filling in small areas that have less than the required thickness, generally involved areas only about 100 m across. Placing sand in these small areas was much less efficient due to two factors. For the Long Island, maneuvering is very difficult, with 20 to 25 min required to turn the vessel around and place it on an exact location at a specific heading. For the split-hull hopper dredges, problems associated with cleanup were due to the fact that once the hull is split, disposal of material continues until the hopper is empty, i.e., the spilt hull cannot be closed until the hopper is empty. Thus during cleanup, considerable amounts of sand end up being placed on areas adjacent to the cleanup locations that already have sufficient thickness.

After completing the project, the hopper dredges were found to have problems with sealing of the hoppers, possibly as a result of structural deformations due to long hours of sailing with the hull cracked.

Duwamish River Demonstration

The first CAD project in Puget Sound in the northwestern United States was in the Duwamish Waterway (Figure 34) as reported by Sumeri (1989). A shoal that limited navigation through the waterway was found to contain contaminated sediments that eliminated the possibility of unconfined open-water disposal. Thus, the Seattle District initiated a demonstration project to dispose of 840 m^3 of contaminated material in a subaqueous depression in the West Waterway and to cap it with 3,220 m^3 of clean maintenance dredged material from the upper Duwamish River (Sumeri 1984). The fine-grained contaminated sediment exited the bottom-dump barge as a slurry and descended rapidly to the bottom as a cohesive mass (convective descent). Three barges using survey positioning systems were used to place the sand cap by "sprinkling" sand at an average rate of 21 m^3/min from incrementally opened split-hull barges. The resulting average cap thickness was 61 cm. The sprinkling procedure using conventional equipment minimized displacement of the contaminated sediment and hastened the consolidation process. Since the capping material was released slowly, it tended to settle to the bottom as individual grains and not as a contiguous mass. Vibracore sediment samples taken up to 5 years following capping showed the interface between the contaminated and cap sediments was sharp throughout the entire monitoring program. Measured contaminant concentrations were either absent or present in low concentrations in the cap material.

One Tree Island Marina

A CAD project involving direct mechanical placement of material was conducted in 1987 for the expansion of the One Tree Island Marina at Olympia, WA (Figure 34). The operation involved dredging of 2,980 m^3 of contaminated material by clamshell with disposal in a deep conical pit dredged on the project site and capping with 2,980 m^3 of clean material.

The dredging operation was conducted in somewhat crowded conditions with the project dimensions of 48.8 by 91.5 m situated between two other marinas (Figure 35). First, the contaminated layer overlying the location

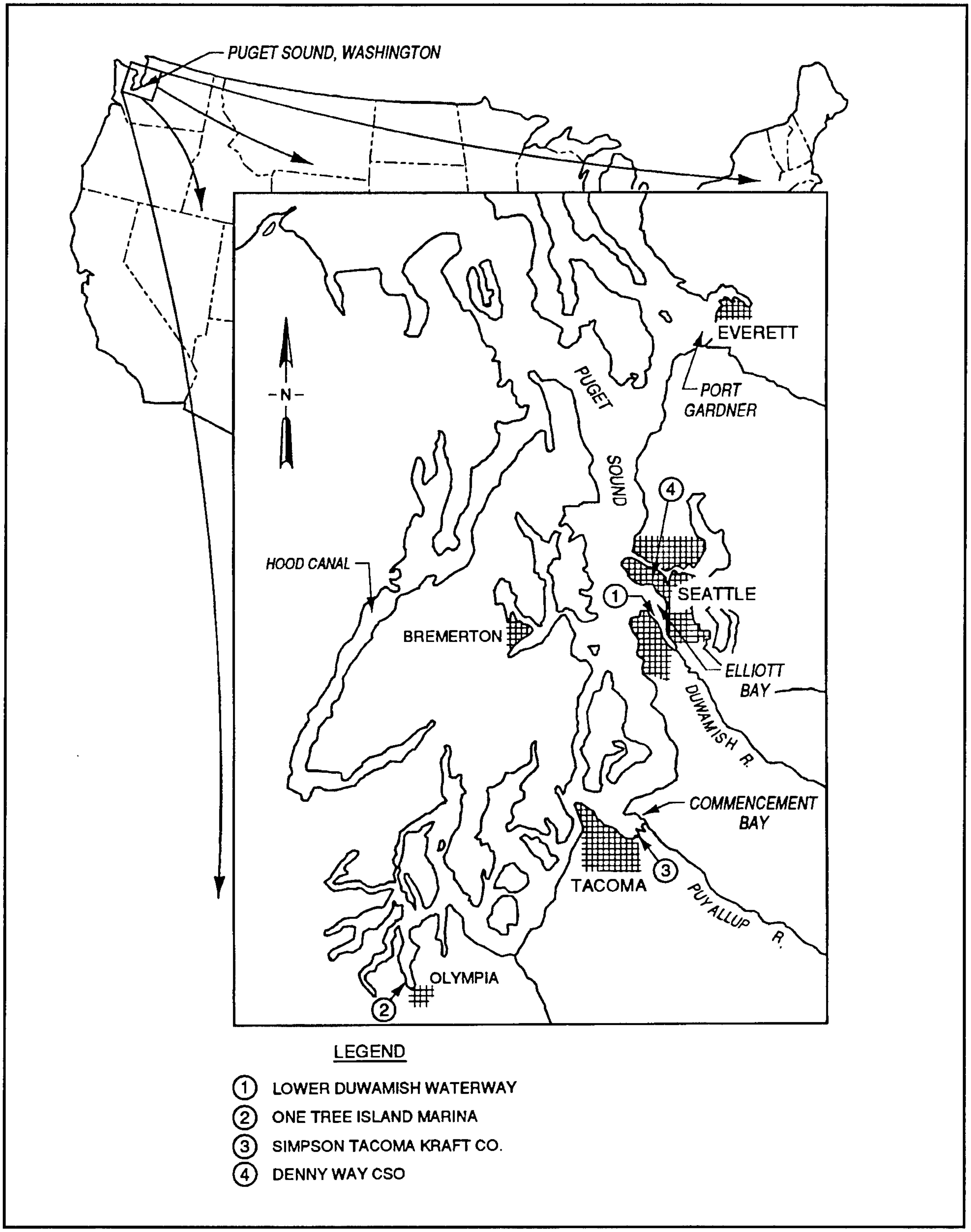


Figure 34. Puget Sound capping projects

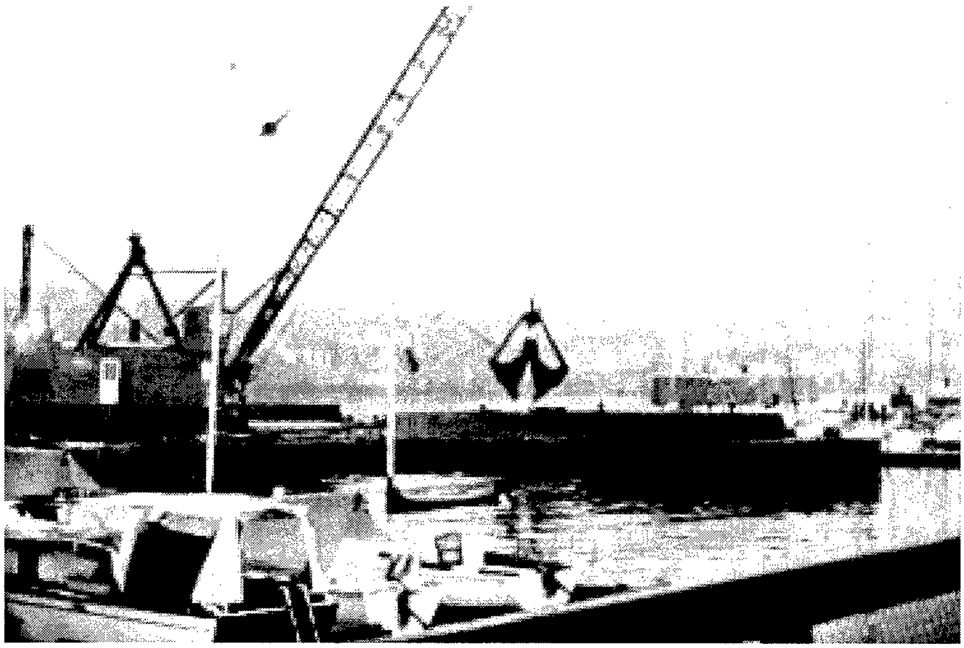


Figure 35. One Tree Island Marina project

of the pit was dredged by clamshell into three barges. Next, the clean conical pit and additional clean material were dredged into an additional split-hulled barge and disposed at another deep-water site. The pit capacity was confirmed, and then the three barge loads of contaminated material were placed in the pit. Finally, more clean material was dredged by clamshell directly into the pit to provide the 1.2-m minimum cap over the contaminated sediment. During dredging, a 45-m dilution zone extending radially from the point of dredging was specified, and outside this area, local water quality standards were maintained. A monitoring program was conducted to evaluate the effectiveness of the cap.

Simpson Tacoma Kraft

In 1988, the Simpson Tacoma Kraft Company capped approximately 17 acres of in situ contaminated nearshore bottom area with 0.6 to 3.7 m of sand hydraulically dredged from the Puyallup River (Sumeri 1989). The contaminated bottom sediments were the result of 37 years of discharging untreated mill wastewater, log storage and chipping operations, and stormwater discharges. The site was a designated EPA Superfund site.

The Puyallup River material was predominantly medium sand with some clay and small fractions of fine and coarse sand and traces of gravel. This material was determined to be relatively clean by chemical and bioassay testing and suitable for capping. Twelve- and ten-inch (30.5- and 25.4-cm) hydraulic dredges were used to dredge approximately 152,910 m^3 of capping material. This material was transported approximately 1 km through floating and submerged pipeline to a spud barge for distribution over the contaminated sediment area. A 2.4- by 4.3-m plywood diffuser box with baffles and 15-cm side boards containing holes throughout was used to distribute the sand slurry over a wide area. This device essentially sprinkled the sand over the contaminated fine-grained sediment on the bottom. The spud barge and boom extension were swung about the spud and controlled by anchor lines. The cap was placed by swinging the plywood box ("sand box" as shown in Figure 7) back and forth until manual leadline soundings indicated the desired cap thickness was attained. Acoustic depth sounders were ineffective due to high sand load and entrained air in the water column. The barge was moved ahead 3.1 m providing a one-third overlap, and the swinging procedure was repeated. Subsequent movements of the spud barge and spreading of the cap material were made until the contaminated area was completely capped. Physical, chemical, and biological monitoring were initiated to determine cap effectiveness during the first 5 years following cap placement.

Denny Way

The Denny Way Combined Sewer Overflow (CSO) is located in the lower Duwamish River in Puget Sound (Sumeri 1989). It discharges both untreated sanitary sewage and stormwater runoff and acts as a relief point during peak storm events each year. The bottom sediments in the area off the Denny Way CSO (Figure 34) were found to be contaminated. Subsequently, a CSO control plan and source control activities were instituted to reduce the toxicant loading.

The in situ contaminated sediments at Denny Way were capped with sand using a similar procedure as used in the Duwamish capping project. For this project, sand placement needed to be more accurate. Clean sands were obtained from a maintenance dredging project and transported to the site by a bottom-dump barge. Placement of the cap was completed by pushing the barge sideways and sprinkling a 39-m-wide sand blanket. Barge displacement was measured with two pressure transducers installed in stilling wells at each end of the barge, and these displacement signals were telemetered to the microprocessor onboard the attending tug. The navigational position of the barge was tracked by a laser positioning system, which also telemetered the tugboat and monitored position and sand-sprinkling rate. A cap of 0.6 to 0.9 m was placed at the Denny Way CSO site, and monitoring of the cap effectiveness was instituted.

Port of Los Angeles/Marina del Ray

A large CAD project has recently been completed in the Port of Los Angeles (LA), and this project is the first to be implemented in California. The CAD site is constructed inside and adjacent to the main breakwater in LA Harbor and is known as the Permanent Shallow Water Habitat (PSWH) site. Materials placed in the site include contaminated materials from channel deepening within LA Harbor and contaminated materials from the Marina del Ray Project. Subaqueous dikes were first constructed using suitable quarry run materials from Catalina Island. Contaminated sediments from the harbor were placed by surface release at the site. Materials from the Marina del Ray Project were placed at the site using geotextile bags, the first demonstration of this technology as an application for placement of contaminated dredged material.

The PSWH site was originally designed by the Port of Los Angeles as an environmental mitigation measure for the Pier 400 harbor development project. Site design called for filling the 190-acre area to raise the natural bottom from 40- to 45-ft depths to depths less than 20 ft, creating a shallow-water foraging area for the endangered California least tern. Quarried stone from Catalina Island was used for construction of the subaqueous berm (see Figure 36). Approximately 543,000 cu yd of contaminated material from the harbor were placed within the site. These sediments had elevated levels of contaminants and were considered unsuitable for open-water disposal and were also undesirable from the standpoint of placement in the Pier 400 engineered landfill.

The contaminated sediment was placed in the center of the 94-acre portion of the overall 190-acre site. The 94-acre area was laterally separated from the outer boundaries of the site by buffer zones ranging from 200 to 650 ft, all of which were slated for capping with clean material. The widest (650-ft) buffer was located on the breakwater side to ensure the contaminated sediments would remain isolated in the event of a rare catastrophic storm that might breach the breakwater. Approximately 4 million cu yd of clean material from the harbor, which was physically unsuitable for landfill construction, comprised the lower (thickest) layer of the cap. Clean sand was used for the final 2 ft of cap to resist erosion and provide suitable substrate for the tern habitat. Together, this resulted in a cap thickness generally exceeding 15 ft. Such a cap thickness is far in excess of that required for effective capping from the standpoint of containment and was dictated in part by site geometry and dredging volumes.

The sequence of material placement was also driven in part by the dredging requirements for the overall Pier 400 project. The placement of initial portions of contaminated material was by clamshell dredge. This material was placed in the "central area" of the PSWH, while other initial elements were mechanically placed in the "perimeter area." The initial capping material was placed over the "central area" using a hopper dredge. The subsequent capping layers were placed by pipeline dredge.

Placement of a sand cover was completed after a waiting period of 11 months to allow for consolidating the fine-grained capping material and minimizing the mixing of sand with the fine material.

Prior to initiation of the Pier 400 project, the PSWH site was selected for placement of additional contaminated material from the Marina del Ray project located 35 miles from LA Harbor. This project involved approximately 55,000 cu yd of sandy contaminated sediments, which also contained potentially floatable debris. The initial scheduling of operations at Marina del Ray would have required placement of this material at the PSWH site prior to construction of the subaqueous berms. To avoid dispersion during placement and spreading of contaminated material in absence of the berms, the permit required use of geotextile bags for the

Marina del Ray material (Mesa 1995). Actual placement was initiated following completion of the berms, so the geotextile bags were not actually required as a control measure; but the project proved to be a valuable field demonstration of this innovative concept.

The sediments were dredged using a clamshell and placed in a split-hull scow lined with two layers of geotextile (a nonwoven inner liner and a woven outer shell) forming a container. Following completion of filling of a barge, the geotextile material was brought over the top of the barge, and the edges were sewn closed to form the completed container. Modifications were made to the scow bulkheads to reduce the width and length of the filled volume to allow easier release of the filled bags.

The first geocontainer was filled with approximately 1,900 cu yd of material. Because of drainage of the sandy sediment during transport and subsequent bridging action, the first container failed to fall completely from the barge. Water jets were finally employed to fluidize the material and release the bag. Subsequent bags were only filled with approximately 1,300 cu yd, and additional fabric was used in forming the containers, providing more "slack" in the containers to help with release. A total of 44 containers were placed (Figure 36).

All contaminated materials were successfully placed within the subaqueous dikes, and the dikes have performed as intended. Bathymetric and sediment profiling image camera monitoring confirmed that approximately 98 percent of the contaminated material was retained behind the subaqueous dike, and that the thickest deposits immediately outside the dike were generally less than 5 cm (the regulatory limit set for the project in advance).

Rotterdam Harbor

As a consequence of local effluent discharge from chemical industries sited around the 1st Petroleum Harbor in the Port of Rotterdam, the harbor basin contained heavily contaminated material. Several options (upland, open water, dredged pits, and confined behind a sheet-piled dam) were considered for disposing of the contaminated material as described by Kleinbloesam and van der Weijde (1983). The alternative finally selected was a CAD project that consisted of excavating pits in the 1st Petroleum Harbor, dredging the contaminated material, disposing of it in the pits, and capping and lining the pit with clean material (Figure 37). The plan, called the Putten Plan, had to be executed so that dispersion of pollutants into the surface water and groundwater was very low, but acceptable. Special dredging equipment was used for the disposal operation, and studies were conducted to determine the dispersion of the contaminants.

The first dredge pit was 550 by 120 m at the bottom and was 15 m deep with a capacity of 1.4 million m^3. The silt from the pit dredging was disposed at sea, and the sand was used at various landfill projects. Two additional pits were dredged; the contaminated dredged material was taken to the first pit, and the clean material was used or discharged at sea. A third

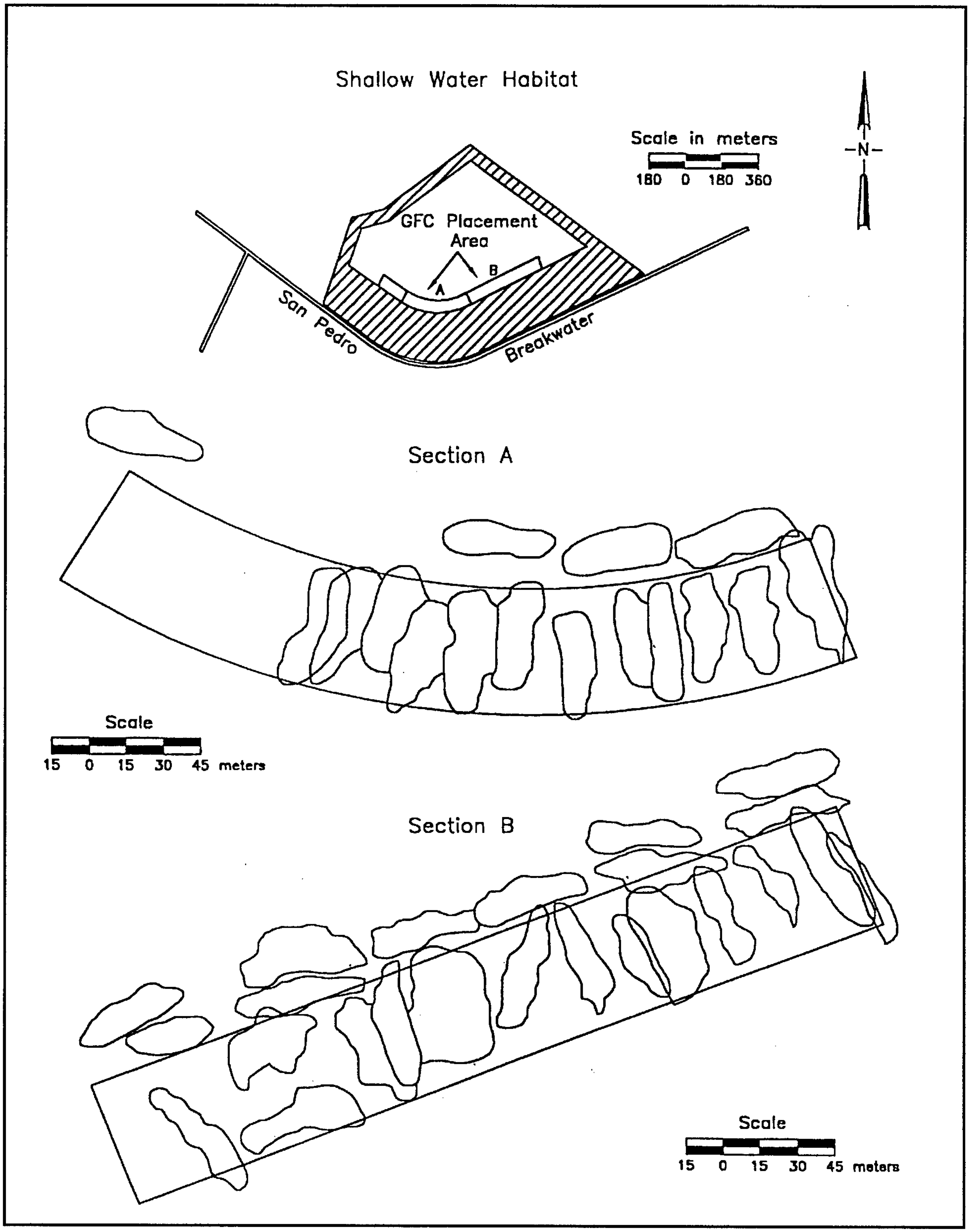


Figure 36. Marina del Ray project plan showing location of berms and geotextile bags

pit was needed to compete the disposal of all expected contaminated material. This procedure (Figure 37) was to be completed only once, and subsequent maintenance would be completed using normal methods.

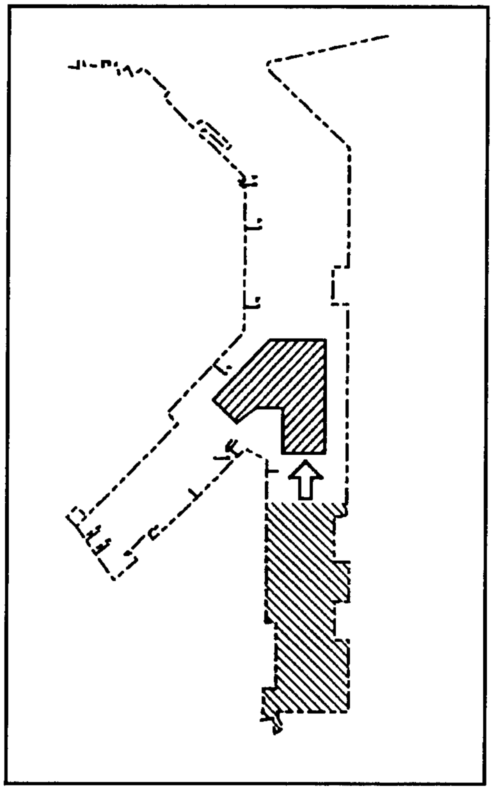


Figure 37. Rotterdam Harbor CAD project

A suction dredge was converted to act as the discharge vessel with the suction pipe used as the discharge pipe. Conditions on the suction dredge operation were (a) no overflow, (b) no water jets in suction process, (c) lower working speed, (d) must use onboard pumping systems for contaminated sediment discharge, (e) contaminated water from silt and degassification must not be discharged overboard, and (f) contaminated mixtures cannot be pumped overboard. The discharge pipe was extendable to 30 m and was equipped with a modified discharge opening (diffuser). The diffuser directed the discharge radially and reduced the exit velocity to between 0.3 and 0.4 m/sec. The dredge was also equipped with a degassification system. Contaminated material was dredged with a modified stationary suction dredge. Its suction mouth was equipped such that only the upper layer of the dredged material was touched, and the suction intake had no moving parts or waterjets. The objective was to maintain the in situ density of the dredged contaminated material throughout the dredging, transporting, and discharging operations. Pollution of the groundwater through the bottom of the dredge pit was also of concern. After researching this problem, it was decided to place a layer of clay as a liner in the bottom of the dredge pit.

Hiroshima Bay

Hiroshima Bay in the Inland Sea of Japan was the site of bottom-sediment improvement testing using a special barge unloader sand spreader (Kikegawa 1983). The investigation demonstrated that the sand-overlaying process was successful using a barge unloader sand spreader (Figure 10), and the sand layer had only minor irregularities in thickness with a mean thickness of 0.5 m. Coarse particle size (0.1 to 10 mm) containing shells with silt content of 0.1 to 0.3 percent was used as the overlaying material. The discharge sand quantity during the spreading operation was estimated using the pump suction pressure. Bottom sediment resuspension during discharge was measured with a portable turbidity instrument, which showed the resuspension of the bottom sediment was up to 1.5 m above the seafloor. The depth of spreading did not cause any noticeable differences in the spreading capability. The sand spreading did result in turbulence in the bottom sediment, but contamination of the surrounding water did not occur. The success of the sand-spreading demonstration was above expectations, but it was concluded that a new type of sand spreader would be needed for larger scale operations.

A conveyor barge (Figure 11) with 18 hopper bins was used in Hiroshima Bay for another sand-spreading test (Togashi 1983). The barge could discharge 2,000 m^3 in 1 hr. A telescopic tremie tube was installed, and the length of the tube was adjusted so that the sand discharged would not disturb the spread of the sludge as it contacted the seafloor. The sea sand had a average specific gravity of 2.62 and silt content of 0.6 to 1.5 percent. The design thickness was 0.5 m. Results of the field tests showed the average 0.5-m thickness was obtained using a volume equivalent of 0.25 m of overlay placed twice from a height of 10 to 12 m above the bottom. The sand thickness was stable; the impact on the bottom sediment was diminished at this height, and turbidity and resettling were minimized. This conveyor barge method was considered to be an efficient and mobile technique for sand overlaying and is applicable in a wide range of areas.

11 Summary and Recommendations

Summary

This report presents technical guidance for subaqueous dredged material capping. The guidance is summarized as follows:

a. Capping is the controlled accurate placement of contaminated material at an open-water disposal site, followed by a covering or cap of clean isolating material. Within the context of capping, the term "contaminated" refers to material that needs isolation from the benthic environment, while the term "clean" refers to material found to be suitable for open-water disposal.

b. A capping operation must be treated as an engineered project with carefully considered design, construction, and monitoring to ensure that the design is adequate.

c. There is a strong interdependence between all components of the design for a capping project. By following an efficient sequence of activities for design, unnecessary data collection and evaluations can be avoided, and a fully integrated design is obtained.

d. The basic criterion for a successful capping operation is simply that the cap thickness required to isolate the contaminated material from the environment can be successfully placed and maintained.

e. The contaminated sediment must be characterized from physical, chemical, and biological standpoints. Physical characteristics are of importance in determining the behavior of the material during and following placement at a capping site. Chemical and biological characterization data for the contaminated material to be capped are useful in determining potential water column effects during placement and acceptable exposure times before placement of the cap begins.

f. The capping sediment must also be characterized from the physical, chemical, and biological standpoints. Physical characteristics determine the behavior during placement of the cap and long-term consolidation and stability against erosion. Chemical and biological characterization should determine if the capping sediment is acceptable for unrestricted open-water disposal (i.e., a "clean" sediment).

g. The selection of an appropriate site is a critical requirement for any capping operation. The general considerations for selection of any nondispersive open-water site also apply to selection of a site for capping, but a capping site requires special consideration of bathymetry, currents, water depths, bottom-sediment characteristics, and operational requirements. In general, capping sites should be located in relatively low-energy environments with little potential for erosion of the cap.

h. A number of different equipment types and placement techniques can be considered for capping operations. Conventional discharge of mechanically dredged material from barges and hydraulically dredged material from hopper dredges or pipelines can be considered if the anticipated bottom spread and water column dispersion are acceptable. If water column dispersion must be reduced or if additional control in placement is required, use of diffusers, tremies, and other equipment needed for submerged discharge can be considered. Controlled discharge and movement of barges and use of spreader plates or boxes with hydraulic pipelines can be considered for spreading a capping layer over a larger area. Compatibility between equipment and placement technique for contaminated and capping material is essential for any capping operation.

i. Accurate navigation to the disposal site and precise positioning during material placement are required for capping operations. State-of-the-art equipment and techniques must be employed to ensure accurate placement to the extent deemed necessary. Diligent inspection of operations to ensure compliance with specifications is essential.

j. Scheduling of the contaminated-material placement and capping operation must consider both exposure of the contaminated material to the environment and engineering and operational constraints.

k. Evaluation of potential water column effects due to placement of contaminated material must be performed. If water column release is unacceptable, control measures must be considered to reduce the potential for water column effects, or other dredging equipment and placement techniques or use of another capping site can be considered.

l. The cap must be designed to chemically and biologically isolate the contaminated material from the aquatic environment. The determination of the minimum required cap thickness is dependent on the physical and chemical properties of the contaminated and capping sediments, the potential for bioturbation of the cap by aquatic organisms, and the potential for consolidation and erosion of the cap material.

m. The spread and mounding behavior of contaminated material during placement must be evaluated to predict the geometry of the deposit and resulting cap material requirements. The capping material behavior must be similarly evaluated to determine if the design of the cap and volume of capping material available are adequate. The smaller the "footprint" of the contaminated material as placed, the less volume of capping material will be required to achieve a given cap thickness.

n. An evaluation of the consolidation and long-term potential for erosion of the mound or deposit must be conducted to ensure that the required cap thickness can be maintained. The design-cap thickness must be adjusted to account for potential erosion and consolidation. The cap can also be armored with coarser material to minimize erosion.

o. Monitoring of capped sites is required during and following placement of the contaminated and capping material to ensure that an effective cap has been constructed and to ensure that the cap as constructed is effective in isolating the contaminants and that long-term integrity of the cap is maintained. Design of monitoring programs must be logically developed, prospective in nature, and tiered with each tier having its own thresholds, null hypotheses, sampling design, and management responses based on exceedance of predetermined thresholds.

p. Capping of contaminated material in open-water sites began in the late 1970s, and a number of capping operations under a variety of disposal conditions have been accomplished. Field experience with these projects has shown that the capping concept is technically and operationally feasible.

q. The cost of capping is generally lower than alternatives involving confined (diked) disposal facilities. The geochemical environment for subaqueous capping favors long-term stability of contaminants as compared with the upland environment where geochemical changes may favor increased mobility of contaminants. Capping is therefore an attractive alternative for disposal of contaminated sediments from both economic and environmental standpoints.

Recommendations

As more designs are completed and additional field experience is gained, the technical guidelines in this report should be refined and expanded. Additional research is also recommended to develop improved tools for capping evaluations. Specific recommendations for further research are summarized as follows:

a. More clearly define impacts associated with capping at water depths exceeding 100 ft. PSSDA monitoring has shown material dispersion can be predicted in 300- to 400-ft water depth in Puget Sound.

b. Refine and verify models for short-term fate of dredged material to allow for predictions within the full range of conditions expected at capping sites.

c. Refine and verify models that predict subaqueous mound development due to multiple discharges from barges or hopper dredges or long-term discharge from pipelines. Approaches should included both water column and spread behavior of the discharges and the geotechnical considerations associated with mound-slope stability, density flows, and resistance to bearing failure. Such tools will have application for general open-water site management as well as specific application to capping scenarios.

d. Refine and verify models that predict long-term erosion from dredged material mounds. Additional emphasis should be placed on mounds covered with fine-grained material. Such tools will have application for general open-water site management as well as specific application to capping scenarios.

e. Refine existing estimates of resuspension of contaminated material during cap placement. This work will assist in determining the costs versus benefits of "sprinkling" cap material versus conventional bottom dumping of cap material.

f. Develop engineering guidance on acceptable rates and methods of application of capping material over contaminated material of varying density and shear strength. These techniques should consider the geotechnical behavior related to displacement and mixing of contaminated and capping sediments and resistance of the sediments to bearing failure. Extend the investigation to include penetration of dense (e.g., rock) cap material into contaminated material mounds.

g. Refine existing models for prediction of capped-mound consolidation. This effort will likely require developing or refining instrumentation for in situ geotechnical measurements.

h. The effect of pore water pressure fluctuations within the mound caused by the surface wave climate should be studied to determine possibility of contaminant release and reduced mound stability.

i. Develop predictive tools for evaluation of long-term cap integrity, considering chemical migration via consolidation, bioturbation, and diffusion. Both analytical and modeling approaches should be considered. Refinements to sediment-water interface models for this purpose are ongoing under the Disposal Operations Technical Support Program.

j. Conduct laboratory and field verification studies of long-term cap integrity. Laboratory approaches should include refinement of existing cap-effectiveness tests using columns. Additional laboratory verification of consolidation effects on contaminant migration should be conducted using large geotechnical centrifuges. Field studies should include periodic monitoring and sampling of capped sites to include analysis of core samples.

References

Ackers, P., and White, R. W. (1973). "Sediment transport: New approach and analysis," *Journal of the Hydraulics Division* 99 (HY11), 2041-60.

Adamec, S. A., Jr., Johnson, B. H., and Trawle, M. J. (1988). "Numerical modeling of material from Everett, Washington, Naval Port disposed in Puget Sound," Draft Report, U.S. Army Engineer Waterways Experiment Station, Vicksburg Mississippi.

Allard, R., Farrar, P., Mark, D., Martin, J., Shapiro, B., Lowe, S., and Ko, D. S. (1996). "Creating a 4-D integrated scenario near Camp Pendelton, CA." *Proceedings of the Conference on Coastal Oceanic and Atmospheric Prediction,* Am. Meteorological Soc., Boston, MA.

Allen, J. R. L. (1970). "The avalanching of granular solids on dune and similar slopes," *Journal of Geology* 78 (3), 326-51.

American Public Health Association (APHA). (1986). *Standard methods for the examination of water and wastewater.* 15th ed., Washington, DC.

Ariathurai, R., and Krone, R. B. (1976). "Finite element model for cohesive sediment transport," *Journal of the Hydraulics Division* 102(HY3), 323-38.

Ariathurai, R., MacArthur, R. C., and Krone, R. B. (1977). "Mathematical model of estuarial sediment transport," Technical Report D-77-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Averett, D. E., and Palermo, M. R., Otis, M. J., and Rubinoff, P. B. (1989). "New Bedford Harbor Superfund Project, Acushnet River estuary engineering feasibility study of dredging and dredged material disposal alternatives; Report 11, Evaluation of conceptual dredging and disposal alternatives," Technical Report EL-88-15, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bain, C. C., Westerink, J. J., Luettich, R. A., Jr., Scheffner, N. W. (1994). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuaries; Report 4, Hurricane storm surge modeling using large domains," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1995). "Influence of domain size and grid structure on the response characteristics of a hurricane storm surge model," Technical Report DRP-95-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ballinger, D. C. (1979). "Methods for chemical analysis of water and wastes," EPA 600/4-79-020, U.S. Environmental Protection Agency, Cincinnati, OH.

Barnard, W. D. (1978). "Prediction and control of dredged material dispersion around dredging and open-water pipeline disposal operations," Technical Report DS-78-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bijker, E. W. 1971. "Longshore transport computations," *Journal of the Waterways, Harbors, and Coastal Engineering Division* (WW4), 687-701.

Bohlen, W. F., Gee, A., and Germano, J. D. "Sediment capping of subaqueous dredged material disposal mounds: An overview of the New England experience," Report in preparation by Science Applications International Corporation for U.S. Army Engineer Division, New England.

Bokuniewicz, H. (1989). "Behavior of sand caps on subaqueous dredged material disposal sites," *Oceanic processes in marine pollution, Vol 4, Scientific monitoring strategies for ocean waste disposal.* D. Hood, A. Schoener, and P. K. Parks, ed., Krieger Publishing Co., Malabar, FL.

Bokuniewicz, H. J., Gerbert, J., Gordon, R. B., Higgins, J. L., Kaminsky, P., Pilbeam, C. C., Reed, M., and Tuttle, C. (1978). "Field study of the mechanics of the placement of dredged material at open-water disposal sites," Technical Report D-78-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Borgman, L. E., Miller, M. C., Butler, H. L., and Reinhard, R. D. (1992). "Empirical simulation of future hurricane storm histories as a tool in engineering and economic analysis," *Proceedings of Civil Engineering in the Oceans* V, ASCE, New York.

Borgman, L. E. and Scheffner, N. W. (1991). "The simulation of time sequences of wave height, period, and direction," Technical Report DRP-91-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bosworth, W. S. and Thibodeaux, L. J. (1990). "Bioturbation: A facilitator of contaminant transport in bed sediment," *Environmental Progress* 9(4).

Bowers, G. W., and Goldenblatt, M. K. (1978). "Calibration of a predictive model for instantaneously discharged dredged material," EPA-600/3-78-089, U.S. Environmental Protection Agency, Corvallis, OR.

Boyer et al. (1994). "Recovery, a mathematical model to predict the temporal response of surface water to contaminated sediments," Technical Report W-94-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brandes, H., Silva, A., and Fredette, T. J. (1991). "Settlement of offshore mounds of capped dredged materials," *Maritimes.*

Brandsma, M. G. and Divoky, D. J. (1976). "Development of models for prediction of short-term fate of dredged material discharged in the estuarine environment," Contract Report D-76-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brannon, J. M., et al. (1985). "Effectiveness of capping in isolating contaminated dredged material from biota and the overlying water," Technical Report D-85-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1986) "Effectiveness of capping in isolating dutch kill sediment from biota and the overlying water," Miscellaneous Paper D-86-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brannon, J., and Poindexter-Rollings, M. E. (1990). "Consolidation and contaminant migration in a capped dredged material deposit," *The Science of the Total Environment* 91, 115-26.

Bray, R. N., Bates, A. D., and Land, J. M. (1997). *Dredging, a handbook for Engineers.* 2d ed., John Wiley and Sons, New York.

Brooks, N. H. (1973). "Dispersion in hydrologic and coastal environments," Pacific Northwest Water Quality Laboratory, Northwest Region, U.S. Environment Protection Agency, Corvalis, OR.

Cargill, K. W. (1982). "Consolidation of soft layers by finite strain theory," Miscellaneous Paper GL-82-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cargill, K. W. (1985). "Mathematical model of the consolidation/desiccation process in dredged material," Technical Report D-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Chow, V. T. (1959). *Open channel hydraulics.* McGraw-Hill Book Company, New York.

Christoffersen, J. B., and Jonsson, I. G. (1985). "Bed friction and dissipation in a combined current and wave motion," *Ocean Engineering* 12(5), 387-423.

Clausner, J. E., Palermo, M. R., Banks, D., and Palmerton, J. (1996). "Potential application of geosynthetic fabric containers for open water placement of contaminated dredged material," Environmental Effects of Dredging Technical Note EEDP-01-39, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Clausner, J. E., Scheffner, N. W., and Allison, M. C. (1995). "Assessment of remaining capacity of the Mud Dump site," Letter Report for New York District, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Corson, W. D., Resio, D. T., and Vincent, C. L. (1980). "Wave information study of U.S. coastlines; Report 1, Surface pressure field reconstruction for wave hindcasting purposes," Technical Report HL-80-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cox, J. M., Maresca, P., and Jarvela, A. (1995). "Silent inspector user's manual," Instruction Report DRP-95-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

d'Angremond, K., de Jong, A. J., and de Waard, C.-P. (1986). "Dredging of polluted sediment in the 1st Petroleum Harbor, Rotterdam." *Proceedings of the Third United States/The Netherlands Meeting on Dredging and Related Technology.* Prepared for the U.S. Army Corps of Engineers Water Resources Support Center by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Di Toro, D. M., Jeris, J. S., and Clarcia, D. (1985). "Diffusion and partitioning of hexachlorobiphenyl in sediments," *Environ. Sci. Technol.* 19(12), 1169-75.

Dortch, M. S., Hales, L. Z., Letter, J. V., and McAnally, W. H., Jr. (1990). "Methods of determining the long-term fate of dredged material for aquatic disposal sites," Technical Report D-90-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Duarte, F., Joseph, J., Satterlee, G. (1995). "Construction of geocontainer and geobag contraction dikes to eliminate dredging at Red Eye Crossing." *Proceedings of Ports* '95, ASCE, New York.

Earhart, G., Clarke, D., and Shipley, J. (1988). "Beneficial uses of dredged material in shallow coastal waters; Chesapeake Bay demonstration," Information Exchange Bulletin D-88-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Efron, B. (1982). "The jackknife, the bootstrap and other resampling plans," Society for Industrial and Applied Mathematics, Philadelphia, PA.

________. (1990). "More efficient bootstrap computations," *Journal of the American Statistical Association* 85(409), 79-89.

Elliot, D. O. (1932). "The improvement of the Lower Mississippi River for flood control and navigation," Vol. II, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Environmental Laboratory. (1987). "Disposal alternatives for PCB-contaminated sediments from Indiana Harbor, Indiana," Miscellaneous Paper EL-87-9, 2 Vols, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Environmental Protection Agency (EPA). (1986). "U.S. Environmental Protection Agency, ocean dumping site designation delegation handbook," Office of Marine and Estuarine Protection, Washington, DC.

EPA/U.S. Army Corps of Engineers (USACE). (1991). "Evaluation of dredged material proposed for ocean disposal (testing manual)," EPA-503/8-91/001, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

________. (1998). "Evaluation of dredged material proposed for discharge in inland and near-coastal waters - Testing manual," EPA-823-B-98-004, U.S. Environmental Protection Agency, Washington, DC.

Farrar, P. D., Borgman, L. E., Glover, L. B., and Reinhard, R. D., Pope, J., Swain, A., and Ebersole, B. (1994). "Storm impact assessment for beaches at Panama City, Florida," Technical Report CERC-94-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Francingues, N. R., Palermo, M. R., Lee, C. R., and Peddicord, R. K. (1985). "Management strategy for disposal of dredged material: Contaminant testing and controls," Miscellaneous Paper D-85-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fredette, T. J. (1994). "Disposal site capping management: New Haven Harbor." *Proceedings of Dredging* '94, ASCE, New York.

Fredette, T. J., Anderson, G., Payne, B. S. and Lunz, J. D. (1986). "Biological monitoring of open-water dredged material disposal sites." *IEEE Oceans '86 Conference Proceedings, Washington, DC.*

Fredette, T. J., Bohlen, W. F., Rhoads, D. C., and Morton, R. W. (1988). "Erosion and resuspension effects of Hurricane Gloria at Long Island Sound dredged material disposal site." *U.S. Army Corps of Engineers Seventh Annual Water Quality Seminar Proceedings, Charleston, SC.*

__________. (1989). "Erosion and resuspension effects of Hurricane Gloria at Long Island Sound dredged material disposal sites," Environmental Effects of Dredging Information Exchange Bulletin, Vol D-89-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fredette, T. J., Germano, J. D., Carey, D. A., Murray, P. M., and Kullberg, P. G. (1992). "Chemical stability of capped dredged material disposal mounds in Long Island Sound, USA," *Chemistry and Ecology* 7, 173-94.

Fredette, T. J., Germano, J. D., Kullberg, P. G., Carey, D. A., and Murray, P. "Chemical stability of capped dredged material disposal mounds in Long Island Sound, USA." *1st International Ocean Pollution Symposium, Mayaguez, Puerto Rico. Chemistry and Ecology.* In preparation.

Fredette, T. J., Nelson, D. A., Clausner, J. E., and Anders, F. J. (1990a). "Guidelines for physical and biological monitoring of aquatic dredged material disposal sites," Technical Report D-90-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fredette, T. J., Nelson, D. A., Miller-Way, T., Adair, J. A., Sotler, V. A., Clausner, J. E., Hands, E. B., and Anders, F. J. (1990b). "Selected tools and techniques for physical and biological monitoring of aquatic dredged material disposal sites," Technical Report D-90-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Freeland, G. L., et al. (1983). "Sediment cap stability study of New York dredged material dumpsite," Support Agreement No. NYD 80-124CC, by Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, FL, for U.S. Army Engineer District, New York.

Gibson, R. E., England, G. L., Hussey, M. J. L. (1967). "The theory of one-dimensional consolidation of saturated clays; I, Finite nonlinear consolidation of thin homogeneous layers," *Geotechnique* 17(3), 261-73.

Gibson, R. E., Schiffman, R. L., and Cargill, K. W. (1981). "The theory of one-dimensional consolidation of saturated clays, II, fine non-linear consolidation of thick homogeneous layers," *Canadian Geotechnical Journal* 18, 289-93.

Gordan, R. (1974). "Dispersion of dredged spoil dumped in near-shore waters," *Estuarine and Coastal Marine Science* 2, 349-58.

Greges, M. (1994). "Ocean disposal with capping of dioxin contaminated sediment: New York case history #1." *Proceedings of Dredging* '94, American Society of Civil Engineers, New York, 1278-84.

Gunnison, D., et al. (1987a). "Appendix F: Evaluation of the effectiveness of capping in isolating contaminated Indiana Harbor dredged material from biota and the overlying water," Miscellaneous Paper EL-87-9, Vol II, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1987b). "Development of a simplified column test for evaluation of thickness of capping material required to isolate contaminated dredged material," Miscellaneous Paper D-87-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hales. (1995). "Accomplishments of the Corps of Engineers Dredging Research Program," *Journal of Coastal Research* 11(1), 68-88.

Hands, E. B., and Allison, M. C. (1991). "Mound migration in deeper water and methods of categorizing active and stable berms." *Proceedings of Coastal Sediments '91*, ASCE, 1985-99.

Hayes, D. F., McLellan, T. N., and Truitt, C. L. (1988). "Demonstrations of innovative and conventional dredging equipment at Calumet Harbor, Illinois," Miscellaneous Paper EL-88-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Headland, R. E., Lesnik, J. R., McNeilan, T. W., and Hooper, J. R. (1995). "Feasibility study of sediment restoration alternatives for the southern California natural resource damage assessment; Appendix G: Hydrodynamics and geotechnical assessment of the in-situ capping alternative," Moffatt and Nichols Engineers, Baltimore, MD.

Headquarters, U.S. Army Corps of Engineers (HQUSACE). (1983). "Dredging and dredged material disposal," Engineer Manual 1110-2-5025, 25 March 1983, Washington DC.

__________. (1984). "Shore Protection Manual," Washington, DC.

Hench, J. L., Luettich, R. A., Jr., Westerink, J. J., and Scheffner, N. W. (1994). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuaries; Report 6, Development of a tidal constituent database for the eastern North Pacific," Technical Report

DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Herbich, J. B. (1992). *Handbook of dredging engineering*. McGraw-Hill, Inc., New York.

Ho, F. P., Su, J. C., Hanevich, K. L., Smith, R. J., and Richards, F. P. (1987). "Hurricane climatology for the Atlantic and Gulf Coasts," Technical Report NWS 38, National Weather Service, NOAA, Silver Spring, MD.

Hubertz, J. M., Brooks, R. M., Brandon, W. A., and Tracy, B. A., (1993). "Hindcast wave information for the U.S. Atlantic Coast," WIS Report 30, Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ippen, A. T., ed. (1966). *Estuary and coastline hydrodynamics*. McGraw-Hill Book Co., Inc., New York.

Jarvinen, B. R., Neumann, C. J., and Davis, M. A. S. (1988). "A tropical cyclone data tape for the North Atlantic Basin, 1886-1983: Contents, limitations, and uses," NOAA Technical Memorandum NWS NHC 22.

JBF Scientific Corporation. (1975). "Dredging technology study, San Francisco Bay and Estuary," U.S. Army Engineer District, San Francisco, CA.

Jensen, R. E., Hubertz, J. M., Thompson, E. F., Reinhard, R. D., Bishop, B. J., Brandon, W. A., Payne, J. B., Brooks, R. M., and McAneny, D. S. (1992). "Southern California hindcast wave information," WIS Report 20, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johanson, E. E., Bowen, S. P., and Henry, G. (1976). "State-of-the-art survey and evaluation of open-water dredged material placement methodology," Contract Report D-76-3, prepared by JBF Scientific Corporation for U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H. (1978). "Application of the instantaneous dump dredged material disposal model to the disposal of Stamford and New Haven Harbor material from a scow in the Long Island Sound," Internal Working Document prepared for New England Division, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1979). "Application of the instantaneous dump dredged material disposal model to the disposal of San Diego Harbor material at the 45 and 100 fathom disposal sites," Internal Working Document, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1990). "User's guide for models of dredged material disposal in open water," Technical Report D-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H. (1992). "Numerical disposal modeling." Technical Note DRP-1-02, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H., and Fong, M. T. (1995). "Development and verification of numerical models for predicting the initial fate of dredged material disposed in open water; Report 2, Theoretical developments and verification results," Technical Report DRP-93-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H., and Holliday, B. W. (1977). "Numerical model results of dredged material disposal at ten proposed ocean disposal sites in the Hawaiian Islands," Miscellaneous Paper H-77-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1978). "Evaluation and calibration of the Tetra Tech dredged material disposal models based on field data," Technical Report D-78-47, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H., McComas, D. N., McVan, D. C., and Trawle, M. J. (1993). "Development and verification of numerical models for predicting the initial fate of dredged material disposed in open water; Report 1, Physical model tests of dredged material disposal from a split-hull barge and a multiple bin vessel," Technical Report DRP-93-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Jonsson, I. G. (1966). "Wave boundary layers and friction factors." *Proc., Coast. Engrg. Conf., 10th, Tokyo, Japan.*

Kikegawa, K. (1983). "Sand overlying for bottom sediment improvement by sand spreader." *Management of bottom sediments containing toxic substances: Proceedings of the 7th U.S./Japan Experts Meeting.* Prepared for the U.S. Army Corps of Engineers Water Resources Support Center by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 79-103.

Kleinboesam, W. C. H., and van der Weijde, R. W. (1983). "A special way of dredging and disposing of heavily polluted silt in Rotterdam," World Dredging Congress 1983, Paper M2, Singapore, 509-25.

Koh, R. C. Y., and Chang, Y. C. (1973). "Mathematical model for barged ocean disposal of waste," Environmental Protection Technology Series EPA 660/2-73-029, U.S. Environmental Protection Agency, Washington, DC.

Kraus, N. C., and Larson, M. (1988). "Beach profile change measured in the tank for large waves, 1956-1957 and 1962," Technical Report CERC-86-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Larson, M., and Kraus, N. C. (1989). "SBEACH: Numerical model for simulating storm induced beach change; Report 1, Theory and model foundation," Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lavelle, J. W., Mofjeld, H. O., and Baker, E. T. (1984). "An in situ erosion rate for a fine-grained marine sediment," *J. Geophys. Res.* 89(C4), 6543-552.

Lermans, A. (1979). *Geochemical processes water and sediment environments*. John Wiley and Sons, New York.

Lillycrop, W. J., Garcia, A. W., Howell, G. L., and Grogg, W. E. (1991). "Automated real-time tidal elevation system for offshore dredging operations." Chapter 42. *Tidal hydrodynamics*. B. B. Parker, ed., John Wiley and Sons, Inc., New York, 829-37.

Ling, H. I., Leshchinsky, D., Gilbert, P. A., and Palermo, M. R. (1996). "In-situ capping of contaminated submarine sediments: Geotechnical considerations." *Environmental geotechnics*. A. A. Masashi Kamon, ed., Balkem, Rotterdam, The Netherlands, 575-580.

Luettich, R. A., Jr., Westerink, J. J., and Scheffner, N. W. (1992). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries; Report 1, Theory and methodology of ADCIRC-2DDI and ADCIRC-3DL," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Mansky, J. M. (1984). "Underwater capping of contaminated dredged material in New York Bight Apex," Environment Effects of Dredging, Information Exchange Bulletin, Vol D-84-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Marine Board, National Research Council. (1990). *Managing troubled waters - The role of marine environmental monitoring*. National Academy Press, Washington, DC.

Mark, D. J., and Scheffner, N. W. (1993). "Validation of a continental-scale storm surge model for the cost of Delaware." *3rd International Conference on Estuarine and Coastal Modeling, Chicago, Il.*

Matisoff, G. "Mathematical models of bioturbation." *Animal-sediment relations*. P. L. McCall and M. J. Tevesz, ed., Plenum Press, New York, 289-331.

May, B., Pabst, D., and McDowell, S. L(1994). "Dioxin capping management and monitoring program: Design and implementation." *Proceedings of Dredging "94.* American Society of Civil Engineers, New York, 1027-36.

McAneny, D. "The coastal engineering data retrieval system (CEDRS)," Miscellaneous Paper in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

McDowell, S. (1993). "Comparison of baseline bathymetric surveys: New York Mud Dump site," Report by Science Applications International Corporation, submitted to USAE District, New York, New York.

McDowell, S., May, B., and Pabst, D. (1994). "The December 1992 storm at the New York Mud Dump site." *Proceedings of Dredging*'94, ASCE, New York.

McFarland, V. A. "A bioaccumulation study testing the effectiveness of varying cap apron thicknesses for isolation of dioxin," Report in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

McLellan, T. N., and Truitt, C. L. (1986). "Demonstration of a submerged diffuser for dredged material disposal." *Proceedings of the Conference Oceans '86, Washington, DC.*

McNeil, J., Taylor, C., and Lick, W. "Measurements of the erosion of undisturbed bottom sediments with depth," accepted for publication to *Journal of Hydraulic Engineering.*

Mehta, A. J., Hayter, E. J., Parker, W. R., Krone, R. B., and Teeter, A. M. (1989). "Cohesive sediment transport - I: Process description," *Journal of Hydraulic Engineering,* ASCE, 115(3), 1076-93.

Mesa, C. L. (1995). "Containerization of contaminated dredge sediments - the Marina Del Rey experience." *Proceedings of the 25th Texas A&M Annual Dredging Seminar, TAMU Center for Dredging Studies, College Station, TX.*

Moritz, H. R. (1994). "User's guide for the multiple dump fate model, final report," Contract Report DACW39-94-M-1304, Prepared for the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1997). "Management of ocean dredged material disposal sites at the mouth of the Columbia River." *Proceedings of the Western Dredging Association Eighteenth Technical Conference and Thirtieth Annual Texas A&M Dredging Seminar.* Center for Dredging Studies, Texas A&M University, College Station, TX, 119-139.

Moritz, H. R., and Randall, R. E. (1992). "User guide for the open water disposal area management simulation," Final Report by Texas A&M Research Foundation to U.S. Army Engineer Waterways Experiment Station, Contract Number DACW39-90-K-0015, Vicksburg, MS.

Moritz, H. R., and Randall, R. E. 1995. "Simulating dredged material placement at open water disposal sites," *Journal of Waterway, Port, Coastal, and Ocean Engineering,* ASCE, 121(1).

Morton, R. W. (1980a). "Capping procedures as an alternative technique to isolate contaminated dredged material in the marine environment," Report to USACE, New England Division, Newport, RI, Science Applications, Inc.

__________. (1980b). "The management and monitoring of dredge spoil disposal and capping procedures in central Long Island Sound." *Second annual ocean dumping symposium, Woods Hole, MA.* DAMOS Contribution No. 8, U.S. Army Corps of Engineers, New England, Waltham, MA.

__________. (1983a). "Precision bathymetric study of dredged material capping experiment in Long Island Sound." *Wastes in the ocean, Volume II. Dredged material disposal.* D. R. Kester, I. W. Duedall, B. H. Ketchum, and P. K. Parks, ed., John Wiley and Sons, Inc., New York, 99-121.

__________. (1983b). "Capping procedures as an alternative technique to isolate contaminated dredged material in the marine environment." *Proceedings of the 7th US/Japan Experts Meeting.* U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 108-133.

__________. (1987). "Recent studies concerning the capping contaminated dredged material." *Proceedings of the United States/Japan Experts Meeting on management of bottom sediments containing toxic substances, November 3-6, 1987, Baltimore, MD.*

__________. (1989). "Monitoring the effectiveness of capping for isolating contaminated sediments." *Symposium/workshop on contaminated marine sediments, Tampa, FL.* Nat. Acad. Press, Washington, DC, 262-279.

Morton, R. W., Parker, J. H., and Richmond, W. H., ed. (1984). "Disposal area monitoring system: Summary of program results 1981-1984," DAMOS Contribution #46, Science Applications International Corporation of U.S. Army Engineer Division, New England, Waltham, MA.

Mudrock, A., and MacKnight, S. D. (1991). *Handbook of techniques for aquatic sediment sampling.* CRC Press, Boca Raton, FL.

Myers, A. C. (1979). "Summer and winter burrows of a Mantis shrimp, *Squilla empusa,* in Narragansett Bay, Rhode Island (USA)," Estuarine Coastal Marine Science 8, 87-98.

Myers, T. E., Averett, D. E., Olin, T. J., Palermo, M. R., Reible, D. D., Martin, J. L., and McCutcheon, S. C. (1996). "Estimating contaminant losses from components of remediation alternatives for contaminated sediments," EPA 905-R96-001, March 1996, Assessment and Remediation of Contaminated Sediments (ARCS) Program, U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

Myers, V. A. (1975). "Storm tide frequencies on the South Carolina coast," Technical Report NWS-16, National Weather Service, NOAA, Silver Spring, MD.

Neal, R. W., Henry, G., and Greene, S. H. (1978). "Evaluation of the submerged discharge of dredged material slurry during pipeline dredged operations," Technical Report D-78-44, by JBF Scientific Corp. for U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Nelson, E. E., Vanderheiden, A. L., and Schuldt, D. A. (1994). "Eagle Harbor Superfund Project." *Proceedings of Dredging '94,* American Society of Civil Engineers, New York, 1122-1131.

New York District. (1994). "New York Harbor dredged material management plan: Draft Phase I assessment."

Nichols, M. N., Thompson, G. S., and Faas, R. W. (1978). "A field study of fluid mud dredged material: Its physical nature and dispersal," Technical Report D-78-40, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

O'Connor, J. M., and O'Connor, S. G. (1983). "Evaluation of the 1980 capping operations at the experimental Mud Dump site, New York Bight Apex," Technical Report D-83-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R. (1989). "Capping contaminated dredged material in deep water." *Proceedings of the Specialty Conference Ports 89,* American Society of Civil Engineers, Boston, MA.

__________. (1991a). "Design requirements for capping," Dredging Research Technical Note DRP-5-03, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1991b). "Site selection considerations for capping," Technical Note DRP-5-04, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1991c). "Equipment and placement techniques for capping," Technical Note DRP-5-05, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R. (1994). "Placement techniques for capping contaminated sediments." *Proceedings of Dredging '94, The Second International Conference and Exhibition on Dredging and Dredged Material Placement.* American Society of Civil Engineers, Lake Buena Vista, FL.

__________. "Diffuser for submerged discharge of dredge material," Environmental Effects of Dredging Programs Technical Note in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R., et al. (1989). "Evaluation of dredged material disposal alternatives for U.S. Navy Homeport at Everett, Washington," Technical Report EL-89-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R., Fredette, T. J., and Randall, R. E. (1992). "Monitoring considerations for capping," Dredging Research Technical Notes, DRP-5-07, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R., Maynord, S., Miller, J., and Reible, D. D. (1996). "Guidance for in-situ subaqueous capping of contaminated sediments," Environmental Protection Agency, EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Parker, J. H., and Valente, R. (1988). "Long-term sand cap stability: New York dredged material disposal site," Contract Report CERC-88-2, performed by Science Applications International Corporation under contract to U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Parry, R. (1994). "Constructing beneficial use dredged material projects." *Proceedings of Dredging '94,* ASCE, New York, 547-554.

Parthenaides, E. (1965). "Erosion and deposition of cohesive soils," *Journal of Hydraulics,* Div. Am Soc. Civ. Eng., 91(HY1), 105-138,

Pearson, T. H. (1987). "Benthic ecology in an accumulating sludge-disposal site." *Oceanic processes and marine pollution; Vol. 1, Biological processes and wastes in the ocean.* J. M. Capuzzo and D. R. Kester, ed., Krieger Publishing, Malabar, FL, 195-200.

Pequegnat, W. E., Gallaway, B. J., and Wright, T. D. (1990). "Revised procedural guide for designation surveys of ocean dredged material disposal sites," Technical Report D-90-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Poindexter, M. E. (1989). "Monitoring dredged material consolidation and settlement at aquatic disposal sites," Environmental Effects of Dredging Program Technical Note EEDP-01-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Poindexter-Rollings, M. E. (1990). "Methodology for analysis of subaqueous sediment mounds," Technical Report D-90-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Prater, M. D., Hardy, T. A., Butler, H. L., and Borgman, L. E. (1985). "Estimating error of coastal stage frequency curves." *Proceedings of the 19th International Conference on Coastal Engineering.* ASCE, New York.

Randall, R. E. (1986). "Synthesis procedures for evaluating site capacity for open-water disposal of dredged material," Miscellaneous Paper in review, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Randall, R. E., Clausner, J. E., and Johnson, B. H. (1994). "Modeling cap placement at New York Mud Dump site." *Proceedings of Dredging '94*, American Society of Civil Engineers, New York, 1295-1304.

Resio, D. T., and Hands, E. B. (1994). "Understanding and interpreting seabed drifter (SBD) data," Technical Report DRP-94-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Richardson, T. W., ed. (1993). "Summary of results assessments for proposed capping project New York Bight mud dump dredged material disposal site," Letter report to New York District by the Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Rhoads, D. C., and Boyer, L. F. (1982). "The effects of marine benthos on physical properties of sediments: A successional perspective." *Animal-sediment relations.* P. L. McCall and M. Tevesz, ed., Phenum Press, New York.

Rhoads, D. C., and Germano, J. D. (1982). "Characterization of organism-sediment relations using sediment profile imaging: An efficient method of remote monitoring of the sea floor (REMOTS©), *Marine Ecology Progress Series* 8, 115-128.

Roberts, P. J. W., Ferrier, A., and Johnson, B. H. (1994). "New techniques for experimental studies of dredged material dispersion." *Proceedings of Dredging '94,* American Society of Civil Engineers, New York, 1192-1200.

Rollings, M. P. (1994). "Geotechnical considerations in dredged material management." *Proceedings, First International Congress on Environmental Geotechnics, International Society for Soil Mechanics and Foundation Engineering and Canadian Geotechnical Society, Edmonton, Alberta.*

Rollings, M. P. (1997). "Dredged material consolidation models: Evaluation and comparison of predictive capabilities," DOER Technical Note in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sanderson, W. H., and McKnight, A. L. (1986). "Survey of equipment and construction techniques for capping dredged material," Miscellaneous Paper D-86-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W. (1989). "Disposal site evaluation for the New York Bight," Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_________. (1991a). "A generalized approach to site classification - Dispersive or non-dispersive," Dredging Research Information Exchange Bulletin, Vol. DRP-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_________. (1991b). "A systematic analysis of disposal site stability." *Proceedings of Coastal Sediments '91.* ASCE, 2012-26.

_________. (1992). "Dispersion analysis of Humboldt Bay, California, interim offshore disposal site," Miscellaneous Paper DRP-92-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_________. (1994). "Tidal constituent data base - East Coast, Gulf of Mexico, and Caribbean Sea," DRP Technical Note DRP-1-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., Borgman, L. E., and Mark, D. J. (1993). "Applications of large domain hydrodynamic models to generate frequency of occurrence relationships." *Proceedings 3rd International Conference on Estuarine and Coastal Modeling, Chicago, IL.*

Scheffner, N. W., and Borgman, L. E. (1992). "A stochastic time series representation of wave data," *Journal of Waterways, Ports, Coastal, and Ocean Engineering* 118(4).

Scheffner, N. W., Mark, D. J., Blain, C. A., Westerink, J. J., and Luettich, R. A., Jr. (1994). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuaries; Report 5, A tropical storm database for the east and Gulf of Mexico Coasts of the United States," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., and Tallent, J. R. (1994). "Dispersion analysis of the Charleston, South Carolina, ocean dredged material disposal site," Miscellaneous Paper DRP-94-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., Thevenot, M. M., Tallent, J. R., and Mason, J. M. (1995). "LTFATE: A model to investigate the long-term fate and stability of dredged material disposal sites; User's guide," Instruction Report DRP-95-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, P. R., and Palermo, M. R. (1990). "The automated dredging and disposal alternatives management system (ADDAMS)," Technical Note EEDP-06-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Science Applications International Corporation (SAIC). (1990). "Capping survey, New London disposal site, Feb. 3, 1989," DAMOS Contribution Number 71, U.S. Army Corps of Engineers, New England Division.

__________. (1995a). "Sediment capping of subaqueous dredged material disposal mounds: An overview of the New England experience, 1979-1993," DAMOS Contribution #95. SAIC Report No. SAIC-90/7573&c84 prepared for the U.S. Army Engineer Division, New England, Waltham, MA.

__________. (1995b). "Monitoring cruise at the central Long Island Sound disposal site, July 1990," DAMOS Contribution #94, U.S. Army Engineer Division, New England, Waltham, MA.

__________. (1996). "Monitoring cruise at the Portland Disposal Site, July 1992," DAMOS Contribution Number 108, U.S. Army Corps of Engineers, New England Division.

Scott et al. (1987). "Impact of open-water disposal of Black Rock Harbor dredged material on benthic recolonization at the FVP site," Technical Report D-87-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sea Surveyor, Inc. (1994). "Queens Gate dredging geotechnical and chemical investigation," Report prepared for the Port of Long Beach, Benicia, CA.

Shields, F. D., and Montgomery, R. L. (1984). "Fundamentals of capping contaminated dredged material." *Proceedings of the Conference Dredging '84,* American Society of Civil Engineers, 1, 446-460.

Silva, A. J., Brandes, H. G. Uchytil, C. J., Fredette, T. J., and Carey, D. (1994). "Geotechnical analysis of capped dredged material mounds." *Proceedings of Dredging '94,* ASCE, New York, 410-419.

Stark, T. D. (1991). "Program documentation user's guide: PSDDF89, primary consolidation and desiccation of dredged fill," Instruction Report D-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Stark, T. D. "Program documentation and user's guide: PSDDF, secondary consolidation and desiccation of dredged fill," Report in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sturgis, T., and Gunnison, D. (1988). "A procedure for determining cap thickness for capping subaqueous dredged material deposits," Technical Note EEDP-01-09, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sumeri, A. (1984). "Capped in-water disposal of contaminated dredged material." *Proceedings of the Conference Dredging '84,* American Society of Civil Engineers, 2, 644-653.

_________. (1989). "Confined aquatic disposal and capping of contaminated bottom sediments in Puget Sound." *Proceedings of the WOD-CON XII, Dredging: Technology, Environmental, Mining, World Dredging Congress, Orlando, FL, 2-5 May 1989.*

_________. (1995). "Dredged material is not a spoil: A status on the use of dredged material in Puget Sound to isolate contaminated sediments." *Proceedings of the 14th World Dredging Congress, World Organization of Dredging Associations, Amsterdam, The Netherlands.*

Sumeri, A., Fredette, T. J., Kullberg, P. G., Germano, J. D., Carey, D. A. (1991). "Sediment chemistry profiles of capped in-situ dredged sediment deposits: Results from three U.S. Army Corps of Engineers offices." *WEDA XII Western Dredging Association and Twenty-fourth Annual Dredging Seminar.*

Sumeri, A., Fredette, T. J., Kullberg, P. G., Germano, J. D., Carey, D. A., and Pechko, P. (1994). "Sediment chemistry profiles of capped dredged material deposits taken 3 to 11 years after capping," Dredging Research Technical Note DRP-5-09, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sustar, J. F., and Ecker, R. M. (1972). "Monitoring dredge disposal on San Francisco Bay," OTC Paper #1660, Offshore Technology Conference, May 1972, II405-II412.

Suszowski, D. J. (1983). "Studies on capping of contaminated dredged material by the New York District, Corps of Engineers." *Management of Bottom Sediments Containing Toxic Substances: Proceedings of the 7th US/Japan Experts Meeting.* Prepared for the U.S. Army Corps of Engineers Water Resources Support Center by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 134-145.

Swart, D. H. (1976). "Predictive equations regarding coastal transports." *Proceedings of the 15th Coastal Engineering Conference.* ASCE, 1113-32.

Tavolaro, J. F. (1984). "A sediment budget study of clamshell dredging and ocean disposal activities in the New York Bight," *Environmental Geology and Water Science* 6(3), 133-140.

Teeter, A. M. (1988). "New Bedford Harbor Superfund project, Acushnet River estuary engineering feasibility study of dredging and dredged material disposal alternatives; Report 2, Sediment and contaminant hydraulic transport investigations," Technical Report EL-88-15, Report 2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Teeter, A. M., and Pankow, W. (1989). "Schematic numerical modeling of harbor deepening effects on sedimentation, Charleston, SC," Miscellaneous Paper HL-89-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thoma et al. (1993). "Efficiency of capping contaminated sediments in situ. 2. Mathematics of diffusion - absorption in the capping layer," *Environmental Science and Technology* 27(12).

Togashi, H. (1983). "Sand overlaying for sea bottom sediment improvement by conveyor barge." *Management of bottom sediments containing toxic substances: Proceedings of the 7th US/Japan Experts meeting.* Prepared for the U.S. Army Corps of Engineers Waters Resources Support Center by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 59-78.

Trawle, M. J., and Johnson, B. H. (1986). "Alcatraz disposal site investigation," Miscellaneous Paper HL-86-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Truitt, C. L. (1986a). "Fate of dredged material during open water disposal," Environmental Effects of Dredging Programs Technical Note EEDP-01-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1986b). The Duwamish Waterway capping demonstration project: Engineering analysis and results of physical monitoring," Technical Report D-86-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Truitt, C. L. (1987a). "Engineering considerations for capping subaqueous dredged material deposits—Background and preliminary planning," Technical Note EEDP-01-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1987b). "Engineering considerations for capping subaqueous dredged material deposits—Design concepts and placement techniques," Environmental Effects of Dredging Technical Note EEDP-01-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Truitt, C. L., Clausner, J. E., and McLellan, T. N. (1989). "Considerations for capping subaqueous dredged material deposits," *Journal of Waterway, Port, Coastal, and Ocean Engineering* 115(6).

U.S. Army Corps of Engineers (USACE). 1970. "Laboratory soils testing," Engineer Manual 1110-2-1906, Washington, DC.

__________. (1987). "Confined disposal of dredged material," Engineer Manual 1110-2-5027, Washington, DC.

__________. (1990). "New Bedford Harbor Superfund pilot study, evaluation of dredging and dredged material disposal," U.S. Army Engineer Division, New England, Waltham, MA.

__________. (1991). "Hydrographic surveying," Engineer Manual 1110-2-1003, Washington, DC.

U.S. Army Corps of Engineers/Environmental Protection Agency (USACE/EPA). (1984). "General approach to designation studies of ocean dredged material disposal sites," U.S. Army Engineer Water Resources Support Center, Fort Belvoir, VA.

__________. (1992). "Evaluating environmental effects of dredged material management alternatives - A technical framework," EPA842-B-92-008, Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, DC.

U.S. Department of Transportation. (1984). "Code of Federal regulations," Office of the Federal Register, National Archives and Records Services, General Services Administration, Washington, DC.

Van De Graff, J., and Van Overeem, J. (1979). "Evaluation of sediment transport formulae in coastal engineering practice," *Coast. Engrg.*, Amsterdam, 3, 1-32.

Van Rijn, L. C. (1989). "Handbook of sediment transport by currents and waves," Report H461, Delft Hydraulics Laboratory, Delft, The Netherlands.

Van Rijn, L. C. (1993). *Principles of sediment transport in rivers, estuaries and coastal seas.* Aqua Publications, Amsterdam, The Netherlands.

Van Wijck, J., and Smits, J. (1991). "Underwater disposal of dredged material: A viable solution for the maintenance of dredging works in the River Scheldt," Bulletin No. 73, Permanent International Association of Navigation Congresses.

Wang, X. Q., Thibodeaux, L. J., Valsaraj, K. T., and Reible, D. D. (1991). "Efficiency of capping contaminated bed sediments in situ. 1. Laboratory-scale experiments on diffusion-adsorption in the capping layer," *Environmental Science and Technology* 25(9).

Westerink, J. J., Bain, C. C., Luettich, R. A., Jr., and Scheffner, N. W. (1994). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuarines; Report 2, User's manual for ADCIRC-2DDI," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Westerink, J. J., Luettich, R. A., and Scheffner, N. W. (1993). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuaries; Report 3, Development of a tidal constituent data base for the western North Atlantic and Gulf of Mexico," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

White, P. (1972). "Sediment transport in channels: A general function," Report Int 104, Hydraulics Research Station, Wallingford, England.

Wiley, M. B. (1994). "DAMOS capping model verification," DAMOS Contribution #89, Contract report written by Science Applications International Corporation for U.S. Army Engineer District, New England, Waltham, MA.

__________. (1995). "Deep water capping," DAMOS Contribution #98, Contract report written by Science Applications International Corporation for U.S. Army Engineer District, New England, Waltham, MA.

Williams, D. T. (1983). "Tampa Bay dredged material disposal site analysis," Miscellaneous Paper HL-83-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Wong, K. S., and Duncan, J. M. (1984). "CONSOL: A computer program for 1-D consolidation analysis of layered soil masses," Report No. UCB/GT/84-06, Department of Civil Engineering, University of California, Berkeley, CA.

Zeller, R. W., and Wastler, T. A. (1986). "Tiered ocean disposal monitoring will minimize data requirements," *Oceans '86*, Marine Technology Society, Washington, DC, 3, 1004-1009.

Zeman, A. J. (1993). "Subaqueous capping of very soft contaminated sediments." *Fourth Canadian Conference on Marine Geotechnical Engineering, St. John's, Newfoundland.*

Appendix A
Glossary of Terms

Aquatic environment - The geochemical environment in which dredged material is submerged underwater and remains water saturated after disposal is completed.

Aquatic ecosystem - Bodies of water, including wetlands, that serve as the habitat for interrelated and interacting communities and populations of plants and animals.

Baseline - Belt of the seas measured from the line of ordinary low water along that portion of the coast that is in direct contact with the open sea and the line marking the seaward limit of inland waters.

Bioaccumulation - The accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material.

Capping - The controlled, accurate placement of contaminated material at an open-water site, followed by a covering or cap of clean isolating material.

Coastal zone - Includes coastal waters and the adjacent shorelands designated by a State as being included within its approved coastal zone management program. The coastal zone may include open waters, estuaries, bays, inlets, lagoons, marshes, swamps, mangroves, beaches, dunes, bluffs, and coastal uplands. Coastal-zone uses can include housing, recreation, wildlife habitat, resource extraction, fishing, aquaculture, transportation, energy generation, commercial development, and waste disposal.

Confined disposal - Placement of dredged material within diked nearshore or upland confined disposal facilities (CDFs) that enclose the disposal area above any adjacent water surface, isolating the dredged material from adjacent waters during placement. Confined disposal does not refer to subaqueous capping or contained aquatic disposal.

Confined disposal facility (CDF) - An engineered structure for containment of dredged material consisting of dikes or other structures that enclose a disposal area above any adjacent water surface, isolating the dredged material from adjacent waters during placement. Other terms used for CDFs that appear in the literature include "confined disposal area," "confined disposal site," and "dredged material containment area."

Contained aquatic disposal (CAD) - A form of capping that includes the added provision of some form of lateral containment (for example, placement of the contaminated and capping materials in bottom depressions or behind subaqueous berms) to minimize spread of the materials on the bottom.

Contaminant - A chemical or biological substance in a form that can be incorporated into or onto, or be ingested by, and that harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.

Contaminated sediment or contaminated dredged material - Contaminated sediments or contaminated dredged materials are defined as those that contain sufficient contaminants to warrant isolation from the benthic environment.

Disposal site or area - A precise geographical area within which disposal of dredged material occurs.

Dredged material - Material excavated from waters of the United States or ocean waters. The term dredged material refers to material that has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

Dredged material discharge - The term dredged material discharge as used in this document means any addition of dredged material into waters of the United States or ocean waters. The term includes open-water discharges; discharges resulting from unconfined disposal operations (such as beach nourishment or other beneficial uses); discharges from confined disposal facilities that enter waters of the United States (such as effluent, surface runoff, or leachate); and overflow from dredge hoppers, scows, or other transport vessels.

Effluent - Water that is discharged from a confined disposal facility during and as a result of the filling or placement of dredge material.

Habitat - The specific area or environment in which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for the maintenance of life. Typical coastal habitats include beaches, marshes, rocky shores, bottom sediments, mudflats, and the water itself.

Leachate - Water or any other liquid that may contain dissolved (leached) soluble materials, such as organic salts and mineral salts, derived from a solid material. For example, rainwater that percolates through a confined disposal facility and picks up dissolved contaminants is considered leachate.

Level bottom capping (LBC) - A form of capping in which the contaminated material is placed on the bottom in a mounded configuration.

Open-water disposal - Placement of dredged material in rivers, lakes, estuaries, or oceans via pipeline or surface release from hopper dredges or barges.

Sediment - Material, such as sand, silt, or clay, suspended in or settled on the bottom of a water body. Sediment input to a body of water comes from natural sources, such as erosion of soils and weathering of rock, or as the result of anthropogenic activities, such as forest or agricultural practices, or construction activities. The term dredged material refers to material that has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

Suspended solids - Organic or inorganic particles that are suspended in water. The term includes sand, silt, and clay particles as well as other solids, such as biological material, suspended in the water column.

Territorial sea - The strip of water immediately adjacent to the coast of a nation measured from the baseline as determined in accordance with the Convention on the territorial sea and the contiguous zone (15 UST 1606; TIAS 5639) and extending a distance of 3 nmi from the baseline.

Toxicity - Level of mortality or other end point demonstrated by a group of organisms that have been affected by the properties of a substance, such as contaminated water, sediment, or dredged material.

Toxic pollutant - Pollutants, or combinations of pollutants, including disease-causing agents, that after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator of the U.S. Environmental Protection Agency, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations in such organisms or their offspring.

Turbidity - An optical measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity can be harmful to aquatic life.

Appendix B Model for Chemical Containment by a Cap

by Dr. Danny D. Reible, Louisiana State University[1]

Introduction

This appendix describes a model for evaluation of chemical flux through a cap. Through use of this model, the effectiveness of chemical containment of a cap can be assessed. This model should be applied once remediation objectives are determined, a specific capping material has been selected and characterized, and a minimum cap thickness has been determined based on components for isolation, bioturbation, and consolidation. If the objective of the cap is attainment of a given contaminant flux, the model can be used to estimate the required cap thickness.

This model assumes that the cap is armored such that erosion of the cap does not provide the primary means of contaminant migration. Instead, the contaminants contained within the pore water of the sediment are available to migrate into the cap and subsequently into the overlying water. The pore water concentration, C_{pw}, is always assumed in a state of local equilibrium that is related to the sediment contaminant loading, ω_{sed}, milligrams contaminant per kilogram dry sediment, through an observed partition coefficient, K_d^{obs}, as

$$\omega_{sed} = K_d^{obs} C_{pw} \tag{B1}$$

Thus the initial pore water concentration in the sediment, C_0, is given by

$$C_0 = C_{pw} = \frac{\omega_{sed}}{K_d^{obs}} \tag{B2}$$

[1] This appendix is identical to Appendix B of the report entitled "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments" (Palermo et al. 1996).

The difference between this concentration and the concentration in the overlying water defines the driving force for contaminant release to that water. In addition, it is normally this concentration that defines the sediment quality criteria because it is this concentration that defines the contaminant levels to which benthic organisms are exposed. Benthic organisms are generally the most sensitive organisms in the sediment environment, and any contaminants that they may accumulate may be transferred higher in the food chain. Isolation of contaminants from these benthic organisms is one of the most important motivations for placement of a cap. The objective is to place a cap of sufficient thickness to realize this isolation.

Relationship Between Sediment and Pore Water Concentrations

Equation B1 defines an observed partition coefficient between the sediment and the adjacent pore water. Use of a measured partition coefficient does not require linearity or reversibility of the sorption isotherm, nor does it require specification of the form of the contaminant in the pore water (e.g., dissolved or bound to particles). For a compound that sorbs to soil with an observed partition coefficient of K_d^{obs} (liters/kilogram), the ratio of the total concentration in the soil to that in the pore water is given by the retardation factor, R_f,

$$R_f = \epsilon + \rho_b K_d^{obs} \tag{B3}$$

The retardation factor is so named because contaminant migration in the pore water is slowed by the sorption onto the immobile sediment phase.

The value of K_d^{obs} for either the sediment or the cap should be determined directly by evaluating the ratio of sediment or cap loading to pore water concentration. In the absence of direct measurement of pore water concentrations, however, the value of K_d^{obs} can be estimated for hydrophobic organic compounds that tend to sorb reversibly and nonselectively upon organic matter in the sediment or pore water. For these compounds, the observed partition coefficient can be normalized by the amount of organic carbon present in the sediment or pore water to define a "universal" partition coefficient, K_{oc}, that should be constant for a particular compound. Given such a contaminant at concentration ω_{sed} in the sediment, the concentration dissolved in the pore water is given by

$$C_{diss} = \frac{\omega_{sed}}{K_{oc}\, f_{oc}} \tag{B4}$$

Here f_{oc} is the fraction organic carbon in the sediment in mass organic carbon per mass dry sediment. The same relation applies to the capping material if the concentrations and properties are characteristic of the cap rather than the underlying sediment.

In addition, the water in the pores contains contaminant sorbed to organic carbon (dissolved or particulate organic carbon present at concentration ρ_{oc}, e.g., in milligrams/liter). To a first approximation, the partitioning to this suspended organic matter is also governed by the organic carbon based partition coefficient, K_{oc}, and thus the total pore water concentration for that compound is given by

$$
\begin{aligned}
C_{pw} &= C_{diss}\,(1 + \rho_{oc}K_{oc}) \\
&= \frac{\omega_{sed}}{K_{oc}f_{oc}}\,(1 + \rho_{oc}K_{oc})
\end{aligned}
\qquad \text{(B5)}
$$

Note, however, that the truly dissolved concentration can never exceed the solubility of the contaminant in water, C_w^*, and therefore the pore water concentration is bounded by

$$
C_{pw} \le C_w^*\,(1 + \rho_{oc}K_{oc}) \qquad \text{(B6)}
$$

As a result of this limit, there exists a critical sediment loading, ω_{crit}, above which the contaminant concentration in the pore water is independent of the sediment loading. The dissolved concentration is always given by the water solubility under these conditions, and the total pore water concentration is given by the equality in Equation B5.

$$
\begin{aligned}
&\omega_{crit} = K_{oc}\,f_{oc}\,C_W^* \\
&For\ \omega_{sed} > \omega_{crit} \qquad C_{pw} = C_w^*\,(1 + \rho_{oc}K_{oc})
\end{aligned}
\qquad \text{(B7)}
$$

Thus the observed sediment-water partition coefficient for a hydrophobic organic compound is given by

$$
\begin{aligned}
K_d^{obs} &= \frac{\omega_{sed}}{C_0} && \textit{if measurements are available} \\
&= \frac{K_{oc}\,f_{oc}}{(1 + \rho_{oc}K_{oc})} && \textit{estimate if}\ \omega_{sed} \le \omega_{crit} \\
&= \frac{\omega_{sed}}{C_w^*\,(1 + \rho_{oc}K_{oc})} && \textit{estimate if}\ \omega_{sed} \ge \omega_{crit}
\end{aligned}
\qquad \text{(B8)}
$$

Effective Thickness of a Cap

The effective thickness, L_{eff}, of a cap is reduced by consolidation of the cap, ΔL_{cap}, consolidation in the underlying sediment, ΔL_{sed}, and by bioturbation over a depth, L_{bio}. Bioturbation, the normal life-cycle activities of benthic organisms, leads to mixing and redistribution of contaminants and sediments in the upper layer. The chemical migration rate within the bioturbated zone is typically much faster than in other portions of a cap. In addition, consolidation typically occurs on a time scale that is rapid compared with the design lifetime of a cap. Consolidation of the cap directly reduces the thickness of a cap and the separation between contaminants and the overlying water or benthic organisms while consolidation of the underlying sediment results in the expression of potentially contaminated pore water. Using $\Delta L_{sed,A}$ to represent the thickness of a cap compromised by a contaminant A during consolidation of the underlying sediment, the effective cap thickness remaining for chemical containment is given by

$$L_{eff} = L_0 - L_{bio} - \Delta L_{cap} - \Delta L_{sed,A} \tag{B9}$$

where L_0 is the initial thickness of the cap immediately after placement.

The depth of bioturbation can be assessed through an evaluation of the capping material and recognition of the type, size, and density of organisms expected to populate this material. Because of the uncertainty in this evaluation, the bioturbed zone is generally chosen conservatively, that is, considered to be as large as the deepest penetrating organism likely to be present. Due to the action of bioturbating organisms, this layer is also generally assumed to pose no resistance to mass transfer between the contaminated sediment layer and the overlying water.

The consolidation of a cap can be estimated through use of standard consolidation models; for example, the Corps of Engineers' Primary Consolidation and Dessication of Dredged Fill (PCDDF) model (Stark 1991). Note, however, that in addition to reducing the thickness of a cap, consolidation serves to reduce both the porosity and permeability of a cap causing reductions in chemical migration rates by both advection and diffusion.

The consolidation of the underlying contaminated sediment can also be estimated through consolidation models. These models do not predict the resulting movement of the chemical, however, and a model is described below. The effective cap thickness estimated by Equation B9 is subject to chemical migration by advection and diffusion processes. The long-term chemical flux to the water via these processes can be modeled.

The complete model of chemical movement through the cap must be composed of two components:

- An advective component considering the short-term consolidation of the contaminated sediment underlying the cap.

- A diffusive or advective-dispersive component considering contaminant movement as a result of pore water movement after the cap has fully consolidated.

The first component is operative for all caps but only for a short period of time. The first component allows determination of the effective cap thickness through Equation B9. The resulting effective cap thickness can then be used to assess long-term losses through the cap by advective and/or diffusive processes.

For simplicity and conservatism, the sediment underlying a cap may be assumed to remain uniformly contaminated at the concentration levels prior to cap placement. In reality, migration of contaminants into the cap reduce the sediment concentration and the long-term flux to the overlying water. The consideration of this situation, however, complicates the analysis and the models used to describe contaminant flux. Analytical models are presented for the case of constant concentration in the underlying sediment. The results of a numerical model that incorporates the depletion of the underlying sediment concentrations are referenced for comparison.

Model for Short-Term Cap Losses—Advection During Cap Consolidation

After placement of capping materials, consolidation of both the cap and the underlying sediment occurs. Consolidation of the cap results in no contaminant release since the cap is initially free of contamination. Furthermore, the consolidation of the cap serves to reduce the permeability and, to a lesser extent, the porosity of a cap. Both serve to reduce contaminant migration through the cap by both diffusive and advective processes.

Consolidation of the underlying sediment due to the weight of the capping material, however, tends to result in expression of pore water and the contaminants associated with that water. The ultimate amount of consolidation may be estimated using standard methods; for example, the previously referenced PCD model. The consolidation of the underlying sediment is likely to occur over a short period (e.g., months) compared with the lifetime of the cap. It is appropriate, therefore, to assume that the consolidation occurs essentially instantaneously and estimate the resulting contaminant migration solely on the basis of the total depth of consolidation and the pore water expressed. For a nonsorbing contaminant, the penetration depth of the chemical is identical to that of the expressed pore water. For a sorbing contaminant, the penetration depth is less as a result of the accumulation of chemical on the sediment.

Mathematically, if ΔL_{sed} represents the ultimate depth of consolidation of the underlying contaminated sediment due to cap placement, the depth of cap affected by this pore water (or nonsorbing contaminant), $\Delta L_{sed,pw}$, is given by

$$\Delta L_{sed,pw} \approx \frac{\Delta L_{sed}}{\epsilon} \tag{B10}$$

where ϵ is the porosity of the cap materials. The division by the cap porosity recognizes that the expressed pore water moves only through the void volume formed by the spaces between the grains of the capping material. Equation B10 assumes that the capping material is spatially uniform and that pore water is not preferentially forced through a small fraction of the total cap area.

Although the depth of cap affected by the expressed pore water is given by Equation B10, the migration distance of a sorbing contaminant is less due to accumulation in the cap. The quantity of contaminant that can be rapidly adsorbed by the cap material, ω_{cap} (milligrams/kilogram dry cap material), is generally assumed to be proportional to the concentration in the pore water (C_{pw}, milligrams/liter),

$$\omega_{cap} = K_{d,cap}^{obs} C_{pw} \tag{B11}$$

where the constant of proportionality is the observed sediment-water partition coefficient in the cap. Note that the observed partition coefficient is measured during sorption onto clean cap material since this is the conditions that occur after placement of a clean cap onto contaminated sediment. The maximum quantity that can be sorbed by the cap is given by the product of the observed partition coefficient and the initial pore water concentration of the contaminant in the underlying sediment, C_0.

As a result of sorption onto the immobile sediment, the distance that the contaminant migrates in the cap during consolidation of the underlying sediment by a distance ΔL_{sed} is given by

$$\Delta L_{sed,A} \approx \frac{\Delta L_{sed}}{R_f} \approx \frac{\Delta L_{sed}}{\epsilon + \rho_b K_{d,cap}^{obs}} \tag{B12}$$

This distance must be subtracted from the actual cap thickness to estimate effective cap thickness. Note that this model suggests that the more sorbing a cap, the less important is consolidation in the underlying sediment. Sorption for hydrophobic organics such as polyaromatic hydrocarbons and polychlorinated biphenyls is strongly correlated with the organic carbon content of the sediments. $K_{d,cap}^{obs}$ is typically of the order of hundreds or thousands for these compounds; if a cap contains 0.5-percent organic carbon or more, the loss of effective cap thickness due to penetration of the contaminant is a small fraction of the sediment consolidation distance. Metals also tend to be strongly associated with the solid fraction, again reducing the migration of contaminant out of the sediment as a result of consolidation.

Estimation of Long-Term Losses

Mechanisms and driving force

The effective cap thickness defined by Equation B9 is subject to advection or diffusion or a combination of both throughout the lifetime of the cap. The long-term contaminant release or loss requires estimation of the contaminant flux by these processes. Diffusion is always present, while advection only occurs if there exists a significant hydraulic gradient in the underlying sediments. The relative magnitude of diffusion to advection in the cap of effective thickness, L_{eff}, can be estimated by the Peclet number.

$$Pe = \frac{U_{pw} L_{eff}}{D_{eff}} \qquad \text{(B13)}$$

where

U_{pw} = advective velocity (Darcy or superficial velocity) in the sediment

D_{eff} = effective diffusion/dispersion coefficient

If the magnitude or absolute value of the Peclet number is much greater than one, advection dominates over diffusion/dispersion, while the opposite is true for absolute values much less than one. Advection directed out of the cap will speed contaminant release, while advection directed into the sediment will effectively lengthen the cap.

The average groundwater flow velocity is estimated from the sediment conductivity (K, centimeters/second) or permeability (K, square centimeters) and the local hydraulic gradient.

$$U_{pw} = -K \frac{\partial h}{\partial z} = -\frac{k \rho g}{\mu} \frac{\partial h}{\partial z} \qquad \text{(B14)}$$

where

ρ = density of water (~1 g/cm^3)

g = acceleration of gravity (980 cm·sec^{-2})

μ = viscosity of water (~0.01 g·cm^{-1}·sec^{-1})

$\frac{\partial h}{\partial z}$ = local gradient in hydraulic head with distance into sediment

The minus sign recognizes that the groundwater flow is to regions of lesser hydraulic head. The average groundwater flow is the volumetric seepage rate (volume/time) divided by the sediment-water interfacial area. Thus, lakes with large sediment-water interfacial areas tend to exhibit less potential for advective influences than small streams. Estuarine systems subject to significant tidal fluctuations may also exhibit significant advective transport. Losing streams, in which the advective transport is into the sediment, may exhibit advection but may not be important since the direction of transport is away from the sediment-water interface and long travel distances may be required to impact groundwater of significance. Similarly, advection may be less important in wetlands subject to frequent cycles of flooding followed by infiltration due to the downward vector of advection. The presence of a cap will tend to reduce any advective transport by preferentially channeling flow to uncapped sediment. The permeability of the cap materials may also be selected or modified to minimize advection.

The effect of advection includes both transport by the pore water flow and that by diffusion and dispersion. Dispersion is the additional "diffusion-like" mixing relative to the average pore water velocity that occurs as a result of heterogeneities in the sediments. Thus the description of advection is more complicated than diffusion, and the model for long-term cap losses will be subdivided into models appropriate only when diffusion dominates and models when both advection and diffusion/dispersion are important.

Both processes are operative only for that portion of the contaminant present in the pore water as measured by the concentration C_0. This might include contaminant dissolved in the pore water as well as contaminant sorbed to fine particulate or colloidal matter suspended in the pore water. The best measure of this concentration is through direct pore water measurements. In the absence of pore water measurements, however, linear reversible sorption can be assumed and Equations B5 or B7 apply,

$$C_0 = \begin{cases} \dfrac{\omega_{sed}}{K_{oc}\, f_{oc}} (1 + \rho_{oc} K_{oc}) & \textit{if } \omega_{sed} \leq \omega_{crit} \\ C_w^* \,(1 + \rho_{oc} K_{oc}) & \textit{if } \omega_{sed} \geq \omega_{crit} \end{cases} \tag{B15}$$

where

C_w^* = equilibrium solubility of chemical in water

ω_{sed} = sediment loading (milligrams chemical/kilogram (dry) sediment)

Equation B15 indicates that the pore water concentration increases linearly with the sediment loading until the water is saturated, that is, until the solubility limit is reached. This limit is the normal water solubility adjusted for the sorption onto organic matter in the pore water.

Degradation of contaminants over the long time of expected confinement is a significant benefit of capping that should be incorporated into the design of a cap. Polyaromatic hydrocarbons as well as chlorinated aliphatic and aromatic compounds all exhibit slow but finite rates of degradation or transformation in the generally anaerobic environment beneath a cap. If simple first order degradation kinetics is employed, the sediment loading changes with time according to

$$\omega_{sed} = \omega_{sed}^0 \, e^{-k_r t} \tag{B16}$$

where

ω_{sed}^0 = sediment loading at time of cap placement

k_r = exponential time constant given by $0.693/t_{0.5}$

$t_{0.5}$ = chemical half life in sediment

In the absence of dependable data on rates of degradation or transformation, the conservative assumption of no contaminant depletion is generally assumed.

In the subsequent sections, the movement of contaminants from the sediments through the cap by both diffusion and advection are evaluated. The focus is on the development of simple analytical models that can be expressed in algebraic form. This generally limits the conditions evaluated to uniform sediment and cap physical and chemical properties and an initial contaminant concentration that is both uniform in the sediment and constant. Depletion of contaminant in the sediment by either chemical degradation or mass depletion as a result of the release of material through the cap is not considered. The models are thus conservative indicators of contaminant release from the sediment (that is, they overestimate the concentration in the sediment or the flux of contaminant to the overlying water column).

Diffusion

Diffusion is a process that occurs at significant rates only within the pores of the sediment and is driven by the difference in pore water concentration between the sediment and the cap. The initial concentration of the contaminant in the cap pore water is generally zero, while the concentration in the sediment is given by Equation B15. Even without degradation, however, migration of contaminants into the cap will deplete the underlying sediments as a result of the loss of mass by diffusion through the cap.

Thoma et al. (1993) developed a model of diffusion through a cap that explicitly accounts for depletion in the underlying sediment. A simpler model of diffusion through the cap, however, assumes that the contaminant concentration in the underlying sediment is essentially constant. This would be most appropriate if the contaminant concentration in the sediment far exceeds the critical concentration defined by Equation B7. Because the assumption of no depletion in the underlying sediment overpredicts the driving force for diffusion, and therefore the flux through the cap, it represents a conservative assumption of the effectiveness of the cap. It will therefore be employed in the description that follows.

One should first estimate the steady long-term flux of contaminants through the cap via diffusion. This is the maximum flux that can occur through the cap by the diffusive mechanism.

Maximum flux estimation (steady state)

If diffusion is the only operative transport process through the cap, the pseudo steady-state flux through the cap (assuming constant contaminated sediment pore water concentration and no sorption effects in the cap layer) is given by

$$F = \frac{D_{eff}}{L_{eff}} (C_0 - C_w) \approx K_{cap}(C_0 - C_w) \tag{B17}$$

where

F = chemical flux, $ng \cdot cm^{-2} \cdot sec^{-1}$

D_{eff} = effective binary diffusivity of chemical in cap, cm^2/sec

ε = sediment porosity (void volume/total volume)

L_{eff} = effective cap thickness

C_0 = pore water concentration in sediment beneath cap including dissolved and sorbed to colloidal species, ng/cm^3

C_w = total contaminant concentration in overlying water, ng/cm^3

K_{cap} = effective mass transfer coefficient through cap, cm/sec

The effective diffusion coefficient is generally estimated by the equation of Millington and Quirk (1961)

$$D_{eff} = D_w \, \epsilon^{4/3} \tag{B18}$$

where

D_w = molecular diffusivity of compound in water

ϵ = void fraction or porosity of sediment

Millington and Quirk suggest the factor $\varepsilon^{4/3}$ to correct for the reduced area and tortuous path of diffusion in porous media.

In general, the chemical flux is influenced by bioturbation and a variety of water column processes. Figure B1 shows the definitions of fluxes in a capped system at this pseudo steady state. The flux of chemical through each layer is equal to the sum of the rate of evaporation and flushing. Mathematically, in terms of mass transfer coefficients, one has:

$$\begin{aligned} M &= K_{ov}A_s\, C_0 = K_{cap}A_s(C_0 - C_{bio}) = K_{bio}A_s(C_{bio} - C_{sw}) \\ &= K_{bl}A_s\,(C_{sw} - C_w) = (K_eA_e + Q)C_w \end{aligned} \tag{B19}$$

where

M = rate of chemical loss from system, mg/day = $F*A_s$

K_{ov} = overall mass transfer coefficient, cm/day

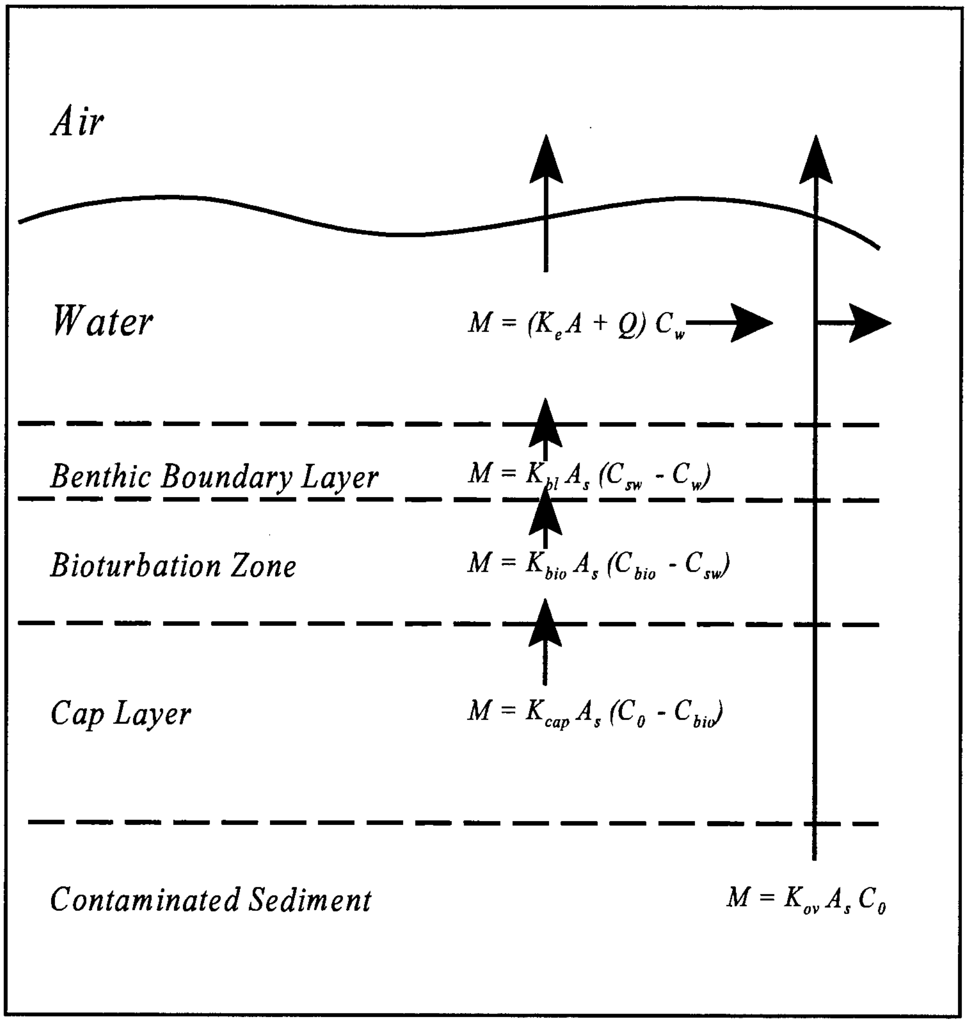


Figure B1. Idealized multilayer contaminant release rates showing individual and overall mass transfer coefficient definitions

A_s = contaminated sediment area, m^2

A_e = evaporative surface area, m^2

C_0 = pore water concentration within contaminated sediment including dissolved and any sorbed to colloidal material

K_{cap} = cap mass transfer coefficient = $D_w\, \epsilon^{4/3}/L_{eff}$, cm/day

C_{bio} = pore water concentration at top of cap, ng/cm^3

K_{bio} = bioturbation mass transfer coefficient = $\dfrac{\eta D_{bio}\, R_f}{L_{bio}}$, cm/day

C_{sw} = pore water concentration at sediment water interface, ng/cm^3

η = desorption efficiency of contaminant from sediment particles

D_{bio} = biodiffusion coefficient, cm^2/day

R_f = retardation factor = $\epsilon + \rho_B K_d^{obs}$

L_{bio} = depth of bioturbation, cm

K_{bl} = benthic boundary layer mass transfer coefficient, cm/day

K_e = evaporation mass transfer coefficient, cm/day

D_e = effective diffusivity = $D_w \cdot \epsilon^{4/3}$, cm^3/day

Q = basin flushing rate, cm^3/day

C_w = chemical concentration in the overlying water, ng/cm^3

K_d = sediment water partition coefficient for chemical = $K_{oc} foc$, cm^3/g

K_{oc} = organic carbon-water coefficient for chemical, cm^3/g

f_{oc} = sediment fractional organic carbon content

ρ_B = sediment bulk density

The overall mass transfer coefficient, K_{ov}, can be obtained from the following

$$\frac{1}{K_{ov}} = \frac{1}{K_{cap}} + \frac{1}{K_{bio}} + \frac{1}{K_{bl}} + \frac{A_s}{K_e A_e + Q} \tag{B20}$$

An analysis of this relationship for reasonable values of L_{eff} suggests that $1/K_{ov} \cong 1/K_{cap}$; therefore, the cap controls the flux to the overlying water, and Equation B17 is valid.

This flux can be used to estimate concentrations in the water (C_w) or at the sediment water interface (C_{sw}) or multiplied by the capped area to determine total release rate. For hydrophobic organics, the concentration in the overlying water at steady state is defined by a balance between the flux through the cap, the rate of evaporation to the air, and the rate of flushing of the water column. For metals and elemental species not associated with volatile compounds, the flux through the cap is balanced only with the flushing of the water column. The overlying water concentration of the contaminant is given by:

$$C_w = \left(\frac{K_{ov} A_s}{K_e A_\ell + Q} \right) C_0 \tag{B21}$$

The concentration at the cap-water interface, which would be indicative of the level of exposure of bottom-surface dwelling organisms, is defined by the balance of the flux through the cap with the flux through the benthic boundary layer. The contaminant concentration at the cap-water interface is:

$$C_{cw} = \frac{K_{ov} C_0}{K_{bl}} + C_w \tag{B22}$$

Either of these concentrations or the estimated fluxes may be compared with applicable criteria for the chemical in question to determine if a specified cap thickness is adequate.

Transient diffusion—breakthrough time estimation

The simple steady-state analysis presented above is not capable of predicting the time required for the contaminant(s) to migrate through the cap layer. Until sorption and migration in the cap is complete, the flux to the water column will be less than predicted by Equation B17. Addressing this problem requires incorporation of time explicitly in the differential mass balance. The following partial differential equation represents a differential mass balance on the contaminant in the pore water of the cap as it diffuses from the contaminated sediment below.

$$R_f \frac{\partial C_{pw}}{\partial t} = D_w \varepsilon^{4/3} \frac{\partial^2 C_{pw}}{\partial z^2} \tag{B23}$$

The conditions of a constant concentration at the sediment-cap interface are applied as specified by Equation B15 and the concentration of the overlying water at the height L_{eff} in the cap. Carslaw and Jaeger (1959) present a solution to the equivalent heat transfer problem that in terms of concentration and mass diffusion can be written

$$F_{diff} = \frac{(C_0 - C_w)\, D_{eff}}{L_{eff}} \left[1 + 2\sum_{n=1}^{\infty} (-1)^n \exp\left(-\frac{D_{eff}\{n\pi\}^2 t}{R_f L_{eff}^2} \right) \right] \tag{B24}$$

where D_{eff} represents $D_w \epsilon^{4/3}$. This solution is also given in this form by Thoma et al. (1993). Note that as $t \rightarrow \infty$, the exponential term approaches zero and the flux approaches the value obtained by the approximation $K_{ov} \approx D_{eff} / L_{eff}$ as indicated by Equation B17. From Equation B24, one can obtain relations for the breakthrough time and the time required to approach the steady-state flux.

Breakthrough time, τ_b, is defined as the time at which the flux of contaminant from the contaminated sediment layer has reached 5 percent of its steady-state value, and the time to reach steady state, τ_{ss}, is defined as the time when the flux is 95 percent of its steady-state value. It is easily shown that

$$\tau_b = \frac{0.54 L_{eff}^2 R_f}{D_w \varepsilon^{4/3} \pi^2} \tag{B25}$$

and

$$\tau_{ss} = \frac{3.69 L_{eff}^2 R_f}{D_w \varepsilon^{4/3} \pi^2} \tag{B26}$$

Advective-dispersive models

When advection cannot be neglected during the operation of a cap, the basic equation governing contaminant movement is

$$R_f \frac{\partial C_{pw}}{\partial t} + U \frac{\partial C_{pw}}{\partial z} = D_{disp} \frac{\partial^2 C_{pw}}{\partial z^2} \tag{B27}$$

where

C_{pw} = contaminant concentration in pore water

$U = U_{pw}$ = Darcy velocity directed outward

D_{eff} = effective diffusion/dispersion coefficient

The effective diffusion/dispersion coefficient is often modeled by a relationship of the form (Bear 1979)

$$\begin{aligned} D_{disp} &= D_{eff} + \alpha U \\ &\approx D_w \, \epsilon^{4/3} + \alpha U \end{aligned} \tag{B28}$$

The first term in this relation is associated with molecular diffusion and is again modeled by the Millington and Quirk (1961) relation. The second term is mechanical dispersion associated with the additional mixing due to flow variations and channeling. α is the dispersivity and is typically taken to be related to the sediment grain size (uniform sandy sediments) or travel distance (heterogeneous sediments). Little guidance exists for the estimation of field dispersivities for vertical flow in sediments. In uniform sandy sediments, the longitudinal dispersivity is approximately one-half the grain diameter, while the transverse dispersity tends to be an order of magnitude smaller (Bear 1979). Dispersion in heterogeneous sediments would be expected to be larger than these estimates.

If the effective dispersivity can be estimated, the contaminant concentration and flux through the cap can be estimated by solutions to Equation B27. One should first consider the long-time behavior of Equation B27 when the sediment originally exhibits a contaminant pore water concentration C_0. If the contaminant is not subject to significant depletion by either degradation or migration through the cap, the flux through the cap ultimately reaches that given by

$$F_{adv} \rightarrow U\,(C_0 - C_w) \qquad as\ t \rightarrow \infty \tag{B29}$$

That is, the contaminant flux due to advection approaches that which would be observed if no cap were placed over the sediment. In such a situation, the cap can be viewed only as a temporary confinement measure until the sediment is removed or depletion renders the contaminant harmless. It should be emphasized, however, that this will only occur when depletion of contaminant in the capped sediment is negligible, a conservative assumption that may significantly overestimate the flux of contaminant through the cap. This assumption is compared with more realistic approaches in an example below.

In the advection-dominated case, it is important to examine the transient release of the contaminant. The conditions on Equation B27 that are appropriate for a cap include

$$\begin{array}{rl} cap\text{-}sediment\ interface\ (z=0) & C_{pw} = C_0 \\ cap\text{-}water\ interface\ (z=L_{eff}) & C_{pw} = C_w \quad (Generally\ C_w \approx 0) \\ initial\ cap\ concentration & C_{pw} = C_w \end{array} \tag{B30}$$

Available analytical solutions describe only homogeneous cap properties and do not satisfy the cap-water interface condition of Equation B30. Instead there are two approximate conditions that are commonly applied instead of the cap-water interface condition.

$$\begin{array}{lll} \dfrac{\partial C_{pw}}{\partial z} = 0 & at\ z = L_{eff} & (finite\ cap) \\ \dfrac{\partial C_{pw}}{\partial z} = 0 & as\ z \rightarrow \infty & (infinite\ cap) \end{array} \tag{B31}$$

The first explicitly recognizes the finite thickness of the cap, while the second assumes that it is infinitely thick. The solution subject to the finite boundary condition is given by Cleary and Adrian (1973), while the solution subject to the infinite boundary condition can be found in Carslaw and Jaeger (1959). For Pe > 1, however, the concentration and flux predictions of either model are essentially identical. Moreover, for Pe < 1 when diffusion dominates, the given finite cap condition is inappropriate and causes the solution to underpredict the contaminant flux through the cap. The solution for the infinite cap is also simpler to use. For these reasons, only the infinite cap model will be described in this section. However, the full boundary conditions of Equation B30 or heterogeneous sediment properties can be described using numerical solvers as illustrated in the example.

The solution to Equation B27 subject to the infinite cap condition in homogeneous sediment is given by

$$C_{pw}(z,t) = \frac{(C_0 - C_w)}{2}\left[erfc\left(\frac{R_f z - Ut}{2\sqrt{R_f D t}}\right) + \exp\left(\frac{Uz}{D}\right) erfc\left(\frac{R_f z + Ut}{2\sqrt{R_f D t}}\right)\right] \tag{B32}$$

Here *erfc* represents the complementary error function that is given by 1 - *erf*, the error function. The error function is a tabulated function (e.g., Thibodeaux 1996) and is commonly available in spreadsheets and computer languages. It ranges from 0 at a value of the argument equal to zero to 1 at a value of the argument equal to infinity. The model is most useful in predicting the penetration of the contaminant into the cap and the time until the sediment-water interface begins to be significantly influenced by the cap, i.e., the breakthrough time. The breakthrough time can be estimated by evaluating Equation B32 for $z = L_{eff}$ and determining the time required until $C_{pw}(L_{eff},t)$ is equal to some fixed fraction of the concentration in the underlying sediment; for example, until $C_{pw}(L_{eff},t) = 0.05\ C_0$. The flux into the overlying water at any time could also be evaluated by computing

$$F(L_{eff},t) = U\ C_{pw}(L_{eff},t) - D_{eff}\frac{\partial C_{pw}(L_{eff},t)}{\partial z} \tag{B33}$$

Note that Equations B32 and B33 can also be applied to conditions of mild erosion or deposition on the cap. Erosion or deposition give rise to an effective velocity directed downward with deposition and upward with erosion. Because erosion buries or uncovers sediment and its associated contaminants, the effective velocity influencing the pore water concentration is the erosion or deposition velocity multiplied by the retardation factor.

$$U = \begin{matrix} U_{pw} + U_{erosion} R_f & \quad \textit{Erosion} \\ U_{pw} - U_{deposition} R_f & \quad \textit{Deposition} \end{matrix} \tag{B34}$$

That is, sediment burial or deposition gives rise to a rapid burial or exposure of contaminants as a result of the sorbed load on the sediment particles.

Models for More General Cases: Numerical Solutions

All of the models discussed thus far assume that the concentration in the sediment remains unchanged despite the loss of contaminant to the overlying water. This simplification is necessary to apply the presented analytical solutions but leads to overly conservative results. For example, in an advective dominated system, Equation B29 will describe the flux to the overlying water at long time only if depletion is not accounted for. It should be emphasized that the depletion referred to here is simply accounting for the mass of contaminant lost to the overlying water. Degradation of the contaminant is not considered.

To overcome this limitation of the preceding models, it is necessary to turn to a numerical simulation of Equation B27. The numerical simulation should apply Equation B27 both within the cap and in the underlying sediment assuming that the concentrations and fluxes are continuous at the sediment water interface. Arbitrary initial and boundary conditions could be applied. For the particular case of an initially clean sediment cap overlying a finite layer of contaminated sediment, the author has developed such a numerical solution. This model is coded in FORTRAN and employs IMSL subroutines to conduct the numerical calculations. An illustrative example using the model is presented later as is a contact address for acquisition of the model.

Models for Uncapped Sediment

Although the primary purpose is the evaluation of contaminant concentrations and fluxes associated with capped sediment, it is often convenient to compare these quantities with concentrations and fluxes that would be observed in the absence of a cap. Models similar to those above are available for uncapped conditions and are especially useful for comparison purposes.

Let us consider the solution to Equation B27 subject to the uncapped boundary conditions

$$\begin{aligned} &\textit{sediment-water interface } (z=0) && C_{pw} = C_w \\ &\textit{deep sediment } (z\rightarrow\infty) && C_{pw} = C_0 \textit{ or } \frac{\partial C_{pw}}{\partial z} \rightarrow 0 \\ &\textit{initial sediment concentration} && C_{pw} = C_0 \end{aligned} \tag{B35}$$

These are the same conditions, however, as those leading to Equation B32 if the z coordinate is directed into the sediment rather than out through the cap and if the roles of C_0 and C_w are reversed. Thus Equation B32 can be used to evaluate concentrations in the uncapped case as well. Both the sense of U and z must be reversed, and $z = 0$ now represents the sediment-water interface. Similarly, the flux from the sediment to the overlying water is given by

$$F(0,t) = U\, C_{pw}(0,t) - D_{eff} \frac{\partial C_{pw}(0,t)}{\partial z} \tag{B36}$$

Similarly, finite contaminated layer models could be adapted from Equation B24. This would not be a fair basis for comparison, however, in that the uncapped model would explicitly account for depletion of the sediment contaminants as a result of the loss to water while the cap version of the solution assumes that the sediment concentration remains constant.

Parameter Estimation

Use of any of the above models requires estimation of a variety of model parameters. The most important of these parameters and an example calculation are presented below. These include the porosity (ϵ), bulk density (ρ_b), and organic carbon content (f_{oc}) of the cap material; the partition coefficient (K_d) for the chemical(s) between the pore water and the cap material; the diffusivity of the chemical(s) in water (D_W); the depth of bioturbation (L_{bio}) and a biodiffusion coefficient (D_{bio}); benthic boundary layer (K_{bl}) and evaporation (K_c) mass transfer coefficients; and for flowing systems, the water flushing rate (Q). Information should be obtained on the degradation half-life or reaction rate of chemicals of concern in the specific project if such information is available.

Contaminant properties

Contaminant properties include water diffusivity and sediment-water or cap-water partition coefficient. The water diffusivity of most compounds varies less than a factor of two from 1×10^{-5} cm^2/sec. Higher molecular weight compounds such as PAHs tend to have a water diffusivity of the order of 5×10^{-6} cm^2/sec. The water diffusivity can be estimated using the Wilke-Chang method (Bird, Stewart, and Lightfoot 1960). Compilations of diffusivities are also available (Thibodeaux 1996; Montgomery and Welkom 1990).

The preferred means of determining the partition coefficient is through experimental measurement of sediment and pore water concentration in the sediment or cap. In this manner, any sorption of contaminant onto suspended particulate or colloidal matter is implicitly incorporated. If such measurements are unavailable, it is possible to predict values of the partition coefficient, at least for hydrophobic organic compounds, using Equation B8. K_{oc} values are tabulated (e.g., Montgomery and Welkom 1990) or may be estimated from solubility or the octanol-water partition coefficient using the methods in Lyman, Reehl, and Rosenblatt (1990). For other contaminants, including metals, little predictive guidance exists.

It should be emphasized that the pore water concentration, C_0, appearing in the models is not the truly dissolved concentration but that corrected for the amount sorbed on the colloidal matter. Note that Equation B8 suggests that the apparent partition coefficient approaches the constant, f_{oc}/ρ_{oc} as $K_{oc} \rightarrow \infty$. That is, the apparent partition coefficient is no longer a function of the hydrophobicity of the contaminant when the product $\rho_{oc}K_{oc}$>>1. For example, the apparent partitioning of pyrene, with a K_{oc} ~10^5 L/kg and any compound more hydrophobic, is dominated by pore water organic matter at concentrations greater than about 10 mg/L.

Physical characteristics

The long-term average water flushing rate should be measured onsite to evaluate water-side mass transfer resistances. Cap material properties are dependent on the specific materials available and should be measured using standard analytical methods.

Mass transfer coefficients

A turbulent mass transfer correlation (Thibodeaux 1996) can be used to estimate the value of K_{bl} in the water above the cap:

$$Sh = 0.036\ Re^{0.8}\ Sc^{1/3} \tag{B37}$$

where

Sh = Sherwood number = $\dfrac{K_{bl} \cdot x}{D_w}$

Re = Reynolds number = $\dfrac{x \cdot u}{\nu}$

Sc = Schmidt number = $\dfrac{\nu}{D_w}$

ν = kinematic viscosity of water, 0.01 cm²/sec at 20 °C

u = benthic boundary layer water velocity, cm/s

x = length scale for the contaminated region - here $x = \sqrt{A_s}$ is taken where A_s is area of contaminated region, cm

As indicated previously, however, the benthic boundary layer mass transfer coefficient is rarely significant in the estimation of contaminant flux through the cap.

Transport by bioturbation has often been quantified by an effective diffusion coefficient based on particle reworking rates. A bioturbation mass transfer coefficient can then be estimated from the following relation assuming linear partitioning between the sediment and water in the bioturbation layer

$$K_{bio} = \frac{D_{bio}\rho_b K_d \eta}{L_{bio}} \tag{B38}$$

where η is a desorption efficiency of the chemical once the particle carrying it has been reworked to the sediment-water interface. η would tend to be small for more hydrophobic compounds that tend to desorb slowly at the surface and large for compounds that are more soluble. In the absence of experimental information to the contrary, η is assumed to be 1. The biodiffusion coefficient and the depth of bioturbation are important factors in the determination of the required cap thickness, and thus the best possible estimates should be used. The ranges for D_{bio} and L_{bio} are quite large, and an extensive tabulation is presented by Matisoff (1982). An examination of these data suggests that a depth of bioturbation of 2 to 10 cm is typical and that biodiffusion coefficients are generally in the range of 0.3 to 30 cm^2/year. As indicated previously, however, the contaminant flux is controlled by transport through the cap and is essentially insensitive to the bioturbation mass transfer coefficient. The contaminant concentration in the bioturbated layer, however, is heavily dependent upon the biodiffusion coefficient.

Evaporation mass transfer coefficient

The overall evaporation mass transfer coefficient is taken as equal to the water-side mass transfer coefficient. This is generally valid for volatile organic compounds but less true for many PAHs, which tend to exhibit significant air-side mass transfer resistances. A water-side mass transfer coefficient for evaporative losses is given by Lunny, Springer, and Thibodeaux (1985) as

$$K_e = 19.6\,U_x^{2.23} D_w^{2/3} \tag{B39}$$

where U_x is the wind speed at 10 m (miles/hour), D_w has units of square centimeters/second, and K_e has units of centimeters/hour. Lyman, Reehl, and Rosenblatt (1990) provide information on air-side coefficients that may be important for some compounds, notably low-volatility PAH compounds.

Example

Several design bases are possible for specifying the physico-chemical containment afforded by a cap. There are at least five quantities that may be of interest to the cap designer and for which models were presented here. These are the breakthrough time, the pollutant release rate (as a source term input to other fate and effects models), concentrations at the sediment-water interface or in the overlying water column, and the time to approach steady state. The two physico-chemical properties of the cap material that have the largest effect on the efficacy of the cap are the organic carbon content and the cap thickness. Each of these calculations will be illustrated given a cap thickness. In general, the process would be applied iteratively using a guessed cap thickness until the desired breakthrough times, fluxes, etc, are achieved.

The selected example considers a sediment contaminated with a moderately hydrophobic polyaromatic hydrocarbon, pyrene. The contaminant is initially present in the upper 35 cm of sediment at a level of 100 mg/kg. A cap of initial thickness of 50 cm is placed over this sediment. Both the cap and the sediment contain 1-percent organic carbon. Consolidation of the cap after placement reduces the cap thickness to 45 cm. The sediment also consolidates 5 cm as a result of cap placement. Bioturbation is expected to influence the upper 10 cm of sediment or cap. These and other problem parameters are collected in Table B1. The calculation procedure is detailed below.

Table B1
Physico-Chemical Properties of Site Parameters for Example

Cap Properties		
Initial cap thickness	(L_o)	50 cm
Consolidation distance within cap	(ΔL_{cap})	5 cm
Consolidation distance of underlying sediment	(ΔL_{sed})	5 cm
Organic carbon content	(f_{oc})	0.01
Porosity	(ϵ)	0.5
Bulk density	(ρ_b)	1.25 g/cm^3
Colloid concentration	(C_c)	10 mg/L
Effective cap thickness	(L_{eff})	35 cm
Pyrene Properties		
Solubility	(s)	150 μg/L
Diffusivity in water	(D_w)	5×10^{-5} cm^2/sec
Organic carbon partition coeff.	(K_{oc})	10^5 L/kg
Mass transfer coeff. at air-water interface	(K_e)	7 cm/hr
Mass transfer coeff. at cap-water interface	(K_{bl})	1 cm/hr
Site Properties		
Bioturbation depth	(L_{bio})	10 cm
Biodiffusion coefficient	(D_{bio})	10 cm^2/year
Seepage velocity in sediment (assume outflow)	(U)	10 cm/year
Pyrene sediment loading	(ω_s)	100 mg/kg
Pore water concentration	(C_{pw})	200 μg/L
Area of contaminated sediment	(A_s)	10^4 m^2
Evaporative area	(A_e)	10^4 m^2
Benthic boundary layer velocity	(u)	10 cm/sec
Basin flushing rate	(Q)	1.7×10^{13} cm^3/day
Thickness of contaminated region		35 cm (used in numerical model only)

Estimation of effective cap thickness

The initial cap thickness is reduced by bioturbation (10 cm), consolidation of the cap (5 cm), and penetration of pore water expressed by the consolidation of the underlying sediment. Although the sediment consolidates a distance of 5 cm, causing movement of pore water 10 cm into the cap (cap porosity of 50 percent), the contaminant migration is retarded by sorption onto the organic carbon in the cap. After estimation of the retardation factor associated with sorption onto the cap materials, it is estimated that the chemical penetration into the cap as a result of sediment consolidation is only about 80 μm. Thus the effective cap thickness is

$$\begin{aligned} L_{eff} &= 50\ cm \\ &- 10\ cm (bioturbation) \\ &- 5\ cm\ (consolidation\ of\ cap) \\ &- 80\ \mu m\ (sediment\ consolidation) \\ &\approx 35\ cm \end{aligned}$$

This calculation included an estimate of the partition coefficient and retardation factor for the migration of pyrene through the cap. The partition coefficient and pore water concentrations were estimated based on the sediment loading (Equation B5 and the second of Equations B8). The maximum truly dissolved concentration in the pore water is given by the solubility of pyrene in water (150 μg/L) meaning that in the 1-percent organic carbon sediment with a pyrene K_{oc} = 10^5 L/kg, the sediment loading must be less than 150 mg/kg for this to be true. At sediment loadings above 150 mg/kg, the pore water concentration in the contaminated region must be estimated by Equation B7.

Estimation of long-term losses

The simple analytical models presented in this appendix assume that the zone of contamination is infinitely large and is not depleted by losses through the cap. Since a groundwater seepage velocity is specified in this example, such an assumption means that ultimately the flux through the cap is given by the seepage velocity times the pore water concentration in the sediment beneath the cap or 20 mg$\cdot$m$^{-2}\cdot$year^{-1}. In the absence of any seepage through the cap, the steady-state diffusive flux would apply, 3.6 mg$\cdot$m$^{-2}\cdot$year^{-1}. Both estimates overestimate the actual long-term flux, however, in that they assume that the sediment beneath the cap exhibits a constant concentration. A numerical calculation of the flux is provided later to illustrate the degree of conservatism by these calculations, even if no chemical degradation of the pyrene occurs.

Evaluation of diffusion only mechanism

Using Equations B25 and B26, the breakthrough and steady-state times are given by 669 and 4,600 years, respectively. These estimates assume only diffusion is applicable and that the concentration is again constant.

At steady-state conditions assuming constant sediment concentrations, the diffusion model also allows estimation of pore and overlying water concentrations. Although the predominant mass transfer resistance is the undisturbed cap, the bioturbation zone and the benthic boundary layer resistance influence the concentrations observed in the bioturbation layer, at the sediment-water interface, and in the overlying water.

Example Calculation of Contaminant Flux-Advection/Diffusion Mechanism

In this example, flux predictions by the analytical model of capped sediment are compared with an uncapped case and a numerical model that recognizes the depletion in the underlying sediment due to transport to the overlying water. The numerical model is capable of describing arbitrary and heterogeneous initial conditions and depletion within the sediment. The model is written in FORTRAN and employs IMSL routines for some calculations. Both the analytical model in the form of a Mathcad spreadsheet and the numerical model are available from the author

Danny Reible, Director
Hazardous Substance Research Center/S&SW
Louisiana State University
Baton Rouge, LA 70803
Ph: 504/388-3070, Fax: 504/388-1476, e-mail: reible@che.lsu.edu

The model predictions for flux are shown in Figure B2.

Comparison of Uncapped and Analytical and Numerical Capped Model Predictions

The first case is for a contaminated system with no cap. The result is presented as the solid line in Figure B2. The flux starts out at a high value (effectively infinite at time of first exposure of the contaminated sediment) and decreases with time.

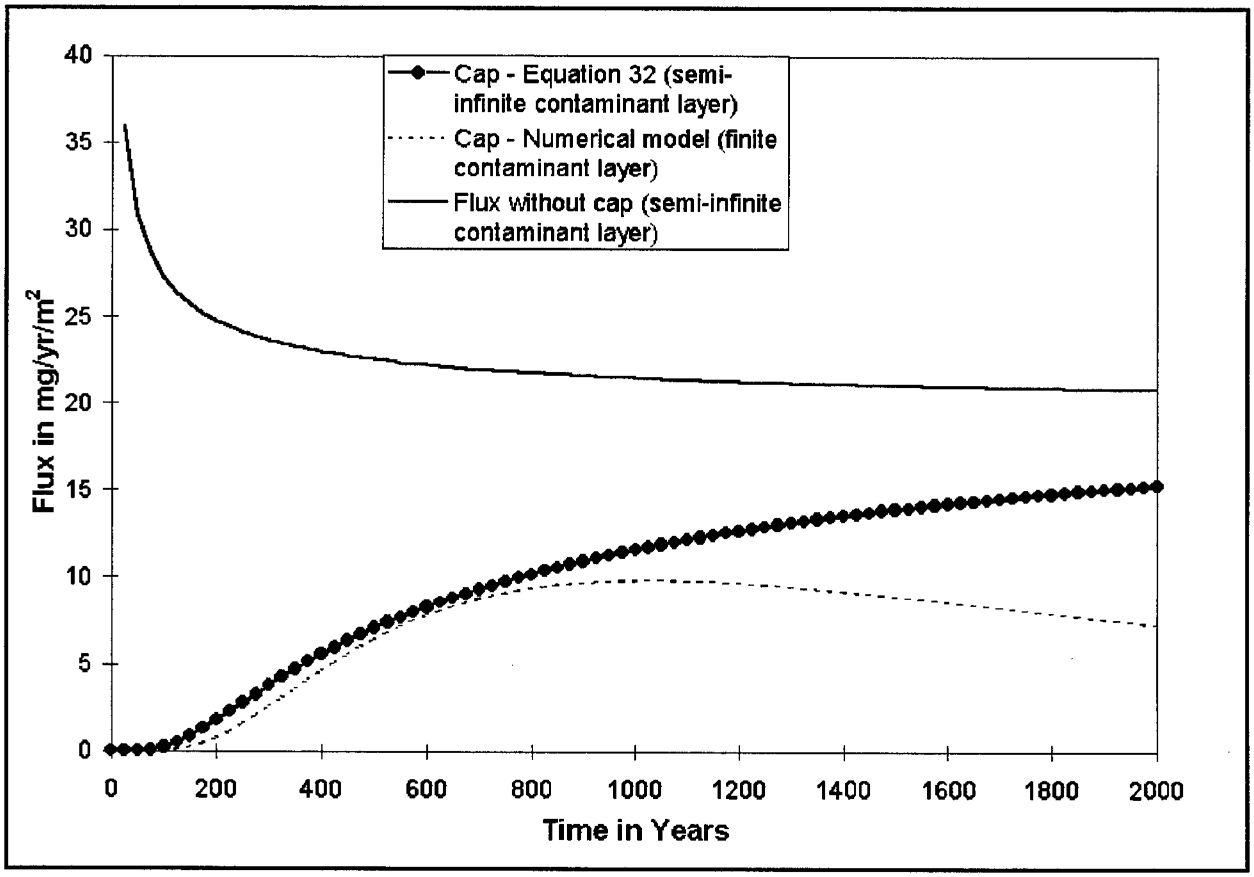


Figure B2. Example calculations of contaminant flux through cap

Example - Mathcad Spreadsheet

Note - All numerical values employed in this simulation are for illustration only. Although some of these values may represent typical field conditions, they do not indicate the range of values encountered in the field and do not therefore allow the drawing of general conclusions as to the effectiveness of capping

Estimation of effective cap thickness

$L_0 := 50 \cdot cm$ Initial thickness of cap

$L_{bio} := 10 \cdot cm$ Thickness effectively mixed by bioturbation

$\Delta L_{cap} := 5 \cdot cm$ Consolidation distance within the cap

$\Delta L_{sed} := 5 \cdot cm$ Consolidation distance of underlying sediment

$\varepsilon := 0.5$ Void fraction in cap

$\rho_b := 0.5 \cdot 2.5 \cdot \frac{gm}{cm^3}$ Bulk density of sediment

$\Delta L_{sed.pw} := \frac{\Delta L_{sed}}{\varepsilon}$ Pore water penetration distance in cap

$\Delta L_{sed.pw} = 0.1 \cdot m$

Estimation of sorption characteristics in cap and retardation factor

$L := 1000 \cdot cm^3$

$\mu g := 10^{-6} \cdot gm$

$K_{oc} := 10^5 \cdot \frac{L}{kg}$ Organic carbon based partition coefficient
Compound assumed: Pyrene

$\rho_{oc} := 10 \cdot \frac{mg}{L}$ Dissolved organic carbon concentration in pore water

$f_{oc} := 0.01$ Fraction organic carbon in sediment

$S := 0.150 \cdot \frac{mg}{L}$ Solubility of pyrene in water

$\omega_{crit} := K_{oc} \cdot f_{oc} \cdot S$ Critical sediment loading $\omega_{crit} = 150 \cdot \frac{mg}{kg}$

$$K_d := \frac{K_{oc} \cdot f_{oc}}{1 + \rho_{oc} \cdot K_{oc}}$$

Observed partition coefficient between sediment and water assumes K_{OC} governs partitioning to dissolved org. carbon

$K_d = 500 \cdot \frac{L}{kg}$ Also assumes sediment $< \omega_{crit}$

$$R_f := \varepsilon + \rho_b \cdot K_d$$

Retardation factor due to sorption onto solid

$R_f = 625.5$

$$\Delta L_{sed.A} := \frac{\Delta L_{sed}}{R_f}$$

Penetration distance of chemical into cap due to consolidation of sediment

$\Delta L_{sed.A} = 7.994 \cdot 10^{-5} \cdot m$ Typically negligible for sorbing caps

$$L_{eff} := L_0 - L_{bio} - \Delta L_{cap} - \Delta L_{sed.A}$$

Effective cap thickness

$L_{eff} = 0.35 \cdot m$

Estimation of long-term losses

a. Determination of Peclet number defining the relative importance of advection to diffusion

$U := 10 \cdot \frac{cm}{yr}$ Seepage velocity in sediment- assume outflow

$D_w := 5 \cdot 10^{-6} \cdot \frac{cm^2}{sec}$ Molecular diffusion coefficient in water

$D_{eff} := D_w \cdot \varepsilon^{\frac{4}{3}}$ Millington and Quirk model for effective diffusivity

$D_{eff} = 1.984 \cdot 10^{-6} \cdot \frac{cm^2}{sec}$

$Pe := \frac{U \cdot L_{eff}}{D_{eff}}$ Peclet number

$Pe = 5.588$ Advection/diffusion both important

Chemical concentration level - assumed deep layer of sediment contaminated to 100 mg/kg

$W_s := 100 \cdot \frac{mg}{kg}$ $C_0 := \frac{W_s}{K_d}$ $C_0 = 200 \cdot \frac{\mu g}{L}$

Note - Ws<150 mg/kg - below critical loading as assumed

Advective flux

$$F_{adv} := U \cdot C_0$$

Advective flux - since a deep layer of contaminated sediment is assumed, the flux at long time is given by this for a seepage outflow

$$F_{adv} = 20 \circ \frac{mg}{m^2 \cdot yr}$$

Dffusive flux - hypothetical unless Pe <<1 and depletion of material in sediment can be neglected

$$F_{diff} := \frac{D_{eff}}{L_{eff}} \cdot C_0$$

Steady-state diffusive flux (assuming no advection and no depletion of contaminants by diffusion through cap)

$$F_{diff} = 3.579 \circ \frac{mg}{m^2 \cdot yr}$$

Transient behavior- assuming diffusion only

$$\tau_b := \frac{0.54 \cdot L_{eff}^2 \cdot R_f}{D_{eff} \cdot \pi^2}$$

Breakthrough time assuming no depletion of contaminant in sediment

$$\tau_b = 669.218 \circ yr$$

$$\tau_{ss} := \frac{3.69 \cdot L_{eff}^2 \cdot R_f}{D_{eff} \cdot \pi^2}$$

Time required to reach hypothetical steady state flux (F_{diff}) assuming no depletion of contaminants in sediment

$$\tau_{ss} = 4572.99 \circ yr$$

Estimation of overall mass transfer coefficient and concentrations in water and at the sediment-water interface assuming quasi-steady diffusion

$$K_{cap} := \frac{D_{eff}}{L_{eff}}$$

Effective mass transfer coefficient in cap–assuming quasi-steady diffusion

$$K_{cap} = 1.789 \circ \frac{cm}{yr}$$

$$D_{bio} := 10 \cdot \frac{cm^2}{yr}$$

Effective bioturbation diffusion coefficient

$\eta := 1$

Fraction of contaminants released at surface between arrival at surface and reburial by bioturbation

$$K_{bio} := \frac{\eta \cdot D_{bio} \cdot R_f}{L_{bio}}$$

Effective bioturbation mass transfer coefficient for particle movement at effective diffusion coefficient Dbio

$$K_{bio} = 625.5 \cdot \frac{cm}{yr}$$

$$K_{bl} := 1 \cdot \frac{cm}{hr}$$

Effective mass transfer coefficient at sediment (cap) - water interface

$$K_e := 7 \cdot \frac{cm}{hr}$$

Effective mass transfer coefficient at air-water interface

$$Q := 1.7 \cdot 10^{13} \cdot \frac{cm^3}{day}$$

Effective flushing rate of overlying water

$$A_s := 10^4 \cdot m^2$$

Area of contaminated sediment

$$A_e := 10^4 \cdot m^2$$

Evaporative area

$$K_{ov} := \left(\frac{1}{K_{cap}} + \frac{1}{K_{bio}} + \frac{1}{K_{bl}} + \frac{A_s}{K_e \cdot A_e + Q} \right)^{-1}$$

Effective overall mass transfer coefficient

$$K_{ov} = 1.784 \cdot \frac{cm}{yr}$$

Typically same as cap coefficient

$$C_w := \frac{K_{ov} \cdot A_s}{K_e \cdot A_e + Q} \cdot C_0$$

Water concentration assuming steady diffusion through cap and only evaporation and flushing losses from water

$$C_w = 5.741 \cdot 10^{-6} \cdot \frac{\mu g}{L}$$

$$C_{sw} := \frac{K_{ov} \cdot C_0}{K_{bl}}$$

Concentration in porewater at sediment (cap)- water interface
This should indicate exposure of benthic organisms

$$C_{sw} = 0.041 \cdot \frac{\mu g}{L}$$

Flux via full - advection diffusion model

$\alpha := L_{eff}$ Set dispersivity to upper bound of cap thickness

$D := D_{eff} + \alpha \cdot U$ Dispersion coefficient sum of diffusion and advective dispersion

$$D = 1.307 \cdot 10^{-5} \cdot \frac{cm^2}{sec}$$

Concentration model - semi-infinite cap with concentration in underlying sediment constant

$$C(L,t) := \left[\left[1 - \mathrm{erf}\left(\frac{R_f \cdot L - U \cdot t}{2 \cdot \sqrt{R_f \cdot D \cdot t}}\right) + \exp\left(\frac{U \cdot L}{D}\right) \cdot \left(1 - \mathrm{erf}\left(\frac{R_f \cdot L + U \cdot t}{2 \cdot \sqrt{R_f \cdot D \cdot t}}\right)\right)\right] \cdot \frac{C_0}{2}\right]$$

Concentration gradient near surface— needed for estimation of diffusion flux

$$DCDZ(L,t) := \frac{1}{2} \cdot \left[\frac{-1}{\sqrt{\pi}} \cdot \exp\left[\frac{-1}{4} \cdot \frac{\left(R_f \cdot L - U \cdot t\right)^2}{\left[R_f \cdot (D \cdot t)\right]}\right] \cdot \frac{\sqrt{R_f}}{\left(\sqrt{D} \cdot \sqrt{t}\right)} + \frac{U}{D} \cdot \exp\left(U \cdot \frac{L}{D}\right) \cdot \left[1 - \mathrm{erf}\left[\frac{1}{2} \cdot \frac{\left(R_f \cdot L + U \cdot t\right)}{\left[\sqrt{R_f} \cdot \left(\sqrt{D} \cdot \sqrt{t}\right)\right]}\right]\right] \cdots \atop + \frac{-\exp\left(U \cdot \frac{L}{D}\right)}{\sqrt{\pi}} \cdot \exp\left[\frac{-1}{4} \cdot \frac{\left(R_f \cdot L + U \cdot t\right)^2}{\left[R_f \cdot (D \cdot t)\right]}\right] \cdot \frac{\sqrt{R_f}}{\left(\sqrt{D} \cdot \sqrt{t}\right)}\right] \cdot C_0$$

$t_{int} := 100 \cdot yr$ t_{int} = time interval desired

$j := 1..20$ j = number of values of time

$F_{adv_j} := U \cdot C\left(L_{eff}, j \cdot t_{int}\right)$ Advective component of flux

$F_{diff_j} := -\left(D_{eff} \cdot DCDZ\left(L_{eff}, j \cdot t_{int}\right)\right)$ Diffusive component of flux

$F_{adv.diff_j} := F_{adv_j} + F_{diff_j}$ Total flux from cap-water interface

Comparison to uncapped flux (This approach recognizes that the same equation is applicable if water-side mass transfer resistances are always negligible)

$$F_{uncapped_j} := U \cdot C\left(0 \cdot cm, j \cdot t_{int}\right) - D_{eff} \cdot DCDZ\left(0 \cdot cm, j \cdot t_{int}\right)$$

Note that both analytical models (capped and uncapped) assume that the contaminant layer is of infinite depth. At long times when this assumption is poor, a numerical simulation should be used in either case as shown in Figure B2.

Summary of Results–also shown in Figure B2 with numerical model results assuming a 35-cm depth of contamination

Time	Conc. at cap water interface	Fluxes via advection, diffusion and combined			
$\frac{j \cdot t_{int}}{yr}$	$\frac{C(L_{eff}, j \cdot t_{int})}{\left(\frac{\mu g}{L}\right)}$	$\frac{F_{adv_j}}{\left(\frac{mg}{m^2 \cdot yr}\right)}$	$\frac{F_{diff_j}}{\left(\frac{mg}{m^2 \cdot yr}\right)}$	$\frac{F_{adv.diff_j}}{\left(\frac{mg}{m^2 \cdot yr}\right)}$	$\frac{F_{uncapped_j}}{\left(\frac{mg}{m^2 \cdot yr}\right)}$
100	0.701	0.07	0.122	0.192	27.266
200	9.399	0.94	0.839	1.779	24.753
300	23.526	2.353	1.426	3.779	23.65
400	38.032	3.803	1.75	5.554	23
500	51.306	5.131	1.905	7.036	22.56
600	63.054	6.305	1.962	8.268	22.238
700	73.369	7.337	1.964	9.301	21.991
800	82.435	8.244	1.934	10.178	21.794
900	90.439	9.044	1.887	10.931	21.631
1000	97.544	9.754	1.831	11.585	21.496
1100	103.888	10.389	1.769	12.158	21.38
1200	109.584	10.958	1.707	12.665	21.28
1300	114.724	11.472	1.644	13.116	21.193
1400	119.387	11.939	1.583	13.521	21.116
1500	123.634	12.363	1.523	13.887	21.047
1600	127.519	12.752	1.466	14.218	20.986
1700	131.086	13.109	1.411	14.519	20.931
1800	134.373	13.437	1.358	14.796	20.88
1900	137.411	13.741	1.308	15.049	20.835
2000	140.227	14.023	1.26	15.283	20.793

Capped Flux < 1% Uncapped Flux for more than 100 years

Capped Flux approximately 1/2 uncapped flux after 1,000 years (Maximum flux if initial contaminant thickness is 35 cm) from numerical model)

In the next case a cap has been placed and the flux through the cap is estimated subject to the previously discussed assumptions of constant concentration in the underlying sediment. This system is described by Equation B32. The result is presented by the broken line in Figure B2. The flux is initially zero until cap breakthrough, and the flux then slowly increases with time. After several thousand years in this example, the flux with and without the cap approaches the constant value of 20 $mg \cdot m^{-2} \cdot year^{-1}$. Again, both models approach the same value because the contaminated region is assumed infinitely thick and advection ultimately controls the flux.

In the final case, the conditions are identical to the capped case above, but mass transfer is recognized to cause depletion of the contaminant beneath the cap and the actual thickness (and therefore finite mass) of the contaminated region is explicitly considered. The thickness of the contaminated region is assumed identical to the effective thickness of the cap, 35 cm. No degradation is assumed, consistent with the previous examples. The solution by the numerical model is given as the dotted line on Figure B2. Of the three models, this is the only one that satisfies the material balance in that the loss to the overlying water is reflected in reductions in mass in the contaminants in the sediment.

The plot of flux with time for an uncapped system shows a high initial flux owing to a large concentration gradient at the surface initially. With depletion in the near-surface sediment, the flux asymptotically approaches a limit given by the advective flux from the deep-sediment concentrations. With a cap, the contaminant takes some time to seep through the clean capped region. Hence there is an initial time period when there is essentially no contaminant flux. Since there is an assumption of constant contaminant concentration at the base of the cap, the flux asymptotically approaches a maximum that would ultimately equal the uncapped flux. The realistic model that accurately accounts for contaminant depletion in the sediment shows a flux that never reaches as high as the flux from either of the two preceding models, and it steadily decreases at long time.

Note that in either capped case, the total mass released to the water column is significantly reduced for any period of time. The total mass released is the integral under the flux curves.

In this example it was assumed that the bioturbated region offers no resistance to the transport of contaminants. A model explicitly accounting for the bioturbated region could also be developed. Similarly, the effect of cap thickness and contaminated layer thickness or inhomogeneity on the long-term flux profile can be studied using the numerical model. This is not possible using the conservative analytical model Equation B32.

Acknowledgments

This appendix was prepared with the partial support of the U.S. Environmental Protection Agency through the Hazardous Substance Research

Center/South and Southwest and through cooperative agreement CR 823029-01-0 from the National Risk Management and Research Laboratory, Cincinnati, OH.

References

Bear, J. (1979). *Hydraulics of groundwater*. McGraw-Hill, New York.

Bird, R. B., Stewart, W. E., and Lightfoot, E. N. (1960). *Transport phenomena.* John Wiley & Sons, New York.

Carslaw, H. S., and Jaeger, J. C. (1959). *Conduction of heat in solids*. 2d ed., Oxford University Press, Oxford, England.

Cleary, R. W., and Adrian, D. D. (1973). "Analytical solution of the convection-dispersive equation for cation adsorption in soils," *Soil Sci Soc. America Proc. 37*, 197-199.

IMSL. (1994). Visual Numerics, Inc., Houston, TX.

Lunney, P. D., Springer, C., and Thibodeaux, L. J. (1985). "Liquid phase mass transfer coefficients for surface impoundments," *Environmental Progress 109* (4), 203-211.

Lyman, W. J., Reehl, W. F., and Rosenblatt, D. H. (1990). *Handbook of chemical property estimation methods: Environmental behavior of organic chemicals*, American Chemical Society: Washington DC.

Matisoff, G. (1982). "Mathematical models of bioturbation," *Animal-sediment relations*. P. L. McCall and M. J. Tevesz, ed., Plenum Press, New York, 289-331.

Millington, R. J., and Quirk, J. M. (1961). "Permeability of porous solids," *Trans. of Faraday Soc.* 57, 1200-1207.

Montgomery, J. H., and Welkom, L. M. (1990). *Goundwater chemicals desk reference*. Vol 1. Lewis Publishers, Inc., Chelsa, MI.

Palermo, M. R., Maynord, S., Miller, J., and Reible, D. D. (1996). "Guidance for in-situ subaqueous capping of contaminated sediments," Environmental Protection Agency, EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Stark, T. D. (1991). "Program documentation and user's guide: PCDDF89, primary consolidation and dessication of dredged fill," Instruction Report D-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thibodeaux, L. J. (1996). *Environmental chemodynamics: Environmental movement of chemicals in air, water and soil.* 2d ed., Wiley & Sons, New York.

Thibodeaux, L. J., and Bosworth, W. S. (1990). "A theoretical evaluation of the effectiveness of capping PCB contaminated New Bedford Harbor Bed Sediment," Final Report, Hazardous Waste Research Center, Louisiana State University, Baton Rouge, LA.

Thoma, G. J., Reible, D. D., Valsaraj, K. T., and Thibodeaux, L. J. (1993). "Efficiency of capping contaminated sediments in situ: 2. Mathematics of diffusion-adsorption in the capping layer," *Environmental Science and Technology* 27, 12, 2412-2419.

Appendix C Capping Effectiveness Tests

Introduction

Results of laboratory tests conducted with samples of the contaminated sediments to be capped and the proposed capping sediments should yield sediment-specific and capping-material-specific values of diffusion coefficients, partitioning coefficients, and other parameters needed to model long-term cap effectiveness. Model predictions of long-term effectiveness using the laboratory-derived parameters should be more reliable than predictions based on so-called default parameters. At present, there are several tests that have been applied for this purpose.

Louisiana State University has conducted laboratory tests to assess diffusion rates for specific contaminated sediments to be capped and materials proposed for caps. A capping simulator cell was used in which a cap material layer is placed over a contaminated sediment, and flux due to diffusion is measured in water that was allowed to flow over the cap surface. Initial tests measured flux of 2,4,6-trichlorophenol (TCP) through various cap materials. These tests showed that the breakthrough time and time to steady state were directly dependent on the partitioning coefficient and that cap porosity and thickness were the dominant parameters at steady state (Wang et al. 1991).[1]

Environment Canada has performed tank tests on sediments from Lake Ontario to qualitatively investigate the interaction of capping sand and compressible sediments. The tests were carried out in 3.6- by 3.6- by 3.7-m observation tanks in which the compressible sediments were placed and allowed to consolidate; sand was released through the water column onto the sediment surface. In the initial tests, physical layering and consolidation behavior were observed. Additional tests are planned in which migration of contaminants due to consolidation-induced advective flow will be evaluated (Zeman 1993).

[1] References cited in this appendix are listed in the References at the end of the main text.

The U.S. Army Corps of Engineers (USACE) has also developed leach tests to assess the quality of water moving through a contaminated sediment layer into groundwater in a confined disposal facility environment (Myers and Brannon 1991). This test has been applied to similarly assess the quality of water potentially moving upward into a cap due to advective forces.[1]

USACE Small-Scale Column Test

The USACE developed a first-generation capping effectiveness test in the mid-1980s as part of the initial examination of capping as a dredged material disposal alternative. The test was developed based on the work of Brannon et al. (1985, 1986), Gunnison et al. (1987), Environmental Laboratory (1987), and Sturgis and Gunnison (1988).

The tests basically involve layering contaminated and capping sediments in columns (Figure C1) and experimentally determining the cap sediment thickness necessary to chemically isolate a contaminated sediment by monitoring the changes in dissolved oxygen, ammonium-nitrate, orthophosphate-phosphorous, or other tracers in the overlying water column.

The thickness of granular cap material for chemical isolation determined using this procedure is on the order of 1-ft for most sediments tested to date. However, this column testing procedure does not account for potential advection nor long-term flux of contaminants due to diffusion. The USACE Small-Scale Column Test is therefore only applicable for evaluation of capping thicknesses for isolation of nutrient-rich sediments.

The procedure for conducting the small-scale column test is presented below.

Chemical tracers

The test uses dissolved oxygen (DO) depletion, ammonium-nitrogen, and orthophosphate phosphorus as tracers because they are easy and inexpensive to measure. A cap thickness that is effective in preventing the movement of these inorganic constituents will also be effective in preventing the movement of organic contaminants that are more strongly bound to sediment (e.g., polynuclear aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and polychlorinated biphenyls (PCBs)). The behavior of soluble-reduced inorganic species (e.g., arsenic) is also similar to the tracers.

Dissolved oxygen depletion in the water column is normally not a problem in an open-water disposal environment, due to mixing and reaeration of the water

---

[1] Personal Communication, 1995, Tommy E. Myers, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

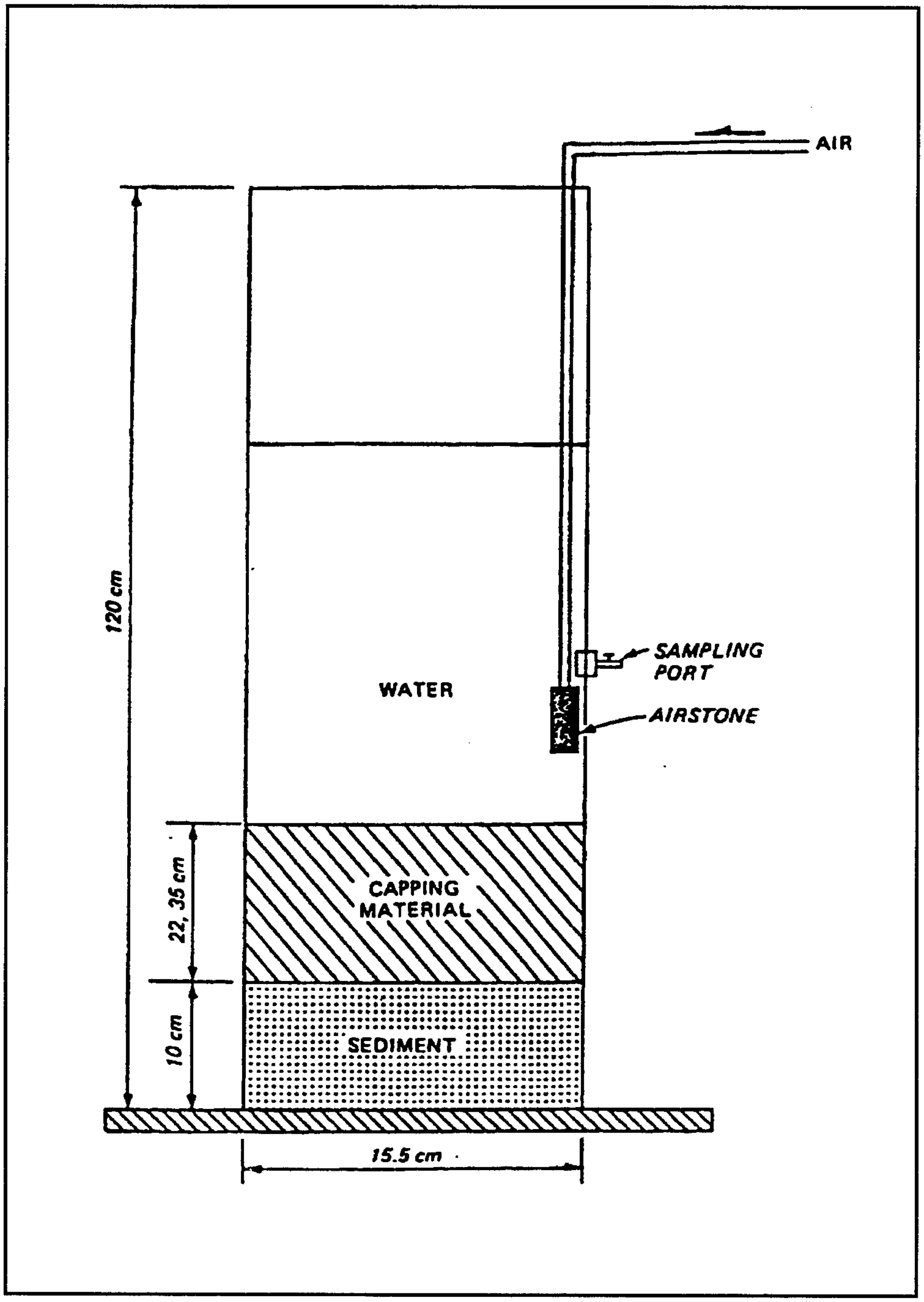


Figure C1. Small-scale column test unit for capping effectiveness (Sturgis and Gunnison 1988)

column. However, DO depletion can be used as a tracer for determining the effectiveness of a cap in isolating an underlying contaminated dredged material having an oxygen demand exceeding that of the capping material. A cap thickness that is effective in preventing or reducing the diffusion of DO into the contaminated sediment will also prevent or reduce the diffusion of DO-demanding species from the contaminated sediment into the overlying water column. Once an effective cap thickness has been achieved, there will be no significant difference in oxygen-depletion rates between the contaminated sediment with cap material and the cap material alone.

A similar rationale is applicable for using ammonium-nitrogen and orthophosphate-phosphorus as tracers. These constituents are released only under anaerobic conditions. However, if the layer of cap material is thick enough to prevent the diffusing materials in the underlying contaminated dredged material from reaching the water column, the release rates from the capped contaminated sediment will be the same as from the cap material alone.

Because of the potential variation of chemical and biochemical properties in sediments, more than one tracer (ammonium-nitrogen, orthophosphate-phosphorus, and DO depletion) must be considered for each application (Brannon et al. 1985, 1986; Gunnison et al. 1987; Environmental Laboratory 1987). Frequently, the contaminated sediment and the proposed capping material are so different that a chemical property of the contaminated sediment is easily distinguishable from that same property of the cap material. However, when the cap material has chemical properties similar to the contaminated sediment, chemical differences are harder to distinguish. In such a case, if only one tracer is measured and negative results are obtained, a second series of tests is necessary.

Water analysis

The release rates of ammonium-nitrogen and orthophosphate-phosphorus must be determined in accordance with procedures recommended by Ballinger (1979). The depletion rate of DO is determined using either the azide modification of the Winkler method, as described in Standard Methods (American Public Health Association 1986), or a DO meter.

Sediment collection

Samples of contaminated sediment must be collected that are representative of sediment to be dredged. Samples of the proposed capping material must also be taken. To ensure that sediment samples are not diluted with large volumes of water, a clamshell dredge or similar device is used to sample both contaminated sediment and capping material. Representative subsamples of both materials are taken for initial bulk analysis and characterization. All sediments are to be placed into polyethylene-lined steel barrels, sealed, and stored at 4 °C until tested.

Sediment sampling and preparation

The capping effectiveness test is run using representative samples of the contaminated and capping sediments (see Chapter 3 of the main text). Sediment samples are composited and mixed, using a motorized mixer (to ensure a homogenous sediment sample). Any unused sediment is returned to the containers, stored at 4 °C, and later discarded if there is no further need for the sediment.

Materials and equipment

The following items are required to conduct the laboratory test:

a. Twelve to fifteen 22.6-L cylindrical plexiglass units, 120 cm in height and 15.5 cm in diameter attached to a 30-cm, 2-plexiglass base (Figure C1). The units should be fitted with a sampling port.

b. Twelve plexiglass plungers, 80 cm in length with a wire hook attached at the top.

c. Twelve pint-size bottles of mineral oil.

d. Six aquarium pumps (two small-scale units per pump) or some other source of air supply.

e. Twelve 1-cm-long air stones.

f. Two plexiglass tubes, 130 cm in length, 7.28-cm inside diameter.

g. Two large funnels, 40.8-cm top diameter, 6.60-cm outside diameter at the base.

h. Tygon tubing, 3.02-mm inside diameter.

Test procedure

Step 1 - Add contaminated sediment to the units. The contaminated sediment is mixed, then placed in the bottom of the small-scale units to a depth of 10 cm (Figure C1). It is important to add the sediment carefully to avoid splashing on the sides of the units. Three of the units are reserved for capping material only as described in Step 2.

Step 2 - Add capping material. The capping material is mixed and then added in varying thicknesses (e.g., 10, 20, and 30 cm) to triplicate units containing the contaminated sediment (Figure C1). Three units with contaminated sediment receive no cap. An additional three units receive 10 cm each of capping material only. Units containing contaminated sediment alone and units with capping material alone serve as controls.

Step 3 - Water addition and unit aeration. For an estuarine or marine simulation, 10 L of artificial seawater is prepared using artificial sea salts to achieve the salinity of the proposed disposal area. For a freshwater simulation, 10 L of either distilled or reverse osmosis water is used. The water is added as gently as possible to each small-scale unit and allowed to equilibrate for 3 days while being aerated. Aeration will ensure that the DO concentration in all units is at or near saturation (within *0.5 mg/L) at the start of the test.

After 3 days of aeration, the airstone is removed, and a plunger and mineral oil are added. The plunger is used for daily mixing to prevent the establishment of concentration gradients in the water column and to ensure a well-mixed column. Mineral oil is used to seal the surface of the water column from the atmosphere to allow the development of anaerobic conditions in the water column. The plunger is suspended between the sediment and the mineral oil. Mixing should be done in a manner that will not disturb the sediment in the bottom of the unit or breach the mineral oil on the surface of the water. After mixing, the plunger is left suspended in the water column.

Step 4 - DO measurements. Water samples are taken immediately after aeration for initial DO determination. Dissolved oxygen is measured daily until the DO is depleted in the water column of the uncapped contaminated sediment. The consequences of reducing the volume of the water column by taking DO samples is accounted for by multiplying the DO concentration (milligrams per liter) by the volume of water remaining in the unit after a given sampling. (See the Calculations section that follows.)

Step 5 - Water sampling and preservation. Water samples to be analyzed for ammonium-nitrogen and orthophosphate-phosphorus are taken immediately after the DO is depleted (Day 0) and subsequently on Days 15 and 30. These water samples should be cleared of particulate matter by passing through a 0.45-m membrane filter, preserved by acidification with concentrated hydrochloric acid (HCl) to pH 2, then stored at 4 °C. After the water column is sampled on Day 30, all water samples (Days 0, 15, and 30) are analyzed. Results from previous small-scale studies (Brannon et al. 1985, 1986; Gunnison et al. 1987; Environmental Laboratory 1987) have shown that complete anaerobic conditions are achieved in the water column within 30 days.

Data interpretation and analyses

The results from these laboratory tests indicate which of the thicknesses tested reduce overlying-water oxygen demand and transfer of ammonium-nitrogen and orthophosphate-phosphorus from the contaminated sediment to the level of the cap material alone.

Oxygen-depletion rates and ammonium-nitrogen and orthophosphate-phosphorus release rates are determined by performing linear regression analyses of mass uptake or release per unit area (milligrams per square meter) versus time. Means and standard deviations are determined for the triplicates, and t-tests are conducted to determine the statistical significance of differences between the means. Rates plotted are the means and standard deviation of three replicates and represent values greater than the controls.

Calculations

The rates in this test are defined as milligrams per square meter per day. The total tracer concentration is determined by Equation C1:

$$T_t = P_d \cdot V_r \tag{1}$$

Then, the rate of release or mass uptake is evaluated using Equation 2,

$$R_a = T_t / A_u / day \tag{2}$$

where

T_t = tracer total concentration (mg) in the unit

P_d = tracer dissolved concentration (mg/ml) as determined by chemical analysis

V_r = volume of water (ml) remaining in the water column after a given sampling

R_a = rate of release or mass uptake, mg/m^2/day

A_u = area (m) of the unit

day = number of days of study

The recommended thickness can then be evaluated by comparing the release rates (R_a) of tracers through the thicknesses tested to the release rates of tracers from the capping material alone. For a given thickness to be considered effective, its release rates must equal those from the capping material alone, or there should be no statistically significant difference.

Figure C2 is an example graph showing oxygen-depletion rates of the Black Rock Harbor sediment capped with sand plotted against cap thickness (centimeters). It is important to note that a series of cap thicknesses ranging from 2 to 26 cm were evaluated. The data points for Figure C2 are means and standard deviations of three replicates. Results show that a 22-cm cap of sand resulted in inhibition of oxygen demand equal to that of the sand cap itself, thus indicating a seal effective in isolating the overlying water column from oxygen demand due to Black Rock Harbor sediment. In this case, the recommended thickness for reducing oxygen demand on the overlying water by the contaminated sediment is 22 cm.

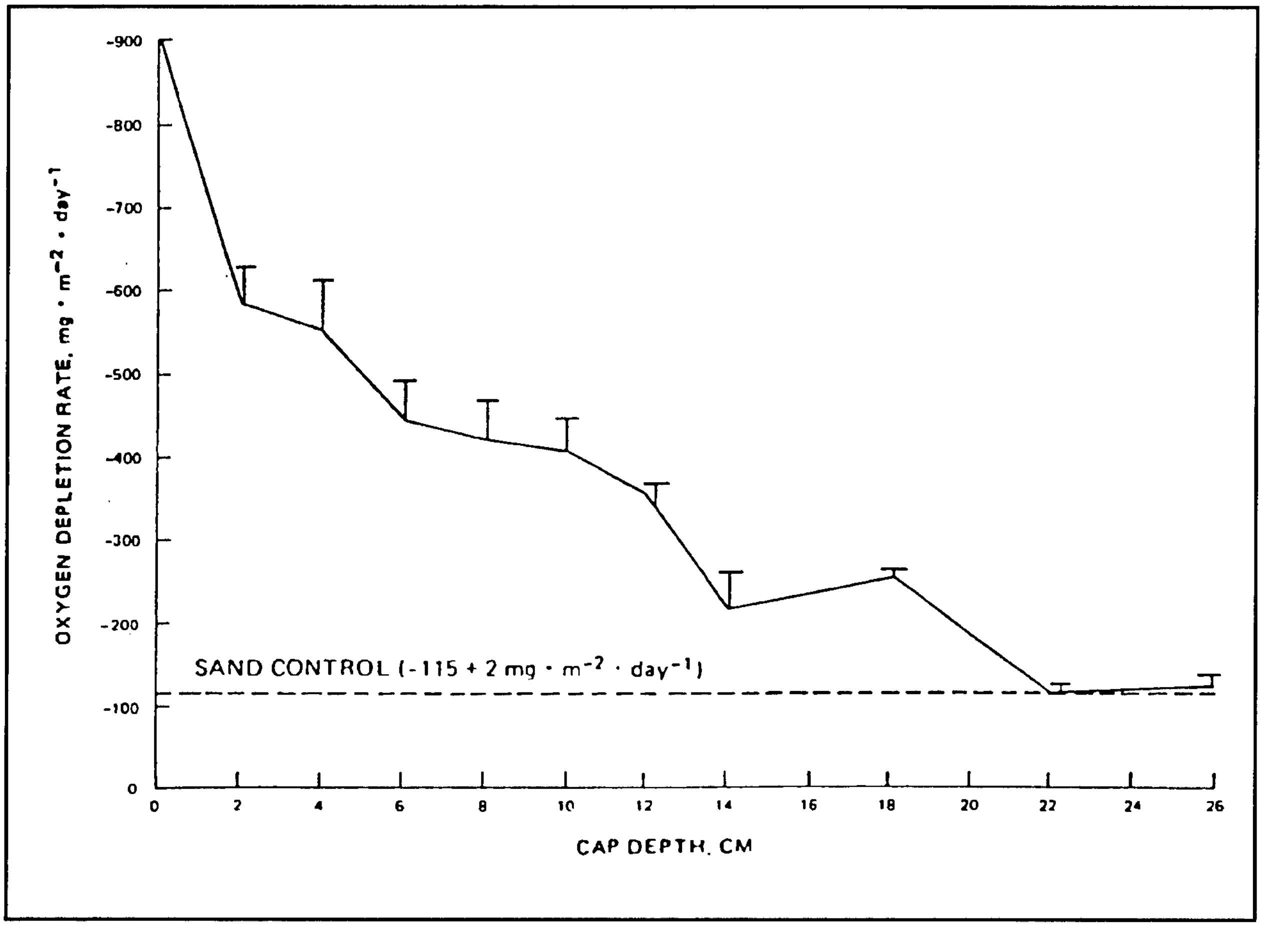


Figure C2. Typical results for effect of sand cap on oxygen command (Sturgis and Gunnison 1988)

Appendix D Short-Term Fate (STFATE) of Dredged Material Model

Introduction

This appendix presents a summary description of the STFATE (Short-Term FATE of dredged material disposal in open water) model, a module of the Automated Dredging and Disposal Alternatives Management System (ADDAMS) (Schroeder and Palermo 1990). ADDAMS is an interactive computer-based design and analysis system in the field of dredged-material management. The general goal of the ADDAMS is to provide state-of-the-art computer-based tools that will increase the accuracy, reliability, and cost effectiveness of dredged-material management activities in a timely manner. The description of STFATE given in this appendix is a summary of the detailed information available in the users guide for the model provided in the inland testing manual for dredged material disposal (U.S. Environmental Protection Agency/U.S. Army Corps of Engineers (EPA/USACE), in preparation).

Theoretical Basis

The STFATE module is based on the earlier DIFID (DIsposal From an Instantaneous Discharge) model originally prepared by Koh and Chang (1973). STFATE has been refined several times to expand its predictive capability over a wider range of project conditions. The model is used for discrete discharges from barges and hoppers. The behavior of the material during disposal is assumed to be separated into three phases: convective descent, during which the disposal cloud falls under the influence of gravity and its initial momentum imparted by gravity; dynamic collapse, occurring when the descending cloud either impacts the bottom or arrives at a level of neutral buoyancy where descent is retarded and horizontal spreading dominates; and passive transport-dispersion, commencing when the material transport and spreading are determined more by ambient currents and turbulence than by the dynamics of the disposal operation. Figure D1 illustrates these phases. Details on the theoretical basis of the model are found in EPA/USACE (1991), EPA/USACE (in preparation), Johnson (1990), Koh and Chang (1973), and Brandsma and Divoky (1976).

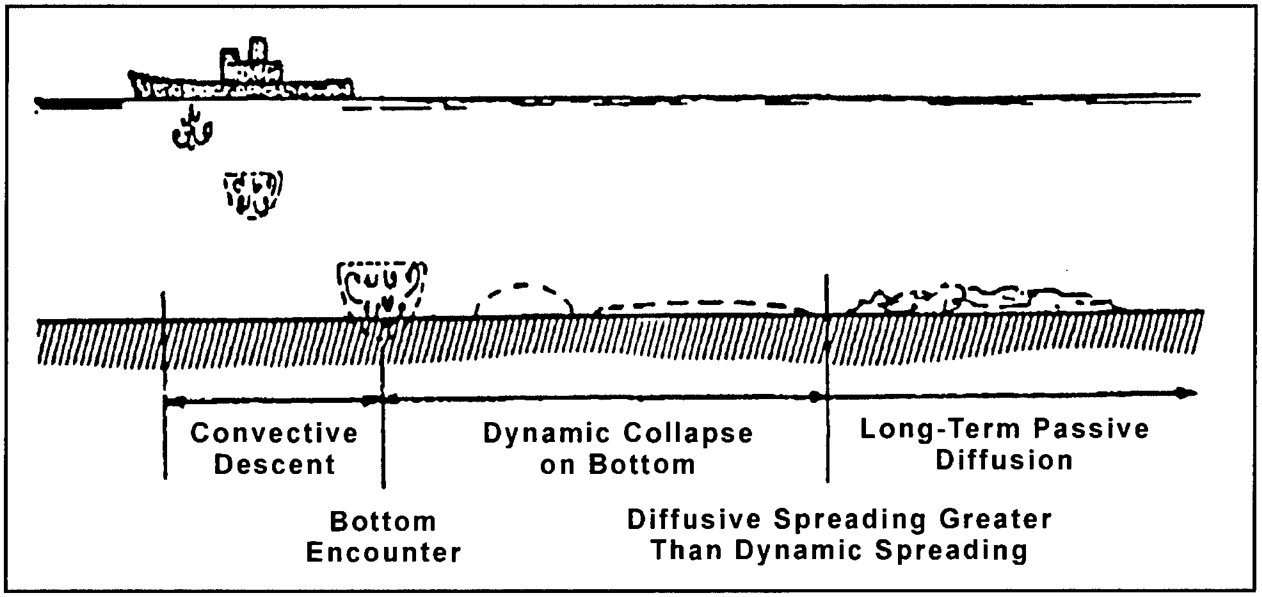


Figure D1. Illustration of placement processes

Model Input

Input data for the model are grouped into the following general areas: (a) description of the disposal site, (b) description of site velocities, (c) controls for input, execution, and output, (d) description of the dredged materials, (e) description of the disposal operation, and (f) model coefficients.

Ambient conditions include current velocity, density stratification, and water depths over a computational grid. The dredged material is assumed to consist of a number of solid fractions, a fluid component, and conservative dissolved contaminants. Each solid fraction has to have a volumetric concentration, a specific gravity, a settling velocity, a void ratio for bottom deposition, critical shear stress, and information on whether or not the fraction is cohesive and/or strippable. For initial-mixing calculations, information on initial concentration, background concentration, and water quality standards for the constituent to be modeled has to be specified. The description of the disposal operation includes the position of the disposal barge or hopper dredge on the grid; the barge or hopper dredge velocity, dimensions, and draft; and volume of dredged material to be dumped. Coefficients are required for the model to accurately specify entrainment, settling, drag, dissipation, apparent mass, and density gradient differences. These coefficients have default values that should be used unless other site-specific information is available. Table D1 lists the necessary input parameters with their corresponding units. Table D1 also lists the input parameters for determining the contaminant of concern to be modeled based on dilution needs. More detailed descriptions and guidance for selection of values for many of the parameters are provided directly on-line in the system.

Model Output

The output starts by echoing the input data and then optionally presenting the time history of the descent and collapse phases. In descent history, the location of the cloud centroid, the velocity of the cloud centroid, the radius of the hemispherical cloud, the density difference between the cloud and the ambient water, the conservative constituent concentration, and the total volume and concentration of each solid fraction are provided as functions of time since release of the material.

At the conclusion of the collapse phase, time-dependent information concerning the size of the collapsing cloud, its density, and its centroid location and velocity as well as contaminant and solids concentrations can be requested. The model performs the numerical integrations of the governing conservation equations in the descent and collapse phases with a minimum of user input. Various control parameters that give the user insight into the behavior of these computations are printed before the output discussed above is provided.

At various times, as requested through input data, output concerning suspended sediment concentrations can be obtained from the transport-diffusion computations. With Gaussian cloud transport and diffusion, only concentrations at the water depths requested are provided at each grid point.

For evaluations of initial mixing, results for water column concentrations can be computed in terms of milligrams per liter of dissolved constituent for Tier II evaluations or in percent of initial concentration of suspended plus dissolved constituents in the dredged material for Tier III evaluations. The maximum concentration within the grid and the maximum concentration at or outside the boundary of the disposal site are tabulated for specified time intervals. Graphics showing the maximum concentrations inside the disposal-site boundary and anywhere on the grid as a function of time can also be generated. Similarly, contour plots of concentration can be generated at the requested water depths and at the selected print times.

Target Hardware Environment

The system is designed for the 80386-based processor class of personal computers using DOS. This does not constitute official endorsement or approval of these commercial products. In general, the system requires a math coprocessor, 640 KB of RAM, and a hard disk. The STFATE executable model requires about 565 KB of free RAM to run; therefore, it may be necessary to unload network and TSR software prior to execution. The model is written primarily in Fortran 77, but some of the higher level operations and file-management operations are written in BASIC; some of the screen control operations in the Fortran 77 programs are performed using an Assembly language utility program.

Availability of Models

All U.S. Army Engineer Waterways Experiment Station (WES) computer models referred to in this report are available as a part of the Automated Dredging and Disposal Alternatives Modeling System (ADDAMS), and can be downloaded from the World Wide Web from the WES Dredging Operations Technical Support (DOTS) homepage at http://www.wes.army.mil/el/dots/dots.html.

References

Brandsma, M. G., and Divoky, D. J. (1976). "Development of models for prediction of short-term fate of dredged material discharged in the estuarine environment," Contract Report D-76-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H. (1990). "User's guide for models of dredged material disposal in open water," Technical Report D-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Koh, R. C. Y., and Chang, Y. C. (1973). "Mathematical model for barged ocean disposal of waste," Environmental Protection Technology Series EPA 660/2-73-029, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, P. R., and Palermo, M. R. (1990). "Automated dredging and disposal alternatives management system, User's Guide," Technical Note EEDP-06-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

U.S. Environmental Protection Agency/U.S. Army Corps of Engineers. (1991). "Evaluation of dredged material proposed for ocean disposal (Testing Manual)," EPA-503/8-91/001, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

__________. "Evaluation of dredged material proposed for discharge in inland and near-coastal waters - Testing manual," Report in preparation, U.S. Environmental Protection Agency, Washington, DC.

Table D1
STFATE Model Input Parameters

Parameter	Disposal Operation Types[1]	Units	Options[2]
Contaminant Selection Data			
Solids concentration of dredged material		g/L	
Contaminant concentration in the bulk sediment		μg/kg	
Contaminant concentration in the elutriate		μg/L	
Contaminant background concentration at disposal site		μg/L	
Contaminant water quality standards		μg/L	
Site Description			
Number of grid points (left to right)	H, B		
Number of grid points (top to bottom)	H, B		
Spacing between grid points (left to right)	H, B	ft	
Spacing between grid points (top to bottom)	H, B	ft	
Constant water depth	H, B	ft	C
Roughness height at bottom of disposal site	H, B	ft	
Slope of bottom in x-direction	H, B	degrees	
Slope of bottom in z-direction	H, B	degrees	
Number of points in density profile	H, B		
Depth of density profile point	H, B	ft	
Density at profile point	H, B	g/cc	
Salinity of water at disposal site	H, B	ppt	Optional
Temperature of water at disposal site	H, B	Celsius	Optional
Grid points depths	H, B	ft	V
Velocity Data			
Type of velocity profile	H, B		
Water depth for averaged velocity	H, B	ft	
Vertically averaged x-direction velocity	H, B	ft/sec	
			(Sheet 1 of 4)

[1] The use of a parameter for disposal operations by a multiple bin hopper dredge is indicated in the table by an H, while a parameter used for disposal from a split-hull barge or scow is indicated by a B.
[2] The use of a parameter for the constant depth option or variable depth option is indicated in the table by a C or V, respectively. Other optional uses for parameters are so indicated.

Table D1 (Continued)

Parameter	Disposal Operation Types	Units	Options
Velocity Data (Continued)			
Vertically averaged z-direction velocity	H, B	ft/sec	
Water depths for 2-point profile	H, B	ft	
Velocities for 2-point profile in x-direction	H, B	ft/sec	
Velocities for 2-point profile in z-direction	H, B	ft/sec	
Velocities for entire grid in x-direction	H, B	ft/sec	
Velocities for entire grid in z-direction	H, B	ft/sec	
Input, Execution, and Output Keys			
Processes to simulate	H, B		
Duration of simulation	H, B	sec	
Long-term time step for diffusion	H, B	sec	
Convective descent output option	H, B		
Collapse phase output option	H, B		
Number of print times for long-term diffusions	H, B		
Location of upper left corner of mixing zone on grid	H, B	ft	
Location of lower right corner of mixing zone on grid	H, B	ft	
Water quality standards at border of mixing zone for contaminant of concern	H, B	mg/L	
Contaminant of concern	H, B		
Contaminant concentration in sediment	H, B	mg/kg	
Background concentration at disposal site	H, B	mg/L	
Location of upper left corner of zone of initial dilution (ZID) on grid	H, B	ft	
Location of lower right corner of ZID on grid	H, B	ft	
Water quality standards at border of ZID for contaminant of concern	H, B	mg/L	
Number of depths in water column for which output is desired	H, B		
Depths for transport - diffusion output	H, B	ft	
Predicted initial concentration in fluid fraction	H, B	mg/L	
Dilution required to meet toxicity standards	H, B	percent	
Dilution required to meet toxicity standards at border of ZID	H, B	percent	

(Sheet of 2 of 4)

Table D1 (Continued)			
Parameter	**Disposal Operation Types**	**Units**	**Options**
Material Description Data			
Total volume of dredged material in the hopper dredge	H	yd^3	
Number of distinct solid fractions	H, B		
Solid-fraction descriptions	H, B		
Solid-fraction specific gravity	H, B		
Solid-fraction volumetric concentration	H, B	yd^3/yd^3	
Solid-fraction fall velocity	H, B	ft/sec	
Solid-fraction deposited void ratio	H, B		
Solid-fraction critical shear stress	H, B	lb/sq ft	
Cohesive? (yes or no)	H, B		
Stripped during descent? (yes or no)	H, B		
Moisture content of dredged material as multiple of liquid limit	H, B		Cohesive
Water density at dredging site	H, B	g/cc	
Salinity of water at dredging site	H, B	ppt	Optional
Temperature of water at dredging site	H, B	Celsius	Optional
Desired number of layers	B		
Volume of each layer	B	yd^3	
Velocity of vessel in x-direction during dumping of each layer	B	ft/sec	
Velocity of vessel in z-direction during dumping of each layer	B	ft/sec	
Disposal Operation Data			
Location of disposal point from top of grid	H, B	ft	
Location of disposal point from left edge of grid	H, B	ft	
Length of disposal vessel bin	H, B	ft	
Width of disposal vessel bin	H, B	ft	
Distance between bins	H	ft	
Predisposal draft of hopper	H	ft	
Postdisposal draft of hopper	H	ft	
Time required to empty all hopper bins	H	sec	
Number of hopper bins opening simultaneously	H		
			(Sheet 3 of 4)

Table D1 (Concluded)

Parameter	Disposal Operation Types	Units	Options
Disposal Operation Data (Continued)			
Number of discrete openings of sets of hopper bins	H		
Vessel velocity in x-direction during each opening of a set of hopper bins	H	ft/sec	
Vessel velocity in z-direction during each opening of a set of hopper bins	H	ft/sec	
Bottom depression length in x-direction	H, B	ft	Optional
Bottom depression length in z-direction	H, B	ft	Optional
Bottom depression average depth	H, B	ft	Optional
Predisposal draft of disposal vessel	B	ft	
Postdisposal draft of disposal vessel	B	ft	
Time needed to empty disposal vessel	B	sec	
Coefficients			
Settling coefficient	H, B		
Apparent mass coefficient	H, B		
Drag coefficient	H, B		
Form drag for collapsing cloud	H, B		
Skin friction for collapsing cloud	H, B		
Drag for an ellipsoidal wedge	H, B		
Drag for a plate	H, B		
Friction between cloud and bottom	H, B		
4/3 Law horizontal diffusion dissipation factor	H, B		
Unstratified water vertical diffusion coefficient	H, B		
Cloud/ambient density gradient ratio	H, B		
Turbulent thermal entrainment	H, B		
Entrainment in collapse	H, B		
Stripping factor	H, B		

(Sheet 4 of 4)

Appendix E
Multiple Dump Fate (MDFATE) of Dredged Material Model

Introduction

This appendix provides information on the computer program Multiple Dump Fate (MDFATE) formally known as Open-Water Disposal Area Management Simulation (ODAMS) (Moritz and Randall 1995). MDFATE is a site management tool that bridges the gap between the STFATE (Johnson 1990) and LTFATE (Scheffner et al. 1995) models. It simulates multiple disposal events at one site to predict the creation of navigation hazards, examine site capacity, and conduct long-term site planning. MDFATE uses modified versions of STFATE and LTFATE for simulations. Similar to LTFATE, local wave and tide information input is required as well as disposal-site boundaries and bathymetry. The disposal-site bathymetry can be either automatically generated (flat or sloping), or actual bathymetric data from an ASCII file can be imported. The suspended solids and conservative tracer portions of STFATE are removed so the modified STFATE version models the convective descent, dynamic collapse, and passive diffusion process only.

Because of the modified LTFATE version, MDFATE can also account for cohesive and noncohesive sediment transport, cohesive sediment consolidation, and noncohesive avalanching. MDFATE can also simulate capping based on the slow release of material from a barge/hopper so it may spread evenly on the bottom with a minimum amount of momentum imparted to the primary mound.

This appendix provides an overview of the theoretical background of MDFATE, personal computer (PC) requirements, required input, and typical output.

Overview of MDFATE

MDFATE was developed to address dredged material placement site management issues. By tracking the volume of material placed in an offshore disposal site from multiple dredging operations, site managers can plan for maximum utilization of the site. Multiple disposals that are point dumped during one specific operation can be simulated to determine if navigation obstructions would be created. For site-use planning, MDFATE will ultimately allow site managers to plan for additional disposal sites as sites reach capacity.

While STFATE simulates short-term processes (seconds to hours) and LTFATE simulates long-term processes (days to months) of dredged material mounding, MDFATE brackets these processes by modeling the accumulation of material on the bottom resulting from multiple disposals.

MDFATE may be roughly categorized into three primary components: grid generation, model execution, and postprocessing. The initial step in executing MDFATE and the foundation of the model is grid generation. Subsequent to grid generation, model execution consists of running the modified versions of LTFATE and STFATE, which provide information to augment the grid. Postprocessing consists of various plotting routines to present model results.

Disposal site-grid generation is based on a user-specified horizontal control (state plane or latitude-longitude) to create a horizontal grid. Presently, MDFATE can accommodate a grid with 40,000 nodes, which will allow representation of a disposal site up to approximately 22,000 by 22,000 ft (100-ft grid interval). ODMDS corner points are specified by the user, and MDFATE creates the horizontal grid based on desired grid intervals.

Vertical control is based on a user-specified datum. MDFATE can automatically create a uniform flat or sloping bottom based on the datum of interest, or MDFATE can overlay actual bathymetric data in ASCII form and apply it to the horizontal grid by a multipoint polynomial interpolation.

Once grid generation is completed, MDFATE can simulate multiple (hundreds) disposal events that can extend over 1 year. The disposal operation is broken down into individual week-long episodes during which long-term processes are simulated by the modified version of LTFATE. Within each week-long episode, the modified version of STFATE is executed that simulates dredged material dumped through the water column to bottom accumulation. Cumulative results are generated for self-weight consolidation, sediment transport by waves and currents, and mound avalanching.

The original version of STFATE simulates single disposal events (i.e., one dump) to model water column concentrations of suspended solids and a conservative tracer (not done for MDFATE version). STFATE also generates a disposal mound footprint identifying the extent of dredged material coverage for the dump as well as mound volume and thickness. Water column currents can be accounted for as well as sloping or depression disposal areas. Differences in material composition can be considered, and layering of different materials in the hopper can be modeled also. Based on material properties, currents, etc., stripping of fines is accounted for, and an estimate of how the material accumulates on the seafloor is provided. STFATE output consists of plots of mound footprint coverage and thickness of bottom accumulation. MDFATE modifies the existing bathymetric grid according to the STFATE-predicted mound footprint and bottom thickness. Subsequent STFATE outputs are appended to the grid, thus creating a composite mound.

For the week-long simulations, LTFATE models the long-term processes affecting the created composite mound. The processes modeled include morphological changes resulting from cohesive and noncohesive sediment erosion, noncohesive sediment avalanching, and cohesive sediment consolidation. For the sediment erosion processes, LTFATE requires input from hydrodynamic databases for tides and waves. The tidal current time-series is generated from user-specified tidal constituents for the site of interest by the program TIDE. Wave statistics from the Wave Information Study (WIS) are used (provided by the user for the site of interest) by the program HPDSIM to generate a wave time-series and ultimately wave-induced currents. The net resulting tidal and wave currents are then used to drive the sediment transport portion of the model. These two routines are also used by the STFATE model within MDFATE to generate the water column currents that affect material settling for the short-term processes.

A summary of the noncohesive and cohesive sediment transport algorithms used by MDFATE can be mound in the description of LTFATE (Appendix F).

The avalanching routine applied in LTFATE is based on a routine developed by Larson and Kraus (1989), who adapted the work of Allen (1970) on slope failure. Allen's (1970) experiments showed that two limiting slopes occurred, angle of initial yield and the residual angle after shearing, which were influenced by the particle deposition-rate gradient, particle concentration at the time of deposition, and particle size and density. Allen (1970) examined the effect of a larger deposition rate at the top of a slope versus the toe of a slope, which in effect produced a steepening by rotating the slope around the toe. When the slope becomes unstable, it avalanches, and a new more stable slope is formed.

To account for consolidation of cohesive sediment, the procedure developed by Poindexter-Rollings (1990) for predicting the behavior of a subaqueous sediment mound was followed. The consolidation calculations used by Poindexter-Rollings (1990) and used in LTFATE were based on finite strain theory introduced by Gibson, England, and Hussey (1967). Numerical solutions were developed by Cargill (1982, 1985). Finite strain theory is well-suited for the prediction of consolidation in cases of thick deposits of fine-grained sediments because it provides for the effect of self-weight, permeability that varies with void ratio, nonlinear void ratio-effective stress relationship, and large strains (Scheffner et al. 1995).

Data Requirements

Data requirements for running MDFATE are much the same as those for STFATE (Appendix D) and LTFATE (Appendix F). As described previously, the user must specify ODMDS corner coordinates and interval size for grid generation. Bathymetric data (including datum) must be provided from an external source or automatically generated. Site locations must be identified to specify necessary constituents for the tidal constituent program and to create the wave time series from the WIS location of interest. Other data needs include volume of material to be dredged, dredged material properties (i.e., composition, voids, density, etc.), characteristics of disposal equipment, disposal duration, water column data (density, currents), and method of disposal vessel control. Four options exist for simulating disposal vessel control:

a. Disposal within a given radial distance of a specific geographic location (i.e., disposal within a certain radius of a buoy). Dumps are randomly placed with a bias applied toward the direction of approach of the disposal vessel.

b. Disposals along transect lines identified by starting and ending coordinates.

c. User-specified coordinates for each disposal load.

d. Prerecorded coordinates for each disposal load.

System Requirements

Recommended minimum system requirements for running MDFATE are as follows:

a. IBM compatible 486.

b. DOS version 5.0 or greater.

c. 592 KB RAM.

d. 8 MB available hard disk space.

e. Printer capable of printing graphics (recommended).

Postprocessing

Model output from MDFATE consists of two-dimensional (2-D) contour plots and 3-D surface images. Output can be either viewed within MDFATE or data exported to an external graphics package for plotting. MDFATE also allows grid comparison where before/after scenarios can be examined to analyze mounding and/or erosion of a dredged material mound. Generic mounds may also be created to model long-term morphological behaviors.

Capping Option

A dredged material capping option was developed for inclusion in the MDFATE model. It is based on a modification to STFATE that allows for the slow release of material from a barge/hopper so it may spread evenly on the bottom with a minimum amount of momentum. The capping option specifically addresses the short-term processes that affect dredged material as it experiences passive transport, diffusion, and settling of solids based on individual particle fall speed. The capping option assumes the material will be placed along multiple transects that are repeated and offset to achieve the desired cap thickness.

The STFATE model and its associated grid domain is used as a kernel within the MDFATE grid domain for every disposal/capping event. The capping module uses STFATE with a grid limited to 25 by 25 square elements as opposed to the standard 45 by 45 rectangular grid elements available in the original version of STFATE. If the capping site is large, each load of cap material may require partitioning to ensure its fit within the adapted STFATE grid. Running the adapted STFATE grid as a kernel within the MDFATE grid and possible material partitioning contributes to a higher level of complexity for the capping module than for MDFATE alone. This complexity, therefore, leads to increased execution time.

Two disposal methods can be simulated with the capping module. One method is the slow release of cap material through the slightly cracked (1 to 2 ft) split hull of a split hull barge/hopper dredge. The second method simulates hydraulic pipeline discharge from a hopper dredge reversing its dredge pumps. The simulation can be either for pumping in the direction of vessel transport or counter to vessel transport as the vessel transects the disposal area.

Due to the DOS 640K memory limitations, the capping module must be run independently of the LTFATE long-term processes simulation. If the user desires to simulate both capping and long-term processes, the MDFATE capping module must first be executed followed by the LTFATE portion of MDFATE.

Typical Output

Figures E1 and E2 show typical MDFATE graphical output, 2-D and 3-D contour plots of bathymetry resulting from MDFATE simulations. Textual output consists of tables showing locations of the dumps, volume differences between two bottom bathymetries, and maximum elevation of mounds created. Also, ASCII files containing tables showing the amount of sediments on the bottom and in the water column, identical to those produced by STFATE are created. Finally, the velocity of the descending jet can also be determined from the STFATE-like files.

Availability of Models

All U.S. Army Engineer Waterways Experiment Station (WES) computer models referred to in this report are available as a part of the Automated Dredging and Disposal Alternatives Modeling System (ADDAMS) and can be downloaded from the World Wide Web from the WES Dredging Operations Technical Support (DOTS) homepage at http://www.wes.army.mil/el/dots/dots.html.

References

Ackers, P., and White, W. R. (1973). "Sediment transport: New approach and analysis," *Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers* 99 (HY11).

Allen, J. R. L. (1970). "The avalanching of granular solids on dune and similar slopes," *Journal of Geology* 78.

Ariathurai, R., MacArthur, R. C., and Krone, R. B. (1977). "Mathematical model of estuarial sediment transport," Technical Report D-77-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cargill, K. W. (1982). "Consolidation of soft layers by finite strain analysis," Miscellaneous Paper GL-82-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1985). "Mathematical model for the consolidation/desiccation process in dredged material," Technical Report D-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

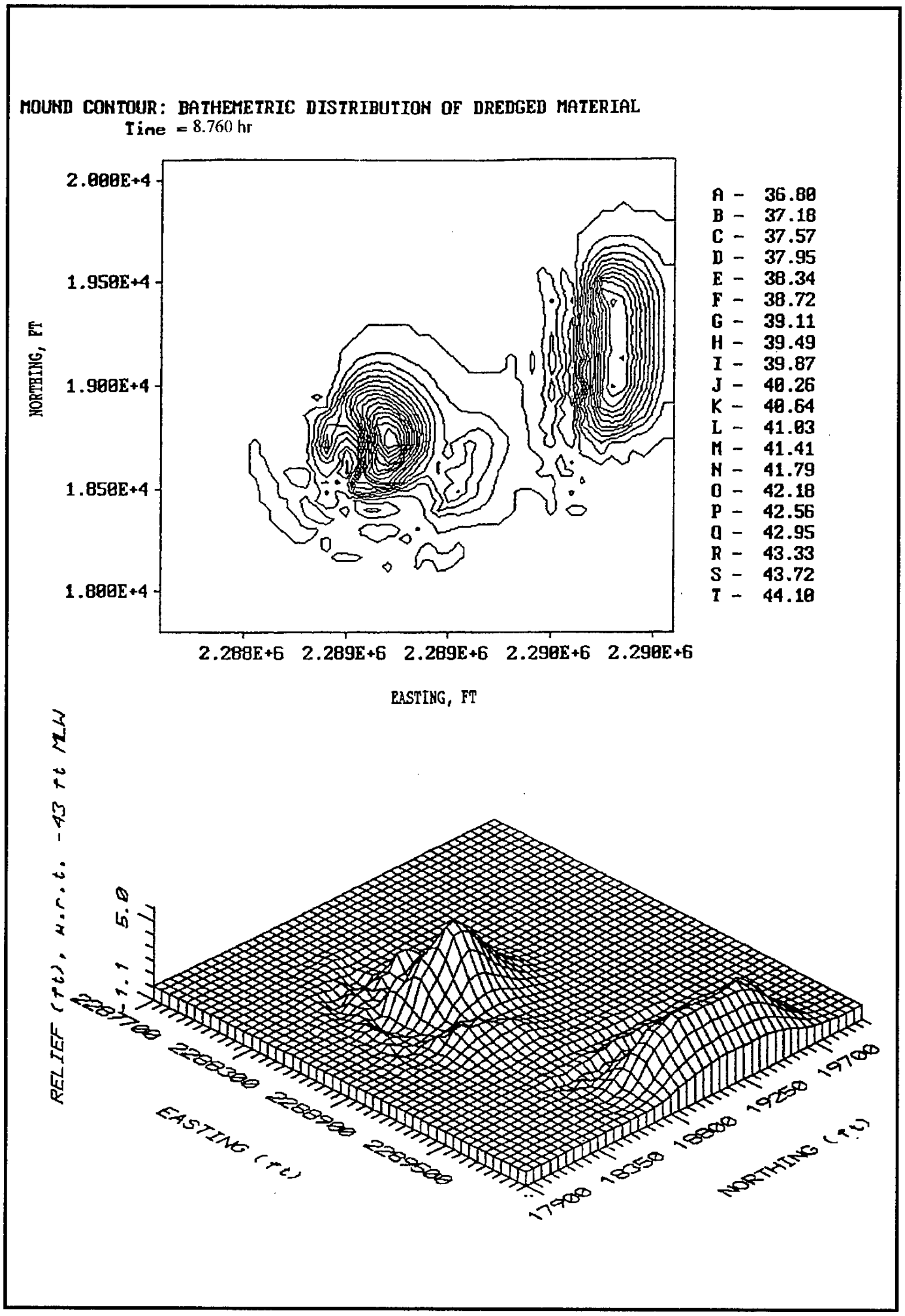


Figure E1. Typical MDFATE model output showing differences between pre-disposal and postdisposal bathymetry

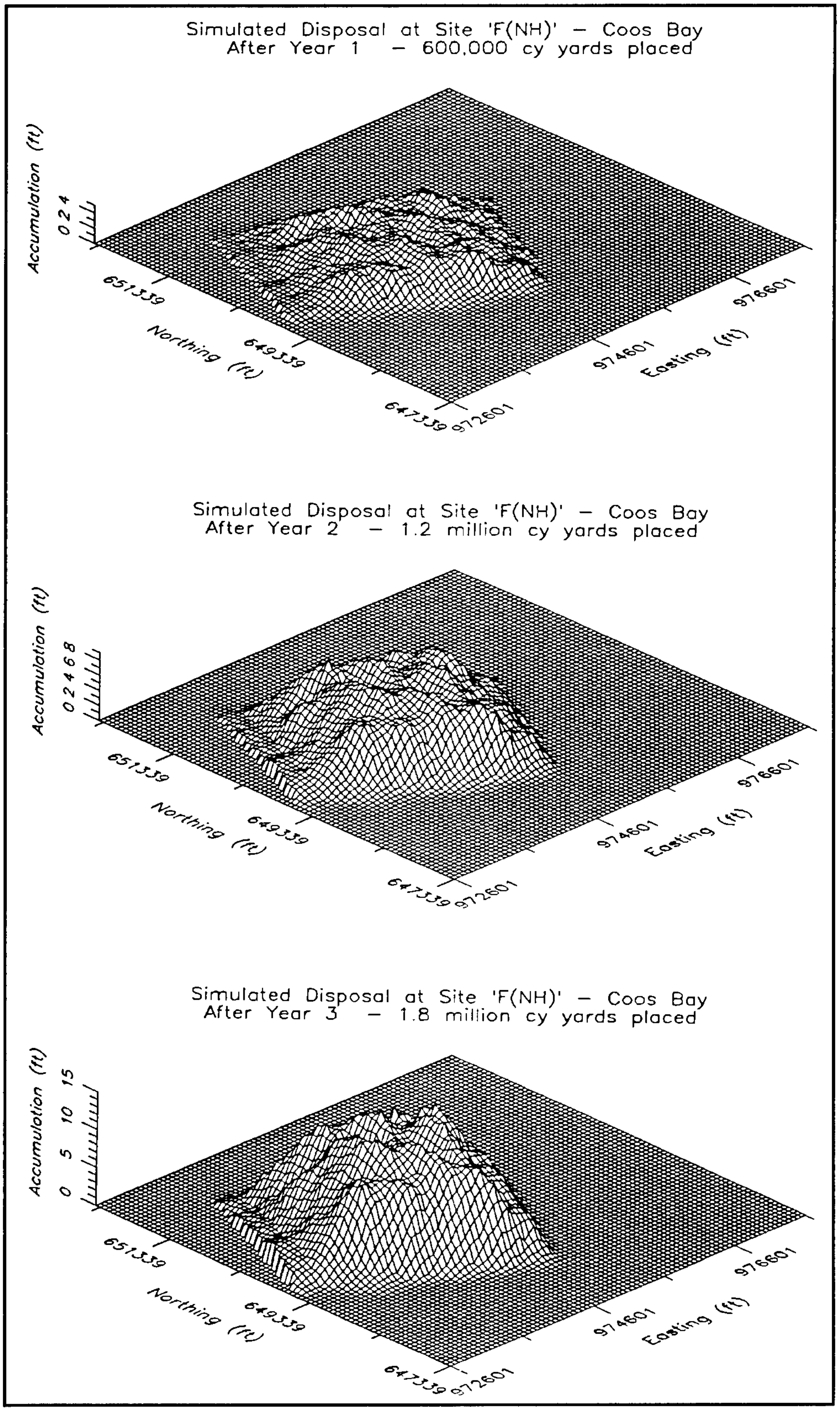


Figure E2. Typical MDFATE model output showing mound formation 1-3 years of disposal at Coos Bay

Gibson, R. E., England, G. L., and Hussey, M. J. L. (1967). "The theory of one-dimensional consolidation of saturated clays; I. Finite non-linear consolidation of thin homogeneous layers," *Geotechnique* 17, 261-273.

Johnson, B. H. (1990). "User's guide for models of dredged material disposal in open water," Technical Report D-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Larson, M., and Kraus, N. C. (1989). "SBEACH: Numerical model for simulating storm induced beach change, Report 1: Empirical foundation and model development," Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Moritz, H. R., and Randall, R. E. (1995). "Simulating dredged-material placement at open-water disposal sites," *Journal of Waterway, Port, Coastal, and Ocean Engineering* 121(1).

Poindexter-Rollings, M. E. (1990). "Methodology for analysis of subaqueous sediment mounds," Technical Report D-90-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., Thevenot, M. M., Tallent, J. R., and Mason, J. M. (1995). "LTFATE: A model to investigate the long-term fate and stability of dredged material disposal sites; User's guide," Instruction Report DRP-95-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Teeter, A. M., and Pankow, W. (1989). "Schematic numerical modeling of harbor deepening effects on sedimentation, Charleston, SC," Miscellaneous Paper HL-89-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

White, P. (1972). "A sediment transport in channels: A general function," Report Int 104, Hydraulics Research Station, Wallingford, England.

Appendix F
Long-Term Fate (LTFATE) of Dredged Material Model

Introduction

This appendix provides information on the computer program used to execute the Long Term FATE (LTFATE) model. LTFATE is a site-evaluation tool that estimates the dispersion characteristics of a dredged material placement site over long periods of time, ranging from days for storm events to a year or more for ambient conditions. Simulations are based on the use of local wave and currents input to the model. Local, site-specific hydrodynamic input information is developed from numerical model-generated databases; however, user-supplied data files can be substituted for the database-generated files described in this report.

LTFATE has the capability of simulating both noncohesive and cohesive sediment transport. In addition, avalanching of noncohesive sediments and consolidation of cohesive sediments are accounted for to accurately predict physical processes that occur at the site. It should be emphasized that LTFATE, although demonstrated to accurately simulate mound movement, is still under development. Modifications are underway that will improve the basic description of sediment processes. These additions include modifications for mounds on a sloped bottom bathymetry and layering of sediments to account for the decrease in cohesive sediment resuspension potential with depth. Also, additional field and laboratory work are necessary to fully understand (and thus be able to model) cohesive sediment erosion and deposition processes under high shear stresses. LTFATE is designed to lend itself easily to code modification to include new processes.

This appendix provides an overview of the theoretical background on which the model is based, the personal computer (PC) requirements to run the model, required input, and typical output. Details on all of these aspects can be found in Scheffner et al. 1995.

Overview of LTFATE

LTFATE is a site-analysis program that uses coupled hydrodynamic, sediment transport, and bathymetry change models to compute site stability over time as a function of local waves, currents, bathymetry, and sediment size. LTFATE was developed to simulate the long-term fate and stability of dredged material placed in open water with an initial intended use for classifying existing or proposed disposal sites as dispersive or nondispersive. If the site is demonstrated to be dispersive, model output will provide an estimate of the temporal and spatial fate of the eroded material. This determination is often difficult to quantify because the movement of sediment is a function of not only the local bathymetry and sediment characteristics, but also the time-varying wave and current conditions. LTFATE overcomes these difficulties by using an information database to provide design wave and current time series boundary conditions that realistically represent conditions at the candidate disposal site.

The wave simulation methodology and the elevation and current databases referenced in this report were developed through the Dredging Research Program (DRP) at the U.S. Army Engineer Waterways Experiment Station (WES). The procedures for generating stochastic wave height, period, and direction time series are reported in Borgman and Scheffner (1991). The database of tidal elevations and currents for the east coast, Gulf of Mexico, and Caribbean Sea are described in Westerink, Luettich, and Scheffner (1993), and the database of tropical storm surge and current hydrographs is reported in Scheffner et al. (1994). These data are used to generate wave and current boundary condition data for use as input to LTFATE for evaluating mound stability. If these databases are not available for the geographic area of interest to the user, then replacement input files will have to be supplied by the user and copied into the appropriately designated files.

Noncohesive mound movement

The LTFATE model uses four coupled subroutines to predict dredged material movement of various types of noncohesive material during different stages of mound evolution. These subroutines simulate hydrodynamics, sediment transport, mound cascading, and bathymetry change. LTFATE uses the equations reported by Ackers and White (1973) as the basis for the noncohesive sediment transport model. The equations are applicable to uniformly graded noncohesive sediment with a grain diameter in the range of 0.04 to 4.0 mm (White 1972). Because many disposal sites are located in relatively shallow water, a modification of the Ackers-White equations was incorporated to reflect an increase in the transport rate when ambient currents are accompanied by surface waves. The modification is based on an application of the concepts developed by Bijker (1971) and enhanced by Swart (1976). This preliminary model was verified to prototype data by Scheffner (1991) and was shown to be a viable approach to providing quantitative predictions of disposal-site stability.

Kraus and Larson (1988) found that in some large wave tank cases, the local slope of a mound of noncohesive material exceeded the angle of repose due to constant waves and water levels. Therefore, the concept of slope failure was incorporated in LTFATE to ensure stability of the dredged material mound by employing an algorithm developed by Larson and Kraus (1989). The algorithm is based on laboratory studies conducted by Allen (1970), who investigated steepening of slopes consisting of granular solids. Allen (1970) recognized two limiting slopes, the angle of initial yield and the residual angle after shearing. If the slope exceeds the angle of initial yield, material is redistributed along the slope through avalanching, and a new stable slope is attained, known as the residual angle after shearing.

Cohesive mound movement

An improved cohesive sediment transport model has recently been incorporated into LTFATE to account for transport of fine-grained material, i.e., silts and clays. Fine-grained sediments are hydraulically transported almost entirely in suspension rather than as bed load; therefore, the Ackers-White equations are not applicable for these conditions. The cohesive sediment transport model requires bottom shear stress as input. The total bottom shear stress due to currents and waves is determined using the combined current/wave >perceived velocity=, V_{wc} (Bijker 1971; Swart 1976) and bottom roughness parameters. This method for calculating shear stress, like most others, is influenced by bottom roughness parameters. These parameters are frequently not available for the study area, and the results may change significantly depending on their values. Bottom roughnesses for typical ocean sediments can be used in lieu of actual data.

The factors influencing the resistance of a cohesive sediment bed to erosion may be best described by Ariathurai and Krone (1976) as: (a) the types of clay minerals that constitute the bed; (b) structure of the bed (which in turn depends on the environment in which the aggregates that formed the bed were deposited), time, temperature, and the rate of gel formation; (c) the chemical composition of the pore and eroding fluids; (d) stress history, i.e., the maximum overburden pressure the bed had experienced and the time at various stress levels; and (e) organic matter and its state of oxidation. It is obvious from this description that the resistance of the bed to erosion will be different not only from site to site, but also potentially with depth at a given location. Therefore, erosion potential is usually considered a site-specific function of shear stress (and sometimes depth). Methods have been developed to determine erosion based on stresses, but these equations require parameters whose values are site specific. A commonly used method of relating erosion to shear stress has been incorporated into LTFATE. This method relates erosion as a function of shear stress to some exponential power. The equation for the erosion rate in grams/square centimeter/second is:

$$\varepsilon = A_O \left(\frac{J - J_{cr}}{J_r} \right)^m$$

where

A_0 and m = site-specific parameters

J = shear stress due to currents and waves

J_{cr} = site-specific critical shear stress below which no erosion occurs (which can reasonably be set to 5 $dynes/cm^2$ if site data are not available)

J_r = a reference shear stress (assumed to be 1 $dyne/cm^2$)

Most research on cohesive sediment erosion has been performed in laboratory settings at moderate shear stresses less than 20 $dynes/cm^2$ (Lavelle, Mofjeld, and Baker 1984). The method incorporated into LTFATE was developed for moderate stresses. Data for high shear stresses are sparse, and the experimental methods are still under development (McNeil, Taylor, and Lick 1996). Despite this, a lot can be determined by using the moderate shear equations in high-shear regions. It would appear from bathymetry measurements in high-shear regions that the above equation can adequately simulate these conditions.

It should be noted that the values of the site-specific parameters used in these methods can vary significantly. Experimentally determined values of A_0 range over several orders of magnitude from 1×10^{-9} to 5×10^{-6} ($g/cm^2/sec$) and m ranges from 1 to 5 (Lavelle, Mofjeld, and Baker 1984). The experimental range of exponent m values coupled with the equation for J demonstrate that the relationship between velocity and erosion is highly nonlinear (J is a function of V^2 and ε is a function of J^m resulting in ε is a function of V^{2m}). Therefore, the rare storm events will produce most of the cohesive sediment erosion for a given year. This is well known to occur in many rivers, lakes, and nearshore environments. Some studies on San Francisco Bay sediments suggest that m ranges from 1-2 for these sediments, assuming they have had long compaction periods (Parthenaides 1965). The higher values of m are reserved for freshwater lake and river sediments. For application of LTFATE, erosion tests should be performed on site sediments. If at all possible, values for A_0 and m should be determined from laboratory experiments on sediment cores extracted from the study area. If no such data are available, values for A_0 and m can be set to 7.6×10^{-8} $g/cm^2/sec$ and 2, respectively. These values will produce a decent conservative (i.e., high) estimate for erosion potential. They were developed for recently deposited sediments at the New York Bight Mud Dump site. They will produce a conservative estimate because they are for recently deposited, and therefore more easily resuspended, sediments.

Required hardware

The following are recommended minimum hardware requirements for running the LTFATE interface on a PC with a standard Disk Operating System (DOS) Version 3.3 or greater:

a. 386-25 MHZ processor (faster processors are recommended, they greatly reduce execution time).

b. Math coprocessor.

c. 620 K resident memory.

d. VGA monitor (required).

e. Hard disk with several megabytes free.

f. HP LaserJet II or III (or compatible) printer for hard copy.

A compiler is not required because the LTFATE interface and model are distributed as executable files together with several data files. The PC version of the LTFATE interface may access all memory within the 640-K DOS limit. Therefore, the LTFATE interface should be run from the DOS prompt with all resident memory programs removed to ensure enough memory exists for model execution. The graphic routine provided in this package, HGRAPH,[1] is non-proprietary and property of the U.S. Government.

Program files

The LTFATE package presently consists of the following three main programs:

a. PC_WAVEFIELD.

b. PC_TIDAL.

c. PC_LTFATE.

LTFATE in its entirety may be used as a complete site evaluation package, or individual programs may be accessed independently for other applications.

PC_WAVEFIELD creates a time series of wave height, period, and direction based on the computed intercorrelation matrix describing the statistical properties of wave height, period, and direction, and their respective interrelationships.

---

[1] The program HGRAPH was developed by Mr. David W. Hyde, Structural Engineer, WES, Structures Laboratory, Vicksburg, MS.

The matrix is computed from a time series of data corresponding to the location of interest.

In PC_TIDAL, a database containing the harmonic constituents for tidal elevation and currents for a site-specific location are used to generate an arbitrarily long sequence of tidal data. PC_TIDAL includes the following two options: (a) simulation of the long-term tide sequence, and (b) generation of time history plots for the tide elevation, velocity components, and direction.

Lastly, the program PC_LTFATE automatically accesses data generated by the programs PC_WAVEFIELD and PC_TIDAL to simulate long-term dredged material mound movement. These two programs require input files describing the statistical distribution of a site-specific wave field and tidal harmonic constituents relative to that site. If these data are not available, the user is required to supply the appropriately named files to substitute for the output files ordinarily generated by the programs PC_WAVEFIELD and PC_TIDAL.

The PC_LTFATE program should be employed only after executing programs PC_WAVEFIELD and PC_TIDAL. PC_LTFATE includes the following four options: (a) seabed geometry configuration program, (b) simulation of dredged material mound movement, consolidation, and avalanching, (c) generation of dredged material mound evolution contour plots, and (d) generation of dredged material mound evolution cross-sectional plots.

Databases for waves, tides, and storm surge to support LTFATE are available only for the east and Gulf coasts of the United States. For these applications in other areas, the user is required to supply time series data for waves and storm surge (for storm-event applications) or provide tidal elevation and current constituents, and wave time series (for long-term simulations). Therefore, it is assumed that the user is proficient in the use of a PC, is able to use an editor (if necessary), and can write simple data construction programs and manipulate files. These skills are necessary in order to transfer user-supplied data into the PC and copy it into the appropriate files that are accessed by LTFATE.

Three external user-supplied input files are required by the model to specify wave, tidal, and storm surge boundary conditions for a specific location of interest. Site-specific files will have to be obtained (the Coastal and Hydraulics Laboratory (CHL), WES, can provide these files) or generated by the user in order to define wave and current boundary condition input corresponding to the location of interest.

The first of these external files, named TIDAL.DAT, is used to define a time series tidal elevation and current boundary condition at the subject disposal mound. The TIDAL.DAT file contains amplitude and epoch harmonic tidal constituents for both elevation and currents corresponding to the location of the mound.

Because the LTFATE model requires both tidal elevation and current (*U* and *V*) time series input, harmonic constituents for all three variables must be contained in the data file. This input file can be generated through execution of the program TIDES.EXE. However, the TIDES.EXE program requires an input database of harmonic constituents at discrete locations and, through interpolation, generates elevation and current constituents for any desired location into the appropriate format in the file TIDAL.DAT. The constituent database has been generated for the east coast, Gulf of Mexico, and Caribbean Sea (Westerink, Luettich, and Scheffner 1993) and described in DRP Technical Note DRP-1-13 (Scheffner 1994). Constituent output for a specific location can be obtained by contacting CHL. The tidal constituent database for the west coast is currently under development.

If tidal constituent coverage of the area of user interest is not available, tidal constituent data will have to be obtained from alternate sources; for example, WES technical reports, the National Oceanic and Atmospheric Administration, university sources, open literature, etc., or through harmonic analyses of available or collected elevation and current time series. Adequate data are usually available, but will have to be located and supplied by the user. An example use of external data is reported by Scheffner and Tallent (1994). If the user supplies the necessary data, it must be formatted as shown in Table F1 and should be named TIDAL.DAT.

Table F1
Example LTFATE Tidal Input Data File—TIDAL.DAT

```
 MOBILE, ALABAMA
  TIDAL HEIGHT HARMONIC CONSTITUENTS  (CM/SEC)
     6     0.0    -5.8   -10.4
CONST   SPEED-D/H     AMP-M  EPOCH-D  AMP-C/S  EPOCH-D
AMP-C/S  EPOCH-D
                   HEIGHT            VEL-U            VEL-V
  M2    28.984104    .01   321.00    4.3    46.      6.7    41.
  S2    30.000000    .01   309.60    1.2    47.      1.8     5.
  N2    28.439730    .00   339.10    0.6   317.      1.2   255.
  K1    15.041069    .13   325.70    8.5   229.     14.3   231.
  O1    13.943036    .12   313.30    6.7   242.     10.4   235.
  M1    14.492754    .00   332.80    0.6   330       0.6   346
```

The second file required for long-term simulation of dredged material mound movement is a file containing a time series of wave height, period, and direction named HPDSIM.OUT. This file can either be user supplied or generated internally by LTFATE and is in the format shown in Table F2. If LTFATE generates the file, the additional file HPDPRE.OUT is required. The HPDPRE.OUT file represents the precomputed cross-correlation matrix corresponding to a WIS station location nearest the mound. The combined LTFATE/HPDPRE.OUT

Table F2
Example LTFATE Wave Input Data File—HPDSIM.OUT

```
START MO = 3  START YR =1987  END MO = 8  END YR =1987
 NYR,NNY,NMO=     20   20   12
 IYEARS=   1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 MONTHS=   1 1 1 1 1 1 1 1 1 1 1 1
 CUTOFF=     0.083333   0.083333   0.083333   0.083333   0.083333
 CUTOFF=     0.083333   0.083333   0.083333   0.083333   0.083333
 CUTOFF=     0.083333   0.083333
 IJY=  1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
 IJM=  1 2 3 4 5 6 7 8 9 10 11 12
 198703 100       1.00000    5.00002   343.83057
 198703 103       1.10000    5.00000    35.42109
 198703 106       1.20000    5.00001    52.58537
 198703 109       1.20000    5.00000    58.00993
 198703 112       1.20000    5.00000    53.44814
 198703 115       1.10000    5.00000    36.73721
 198703 118       1.00000    5.00000   340.76096
 198703 121       0.90000    5.00000   293.34930
 198703 200       0.80000    5.00000   283.34152
 198703 203       0.76876    5.00000   279.52328
 198703 206       0.70000    5.00000   277.62357
 198703 209       0.60000    5.00001   276.96350
 198703 212       0.60000    5.00000   276.80725
 198703 215       0.70000    5.00001   277.28809

   .....................................................

 1987082903       0.90000    6.00001    81.11949
 1987082906       0.90000    6.00002    81.50021
 1987082909       0.90000    5.00002    81.90755
 1987082912       0.80001    5.00003    82.21406
 1987082915       0.80000    5.00001    82.76773
 1987082918       0.70000    5.00002    83.25628
 1987082921       0.60000    5.00000    83.61486
 1987083000       0.60000    5.00000    83.84423
 1987083003       0.60000    5.00002    83.97083
 1987083006       0.50000    5.00001    84.04659
 1987083009       0.50000    5.00001    84.10904
 1987083012       0.50000    5.00000    84.17479
 1987083015       0.50000    5.00000    84.23292
 1987083018       0.50000    5.00000    84.25816
 1987083021       0.60000    5.00003    84.26725
 1987083100       0.80000    5.00003    84.27031
 1987083103       0.90000    5.00002    84.25816
 1987083106       1.00000    6.00002    84.21492
 1987083109       1.10000    6.00001    83.96118
 1987083112       1.10000    6.00001    83.34565
```

wave simulation capability is described by Borgman and Scheffner (1991) and Scheffner and Borgman (1992). This approach is used to generate an arbitrarily long time sequence of simulated wave data that preserves the primary statistical properties of the full 20-year WIS hindcast, including wave sequencing and seasonality. Once the matrix has been computed, multiple wave field simulations can be performed, with each time series stored on the file HPDSIM.OUT.

The primary advantage of using this statistically based wave simulation approach is that the user is not limited to a finite length of data; instead, seasonal or yearly repetitions of time series can be used for evaluations of site stability. Each simulation will be statistically similar to the hindcast data but will contain variability consistent with observations. If HPDPRE.OUT matrix is not available for the location of interest, one can be computed by the user or by CHL through use of a WIS 20-year hindcast input file and execution of the program HPDPRE. If the location of interest is not covered by the WIS hindcast database, existing time series of wave height, period, and direction will have to be supplied by the user.

The long-term simulations described above, i.e., simulations of months to years, compute disposal mound stability as a function of residual currents specified by the user in LTFATE, the normal seasonal wave climate, and the tidal elevation and currents computed from the specified tidal constituents in the TIDAL.DAT file. Storm-event erosion calculations are based on surge elevation and currents and the wave field associated with that specific event. These data are contained in the final input file required by LTFATE, the file STORM.DAT. This file must be assembled from existing databases or generated by the user. However, the file is required only if the user desires to simulate the passage of a storm event over the disposal site.

The STORM.DAT file contains either a tropical or extratropical storm surge elevation and current time series hydrograph with a corresponding storm wave height and period corresponding to the selected event. A database of tropical storm hydrographs for 134 historically based tropical storms has been completed for the 486 WIS and offshore discrete locations along the east and Gulf of Mexico coasts and for selected stations offshore of Puerto Rico. This database is described by Scheffner et al. (1994). The companion extratropical event database for the east and Gulf coasts and Puerto Rico has been completed.

A wave climate corresponding to the selected event can be obtained from either available data (if the surge is historically based) or estimated as a function of storm-associated or design peak wave height and periods. In the New York Bight Mud Dump example shown in the frequency of erosion appendix, the surge elevation and velocities were obtained from numerical simulations of the December 1992 extratropical event. The wave field corresponding to the December event was obtained from National Data Buoy Center data. For future applications, surge and current information is now available in a DRP database (reference). If wave data are not available for the selected event, then design peak wave height and period estimates can be used.

The STORM.DAT file should be created by the user of LTFATE to describe a particular storm event or a storm event of assumed shape and duration. An example of hypothetical event use in disposal analysis is given in Scheffner and Tallent (1994).

Program Output

As stated above, the LTFATE program can simulate movement of dredged material mounds both over the long-term and for storms. The final output of the model is a file containing the new mound bathymetry. The bathymetry files can be viewed either as plan view contour plots or cross sections. Figure F1 shows the initial bathymetry of a small sand mound placed in shallow water (17 ft) off Mobile, AL. Figure F2 shows the bathymetry of the same mound approximately 6 months later. Figure F3 shows the change in cross section of the mound along a line 1,500 ft below the centerline of the mound.

Availability of Models

All WES computer models referred to in this report are available as a part of the Automated Dredging and Disposal Alternatives Modeling System (ADDAMS) and can be downloaded from the World Wide Web from the WES Dredging Operations Technical Support (DOTS) homepage at http://www.wes.army.mil/el/dots/dots.html.

Additional Information

For additional information on the LFTATE program, contact Dr. Norman Scheffner (601) 634-3220 of the Research Division of the Coastal and Hydraulics Laboratory at the U.S. Army Engineer Waterways Experiment Station.

References

Ackers, P., and White, R. W. (1973). "Sediment transport: New approach and analysis," *Journal of the Hydraulics Division* 99 (HY11), 2041-60.

Allen, J. R. L. (1970). "The avalanching of granular solids on dune and similar slopes," *Journal of Geology* 78 (3), 326-51.

Ariathurai, R., and Krone, R. B. (1976). "Finite element model for cohesive sediment transport," *J. Hydraul. Div. Am. Soc. Civ. Eng.* 102(HY3), 323-338.

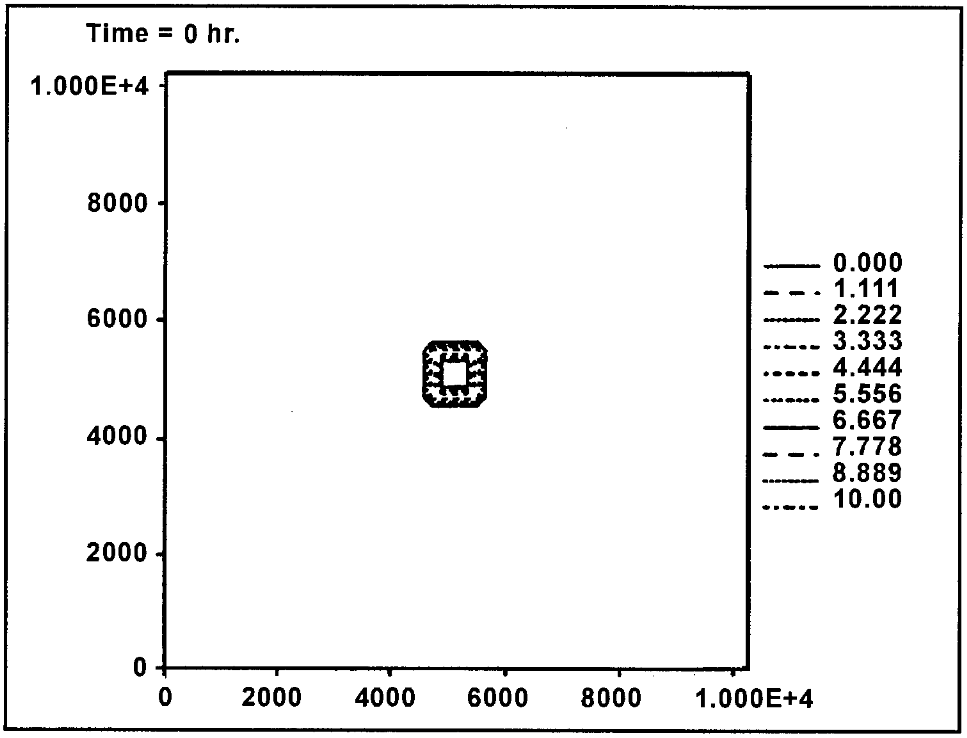


Figure F1. Initial Sand Island mound contours

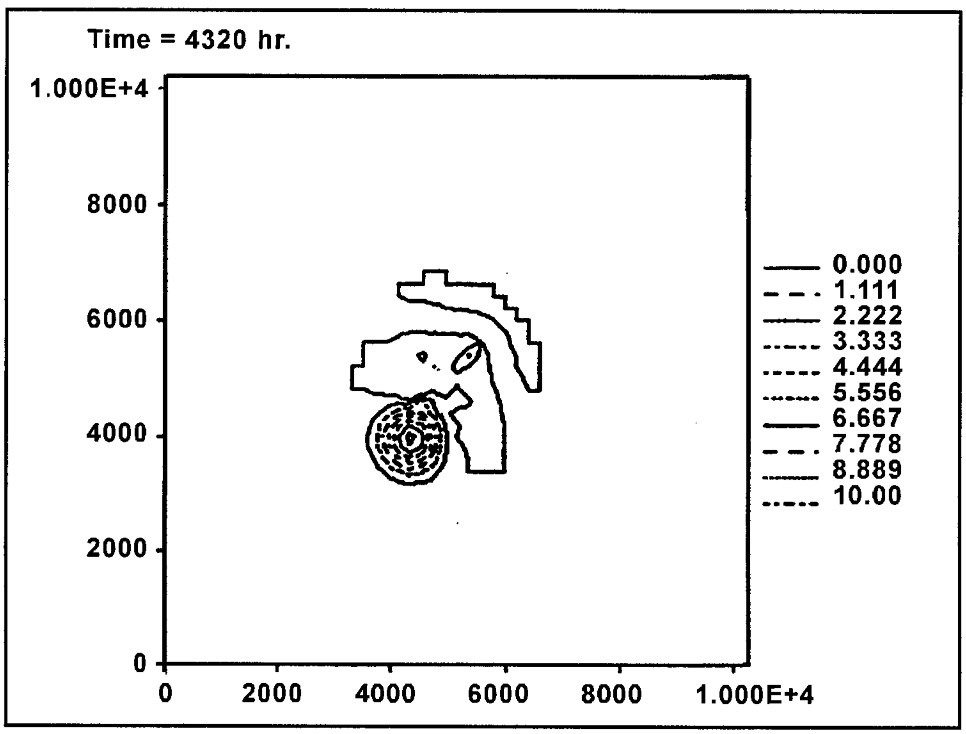


Figure F2. Simulated Sand Island mound contours after 180 days

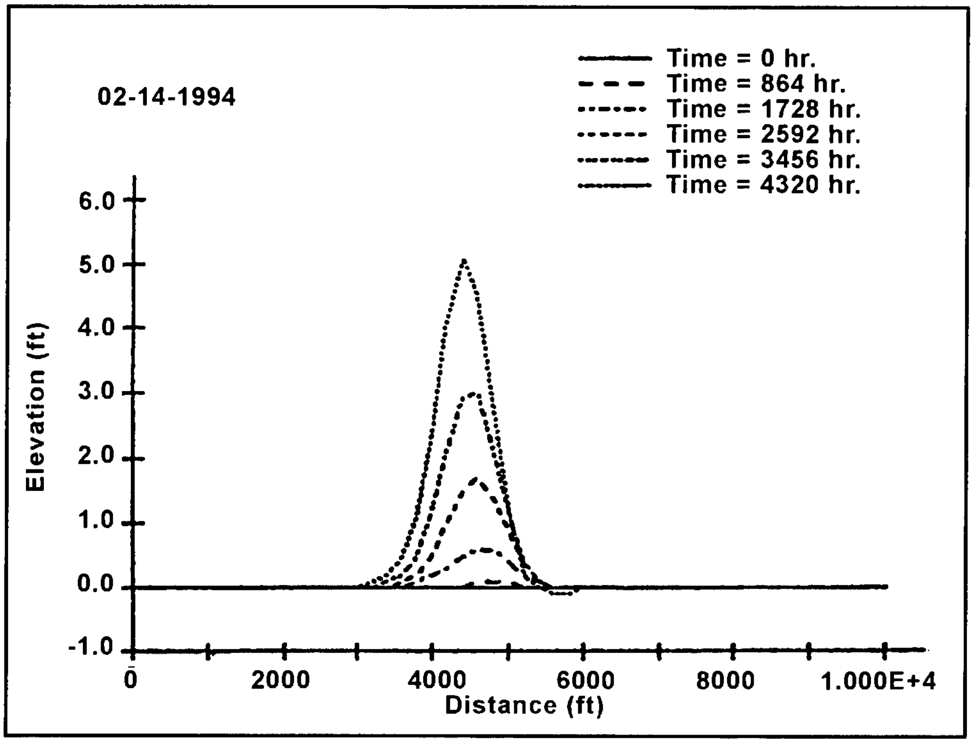


Figure F3. Simulated Sand Island cross section 1,500 ft below centerline

Ariathurai, R., MacArthur, R. C., and Krone, R. B. (1977). "Mathematical model of estuarial sediment transport," Technical Report D-77-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bijker, E. W. (1971). "Longshore transport computations," *Journal of the Waterways, Harbors, and Coastal Engineering Division* (WW4), 687-701.

Borgman, L. E., and Scheffner, N. W. (1991). "The simulation of time sequences of wave height, period, and direction," Technical Report DRP-91-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cargill, K. W. (1982). "Consolidation of soft layers by finite strain theory," Miscellaneous Paper GL-82-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1985). "Mathematical model of the consolidation/desiccation process in dredged material," Technical Report D-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Corson, W. D., Resio, D. T., and Vincent, C. L. (1980). "Wave information study of US coastlines; Surface pressure field reconstruction for wave hindcasting purposes, Report 1," Technical Report HL-80-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Gibson, R. E., England, G. L., and Hussey, M. J. L. (1967). "The theory of one-dimensional consolidation of saturated clays; I, Finite nonlinear consolidation of thin homogeneous layers," *Geotechnique* 17(3), 261-73.

Hands, E. B., and Allison, M. C. (1991). "Mound migration in deeper water and methods of categorizing active and stable berms." *Proceedings of Coastal Sediments '91*, ASCE, 1985-99.

Kraus, N. C., and Larson, M. (1988). "Beach profile change measured in the tank for large waves, 1956-1957 and 1962," Technical Report CERC-86-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Larson, M., and Kraus, N. C. (1989). "ASBEACH: Numerical model for simulating storm induced beach change, Report 1: Theory and model foundation," Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lavelle, J. W., Mofjeld, H. O., and Baker, E. T. (1984). "An in situ erosion rate for a fine-grained marine sediment," *J. Geophys. Res.* 89(C4), 6543-6552.

McNeil, J., Taylor, C., and Lick, W. (1996). "Measurements of the erosion of undisturbed bottom sediments with depth," *J. Hydraul. Eng.* 122(6), 316-324.

Mehta, A. J., Hayter, E. J., Parker, W. R., Krone, R. B., and Teeter, A. M. (1989). "Cohesive sediment transport - I: Process description," *Journal of Hydraulic Engineering*, ASCE 115(3), 1076-93.

Parthenaides, E. (1965). "Erosion and deposition of cohesive soils," *J. Hydraul. Div. Am Soc. Civ. Eng.* 91(HY1), 105-138.

Scheffner, N. W. (1989). "Disposal site evaluation for the New York Bight," Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1991). "A systematic analysis of disposal site stability." *Proceedings of Coastal Sediments '91*, ASCE, 2012-26.

__________. (1992). "Dispersion analysis of Humboldt Bay, California, interim offshore disposal site," Miscellaneous Paper DRP-92-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1994). "Tidal constituent data base - East Coast, Gulf of Mexico, and Caribbean Sea," DRP Technical Note DRP-1-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., and Borgman, L. E. (1992). "A stochastic time series representation of wave data," *Journal of Waterways, Ports, Coastal, and Ocean Engineering* 118(4).

Scheffner, N. W., Mark, D. J., Blain, C. A., Westerink, J. J., and Luettich, R. A. (1994). "AADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries; Report 5, Tropical storm database for the East and Gulf of Mexico Coasts of the United States," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., and Tallent, J. R. (1994). "Dispersion analysis of the Charleston, South Carolina, ocean dredged material disposal site," Miscellaneous Paper DRP-94-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, et al. (1995). "LTFATE: A model to investigate the long-term fate and stability of dredged material disposal sites; User's guide," Dredging Research Program Instruction Report DRP-95-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Swart, D. H. (1976). "Predictive equations regarding coastal transports." *Proceedings of the 15th Coastal Engineering Conference.* ASCE, 1113-32.

Teeter, A. M., and Pankow, W. (1989). "Schematic numerical modeling of harbor deepening effects on sedimentation, Charleston, SC," Miscellaneous Paper HL-89-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Westerink, J. J., Luettich, R. A., Jr., and Scheffner, N. W. (1993). "AADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries; Report 3, Development of a tidal constituent database for the Western North Atlantic and Gulf of Mexico," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

White, P. (1972). "Sediment transport in channels: A general function," Report Int 104, Hydraulics Research Station, Wallingford, England.

Appendix G Procedures for Conducting Frequency-of-Erosion Studies

Introduction

This appendix describes a procedure for determining frequency-of-occurrence relationships for vertical erosion (aka erosion frequency) of dredged material mounds off the Gulf and Atlantic coasts of the United States due to tropical and extratropical storms. The erosion frequency data can be used as a basis for computing the required thickness of the erosion layer portion of a contaminated dredged material mound cap. The design cap must be sufficiently thick to accommodate erosion from storm activity and still provide chemical and biological isolation. The primary goal of erosion frequency studies are therefore to develop information that can be used to determine (a) how thick a cap should be to provide sufficient protection and/or (b) at what depth must a mound with a given cap thickness be located to provide the same level of protection. Specific recommendations for erosion layer thickness design are contained in the body of this report. To make the erosion frequency discussion more easily understood, the procedures are illustrated in an example. The example used is an erosion frequency study done for the U.S. Army Engineer District, New York, as part of a site-capacity study for the Mud Dump disposal site located off Sandy Hook, NJ.

Numerical Models

The ability to effectively conduct erosion frequency studies has been made possible as a result of advances in modeling made by the Corps' Dredging Research Program (DRP) (Hales 1995).[1] The modeling advances were made in two areas. The first area was the development of an integrated hydrodynamic, sediment transport, and bathymetry change model, called Long-Term FATE of Dredged Material (LTFATE) model. This model is capable of modeling the

[1] References cited in this appendix are listed in the References at the end of the main text.

topographic evolution of dredged material mounds over time periods ranging from hours to centuries (Scheffner et al. 1995). A detailed description of LTFATE is found in Appendix F.

The second major modeling advance was the development of a series of databases containing the hydrodynamic driving force time series needed to run LTFATE - water levels and currents. Prior to the DRP, obtaining the hydrodynamic data to run LTFATE was a virtually impossible task because actual storm surge elevation and current data are unavailable except for a few recent storms at selected locations. The water level and current data needed for LTFATE required modeling tides and their associated currents and storm surges due to tropical and extratropical storms over a large area. To accomplish the modeling effort, the DRP funded the development of a state-of-the-art three-dimensional circulation model, called the advanced circulation model, or ADCIRC. A series of reports (Bain et al. 1994; Bain et al. 1995; Luettich, Westerink, and Scheffner 1992; Westerink, Luettich, and Scheffner 1993; and Westerink et al. 1994) describe the model, its development, and testing.

A primary application of ADCIRC for hydrodynamic input required by LTFATE was to compute tides and currents for the east and Gulf coasts. The 20,000 point grid over which ADCIRC computed surface elevations and currents is shown in Figure G1. A companion effort was to compute storm surge levels and the associated currents for 134 major tropical storms (hurricanes) on the east and Gulf coasts (Scheffner et al. 1994). A similar effort has also been conducted for extratropical storms. A comparable effort has been started for the West Coast (Luettich, Westerink, and Scheffner 1994), but the full suite of data needed for routine application of LTFATE for erosion-frequency studies on the West Coast and Great Lakes Coast are not yet available.

Wave data required as input to LTFATE are more readily available, both from gauges and from the Wave Information Studies (WIS) (Hubertz et al. 1994). The WIS series of reports provides hindcast wave heights, periods, and directions data at over one thousand coastal sites on all United States coasts for periods of 20 years or more. WIS wave data are provided at widely spaced (1 degree of latitude) deep-water sites and closely spaced locations (1/4 degree of latitude) in shallow water (typically about 10 m). Wave data can be accessed via a series of WIS reports, more recently electronically via the Coastal Engineering Data Retrieval System (CEDRS) available in Corps Coastal District offices (McAneny, in preparation), and the data are now available on the internet (ref).

Selecting the Proper Methodology for Determining Frequency-of-Occurrence Relationships

There are two methods that have been used by Corps' Districts in coastal design projects for computing frequency-of-occurrence relationships: (a) limited historical data and the selection of one or more "design storms" and/or

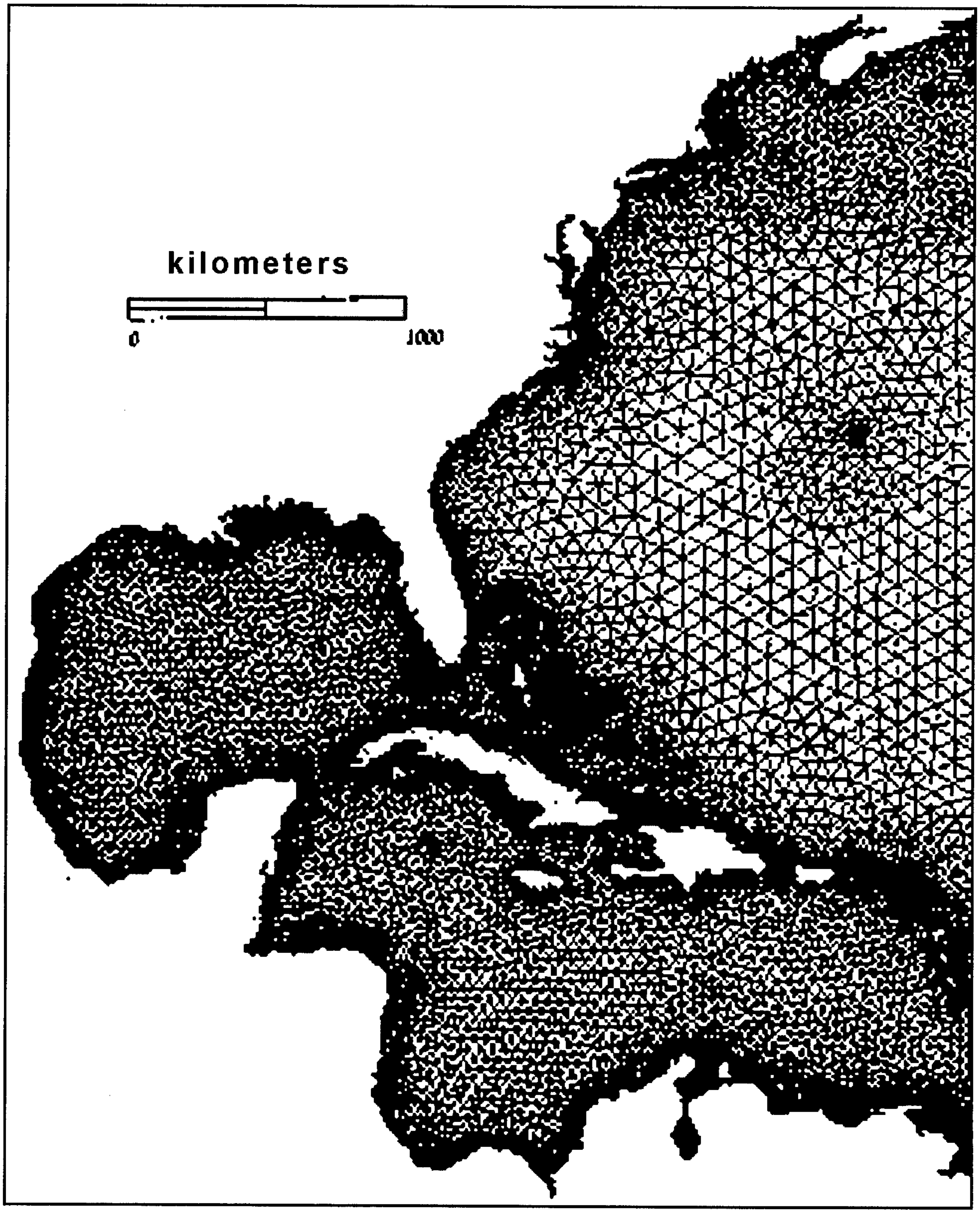


Figure G1. ADCIRC grid for computing surface elevations and currents

(b) application of the Joint Probability Method (JPM). The design storm approach basically involves selecting a severe historic storm event and using it to define a worst case scenario. The disadvantage of this method is that the frequency-of-occurrence of the design storm is usually not well known. Therefore the selected event may impose a more stringent cap design condition than necessary. Conversely, a worst case event may never have occurred at a specific location, and the design storm could lead to an overdesigned cap. In either case, the design storm event provides no information on frequency of occurrence and does not provide any error bands for use in design analysis.

The general JPM approach to assigning frequency relationships begins with parameterizing the storm that generated the effect of concern (e.g., wave height, surge level, bottom current). For hurricanes, descriptive parameters include maximum pressure deficit, maximum winds, radius to maximum winds, speed of translation, and track. The JPM is based on the assumption that the probability for each of the listed parameters can be modeled with empirical, or parametric, relationships. The joint probability of occurrence for a given effect, such as maximum surge, is defined as the probability of a particular storm event, computed as the product of the individual storm parameter probabilities via these assumed parametric relationships. This assumption is the primary basis of the JPM method used in past studies (Myers 1975).

However, the parameters that describe tropical storms are not independent, but are interrelated in some nonlinear sense (Ho et al. 1987). Because the parameters are not independent, joint probability cannot be computed as the product of individual parameter probabilities. Furthermore, it is generally recognized that extratropical storms cannot be effectively parameterized, so parametric probability relationships do not exist. Therefore, the JPM may not provide accurate approximations for tropical storms and is not appropriate for extratropical storms.

The empirical simulation technique (EST) is a statistical procedure for simulating nondeterministic multiparameter systems such as tropical and extratropical storms. The EST, which is an extension of the "bootstrap" statistical procedure (Efron 1982; Efron 1990), overcomes the JPM limitations by automatically incorporating the joint probability of the historical record. The bootstrap method on which EST is based incorporates resampling with replacement, interpolation based on a random walk nearest neighbor techniques with subsequent smoothing. More detailed descriptions of EST can be found in Scheffner, Borgman, and Mark (1993) and Borgman et al. (1992).

In EST, the various geometric and intensity parameters from storms are used to create a large artificial population (several centuries) of future storm activity (Borgman et al. 1992). The only assumption required for EST is that future storms will be statistically similar to past storms. Thus, the future storms generated during EST simulations resemble the past storms but possess sufficient variability to fill in the gaps in the historical data.

To perform the EST, historical storms impacting a site are broken down into the parameters that impact the engineering aspect of interest: storm track, maximum winds, radius to maximum, pressure deficit, etc. These variables are termed input vectors. The storm response of interest, in this case vertical erosion of the capped mound, is also calculated for each historical storm using an appropriate model (in this case LTFATE is used). The response of interest is referred to as response vector. During EST simulations, N-repetitions (say 100 or more) of T-year responses (say 100 to 200 years) of the response vector of interest (vertical erosion for capping projects) are produced providing mean value frequency relationships with accompanying confidence limits such that probability of occurrence can be defined with error band estimates. In other words, the mean vertical erosion for a range of return intervals with confidence limits (based on the number of standard deviations) are produced by the EST procedure.

There have been a number of applications of the bootstrap method and EST to coastal problems. Prater et al. (1985) described error estimation in coastal stage frequency curves for Long Island. Mark and Scheffner (1993) discuss use of the EST to compute frequency of occurrence of storm surge elevations in Delaware Bay. Farrar et al. (1994) describe the use of EST to estimate the frequency of horizontal beach erosion as part of an economic analysis for design of beach fills at Panama City, FL. Most recently, the EST technique was used to predict frequency of vertical erosion estimates for capped mounds at a range of depths at the Mud Dump disposal site located east of Sandy Hook, NJ (Clausner et al. 1996). The work was part of a larger effort for the New York District to determine remaining capacity of the Mud Dump site for both suitable sediments and those requiring capping.

Application of the EST to a capping project involves a series of sequential steps to calculate the cap erosion thickness, which are described in the remainder of this appendix.

Recommended Erosion Frequency Procedure

To define the required cap erosion layer thickness as a function of depth at a specific site, first the erosion frequency must be determined. It consists of a site-specific quantitative analysis approach that requires the completion of several sequential tasks. These tasks are (a) selection of appropriate storm events, (b) development of storm surge elevation and current hydrographs for each event, (c) development of four tidal phase elevation and current hydrographs, (d) development of a wave height and period time series corresponding to each storm event, (e) generation of input files representing the combination of tasks 2-4 to the Long-Term Fate of Dredged Material (LTFATE) model used to predict erosion, (f) execution of the LTFATE model to determine maximum vertical erosion at the site as a result of each of the storm events, (g) development of input files for the Empirical Simulation Technique (EST) program to generate multiple repetitions of storm-event activity and the corresponding vertical erosion, and finally, (h) using the EST program to generate vertical erosion frequency relationships (with error band estimates) for a particular disposal mound configuration.

Detailed descriptions of how each of the above tasks of an erosion frequency study should be conducted follow some background information on the Mud Dump case study example.

Mud Dump Disposal Site Study - Background Information

The frequency-of-occurrence methods described are illustrated in their application to concerns over erosion of capped mounds at the Mud Dump disposal site, the designated dredged material open-water disposal site for the Port of New York and New Jersey (PNY/NJ). Critical to the management of dredged material removed from the PNY/NJ is the remaining capacity within the Mud Dump site. The above procedures were developed to assist in determining the minimum water depths in which capped mounds can be placed without experiencing unacceptable amounts of erosion and therefore directly influence the ultimate capacity of the Mud Dump site to contain contaminated dredged material.

At the time this appendix was written (1996), the Mud Dump disposal site was virtually the only authorized site for open-water placement of dredged material from the PNY/NJ. The site is a 1.12 by 2 n mile rectangle located approximately 6 n miles east of Sandy Hook, NJ (Figure G2), in an area known as the New York Bight. Water depths at the site range from less than 50 ft to over 90 ft. As of October 1994, up to 65 M yd^3 of dredged material (based on scow logs) had been placed in the site. Because the Mud Dump site was the only available disposal site for fine-grained dredged material from the PNY/NJ, the remaining capacity was an extremely important issue in the overall plan for managing dredging and disposal for the Port. Because of the large volume of contaminated material inside the port, the remaining capacity of the Mud Dump site for Category II (requiring special handling, i.e., capping for open-water placement) dredged material (USACE/USEPA 1991) was critical in the sediment management process for the New York District and the PNY/NJ.

At the request of the New York District, the U.S. Army Engineer Waterways Experiment Station's Coastal Engineering Research Center (CERC) conducted a study to define Mud Dump site capacity and other issues related to capping (Clausner, Scheffner, and Allison 1995). Studies to compute the vertical erosion frequency for mounds of various elevations in the Mud Dump site were the most critical part of this effort. Previous studies have shown erosion of fine-grained materials from mound flanks as a result of severe northeasters (McDowell 1993; McDowell, May, and Pabst 1994). At the request of the New York District, mounds with cap elevations ranging from 50 to 75 ft were modeled, with ambient depths of 60 to 83 ft.

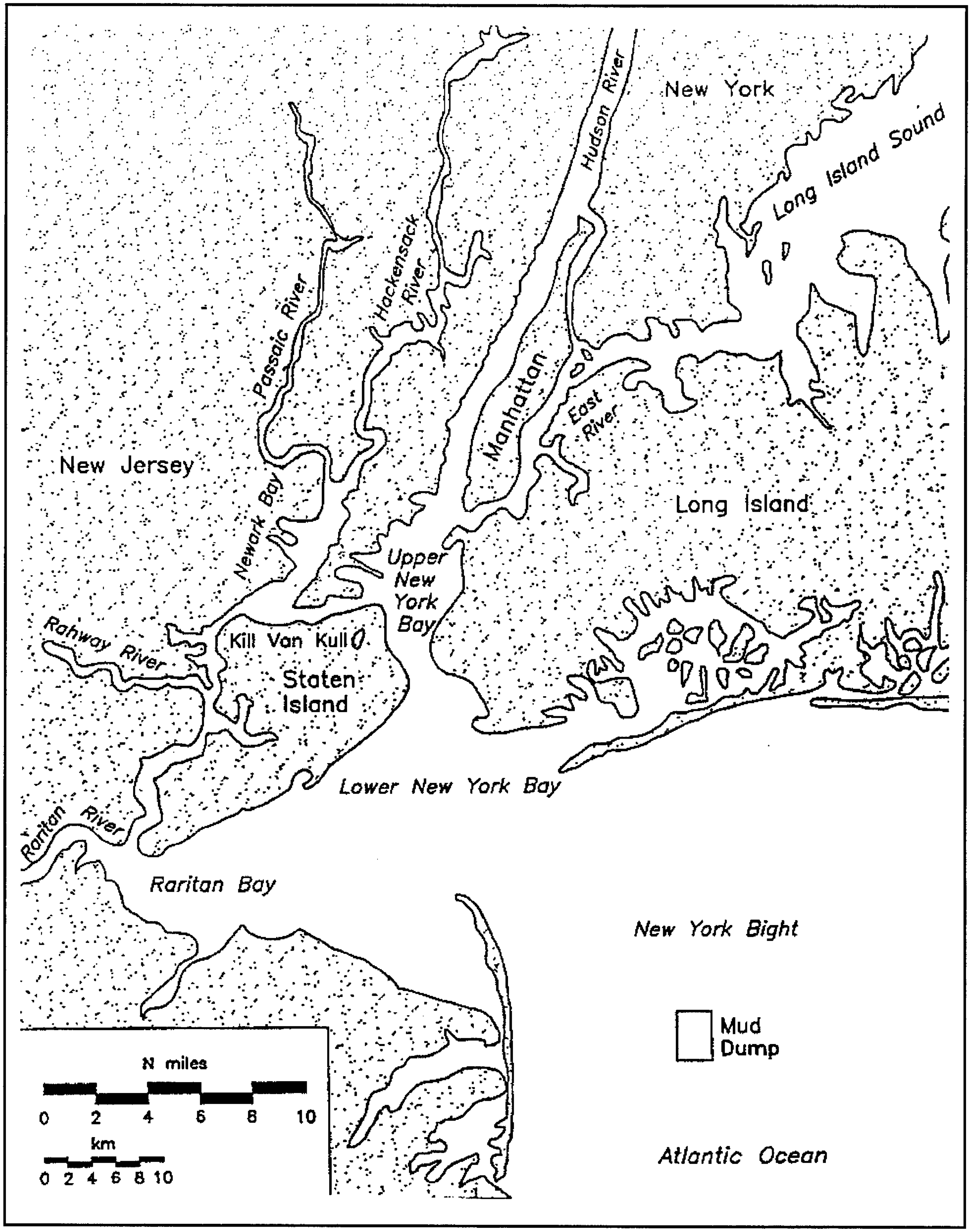


Figure G2. Mud Dump disposal site location map

Storm Selection

The first step in a frequency-of-erosion study is to identify storms that have impacted the site of interest. For sites on the east coast, particularly the northeast coast, both tropical storms (hurricanes) and extratropical storms (northeasters) have to be included. While the tropical storms often have higher winds, the longer duration of the extratropical storms allows them to produce vertical erosion of equal or greater magnitude than hurricanes. Also, northeasters occur much more frequently than hurricanes. For sites on the Gulf coast, northeasters will generally not be a major problem; hurricanes will most likely be the only storms of concern.

Tropical storm selection

The tropical storm database of the National Hurricane Center's HURricane DAT (HURDAT) database (Jarvinen, Neuman, and Davis 1988) is the recommended source of historical events that have impacted the east and Gulf coasts (and therefore the Mud Dump site). The tropical storm database generated by the DRP (Scheffner et al. 1994) contains an atlas of 134 storm events, as well as their respective tracks, that impacted the east and Gulf coasts of the United States. The database contains maximum computed storm surge elevations at up to 486 discrete locations impacted by each event according to the criteria that (a) the minimum pressure of the storm was less than or equal to 995 mb, (b) the eye of the storm passed within 200 statute miles of the location of interest (the Mud Dump site in this application), and (c) the storm generated a surge of at least 1 ft above mean sea level (MSL). The published atlas in Scheffner et al. (1994) tabulates maximum storm surges that have impacted each station and the respective storm events responsible for that surge. Cross-referencing is also provided to show which stations were impacted by each of the 134 events and the respective maximum surge at those stations.

This dual tabulation should be used to identify potential storms impacting the site of interest, the Mud Dump site in this example. Elevation and current hydrographs corresponding to each event and impacted location are available from the DRP database.

The DRP tropical storm database was constructed by simulating the 134 historically based storm events as they propagated over the east coast, Gulf of Mexico, and Caribbean Sea computational domain shown in Figure G1 using the numerical hydrodynamic model ADCIRC described earlier. The DRP database of storm-surge hydrographs and currents was archived at 240 east and Gulf coast Wave Information Study (WIS) stations (Hubertz et al. 1993) with additional locations prescribed for Puerto Rico. To use the DRP tropical storm database information, the WIS station nearest the disposal site of interest is selected. WIS Station 304 (DRP numbering system) is nearest to the Mud Dump site; therefore, storm events impacting this station were selected for the frequency analysis (Figure G3). Station 304 has a depth of approximately 108 ft.

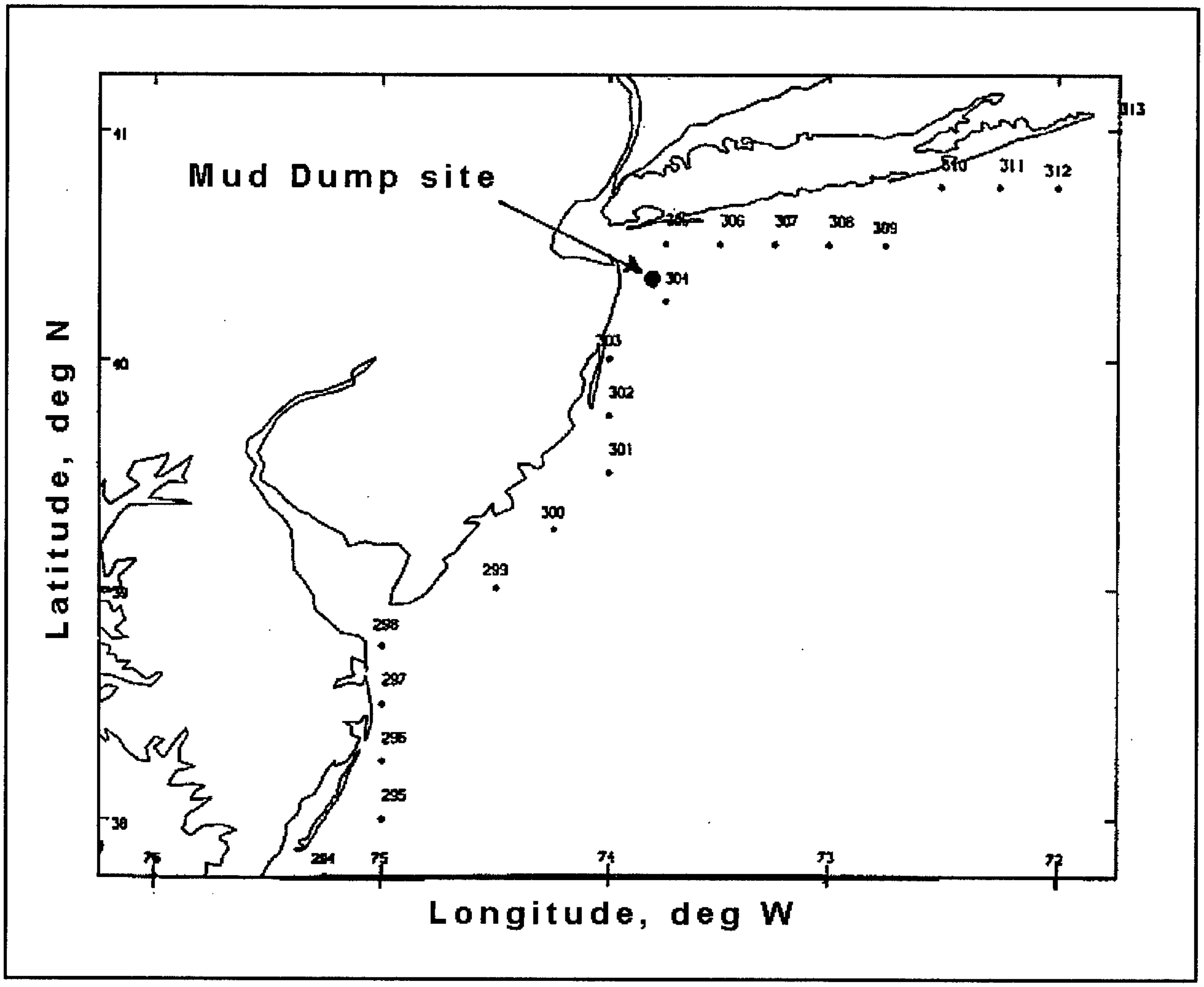


Figure G3. Map showing WIS locations relative to the Mud Dump site

To convert the surge current values from the database location to the disposal site, the mean depth at the two locations is determined. The surge current values should then be assumed to be proportional to the relative depths at the two sites. A mean depth for the Mud Dump site was determined to be approximately 83 ft; therefore, the DRP-generated surge current hydrographs were adjusted according to the criteria that Q=VA=Const; therefore, $V_{Mud} = V_{304}*108/83$.

Sixteen tropical storm events were retrieved from the DRP archives that impacted the location of DRP Station 304 (Mud Dump site) according to the criteria described above. Sixteen tropical storm events in 104 years of record correspond to an annual frequency-of-occurrence of 0.15385 events per year (or one event every 6.5 years). These events are shown in Table G1.

Table G1
Tropical Events Impacting Mud Dump Site

HURDAT Storm No.	Given Name	Date (month/day/year)
296	Not Named	9/22/1929
327	Not Named	8/17/1933
332	Not Named	9/8/1933
353	Not Named	8/29/1935
370	Not Named	9/8/1936
386	Not Named	9/10/1938
436	Not Named	9/9/1944
535	Carol	8/25/1954
541	Hazel	10/5/1954
545	Connie	8/3/1955
597	Donna	8/29/1960
657	Doria	9/8/1967
702	Doria	8/20/1971
712	Agnes	6/14/1972
748	Belle	8/6/1976
835	Gloria	9/16/1985

Extratropical storm event selection

Extratropical events occur at a much greater frequency than tropical events. As a result, a shorter historical time period can be used to represent the range of events that can be expected to impact a particular area. For the extratropical event analysis, approximately 15 to 20 years of winter activity were determined to contain an adequate representation of extratropical events[1] for any area along the east coast of the United States. The 16 winter seasons (September through March) for the period of 1977-78, 1978-79, ... , 1992-93 were selected as the time period for which the DRP extratropical storm database was generated. This time period was selected because it corresponds to dates when the Navy wind-field database containing the extratropical winds was available in an ADCIRC-compatible format. The DRP database was then used as the basis for the extra-tropical frequency analysis described in this appendix.

The DRP extratropical storm database was also constructed by using the ADCIRC numerical hydrodynamic model to simulate all 16 winter seasons over the entire computational domain shown in Figure G1. The U.S. Navy's windfield

[1] Personal Communication, 1994, L. E. Borgman, Professor, University of Wyoming, Laramie, WY.

database, which is archived at every 2.5 degrees of latitude and longitude at a temporal period of 6 hr, was used as input to ADCIRC. The 16 winter season (September-March) input files were prepared by archiving the data within the area of 100° - 60° west longitude and 5° - 50° north latitude, which encompasses the east coast, Gulf of Mexico, and Caribbean Sea as part of ADCIRC's 20,000-node computational grid.

ADCIRC-generated surface elevation and current hydrographs for each 7-month period were archived at 686 locations at a sampling period of 1 hr. Of the 686 stations, 340 correspond to locations (WIS) stations. As for the tropical storms, extratropical storms impacting WIS Station 304 were selected for the frequency analysis.

Storm-Surge Hydrograph Development

Tropical storms

Once identified, the selected tropical storms are retrieved from the DRP database. However, each hydrograph represents the entire storm history, from beginning to end, often a week or more in duration. Because only the erosional effect of the event on the site being studied are of interest, each hydrograph was constructed at a time step of 3 hr to be 99 hr in duration, measured as 48 hr before the well-defined 3-hr duration peak and 48 hr after the peak, for example see Figure G4. The time of peak is selected as the time when the eye of the storm is closest site of interest.

Extratropical storms

For the extratropical storms, the storm event time periods of impact will not be well defined at many locations, including the Mud Dump site. Examination of surge elevation, current magnitude and wave height, and period records from the Mud Dump site did not allow extratropical storms and their duration to be readily identified.

One reason for this difficulty in identifying extratropical storms is the fact that the surge currents accompanying each event are generally relatively small (i.e., on the order of 20-30 cm/sec at the Mud Dump site), and their effects have to be considered with respect to other environmental factors occurring at the time of the storm. These factors include the local depth, the orbital velocities of the wave field, the duration of the event, and the phase of the tide. Therefore, to isolate significant events from the 7-month record, a more quantitative approach to event parameterization is recommended and was developed for the Mud Dump study. This second order parameterization approach is defined following the descriptions of tide and wave field data accompanying the hydrodynamic surge and current response.

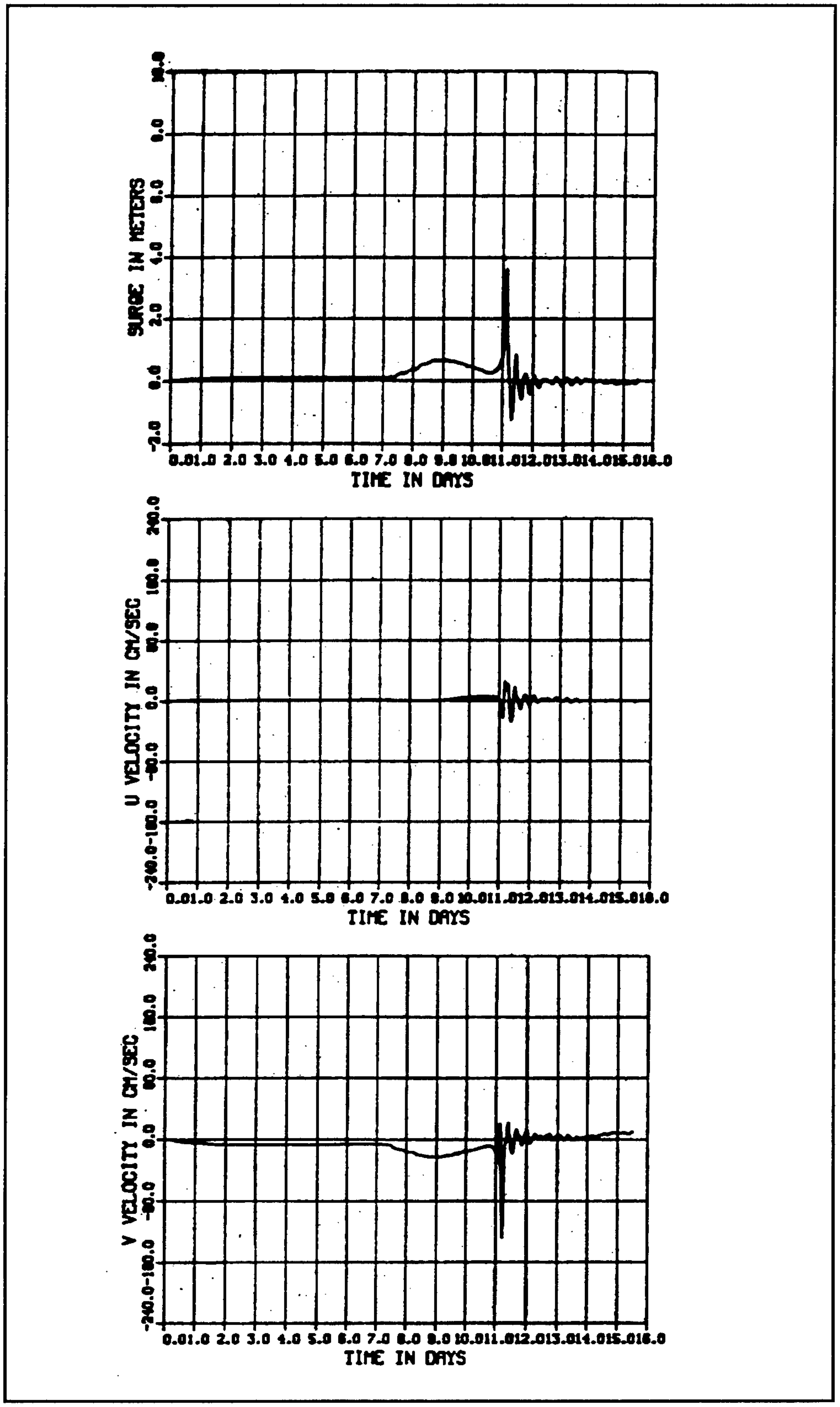


Figure G4. Surge elevation and current hydrograph for Hurricane Gloria, without tides

Tidal Hydrograph Development

The surge hydrographs corresponding to the tropical and 1977-1993 extra-tropical storm seasons were simulated over the domain shown in Figure G1; however, simulations did not include tides at the time of the event, i.e., they were modeled with respect to MSL. Because tide elevation and currents will be a factor in mound erosion, they must be included. When tidal phase is accounted for, each storm event has an equal probability of occurring at (a) high tide, (b) MSL during peak flood, (c) low tide, and (d) MSL during peak ebb. These four phases are designated as phases 0, 90, 180, and 270 degrees, respectively.

Obtaining the needed tidal elevation and current data can most effectively be accomplished by using the DRP-generated 8-constituent (4 primary semidiurnal and 4 diurnal) database of tidal constituents corresponding to each node shown in Figure G1 (Westerink, Luettich, and Scheffner 1993). This effort also made use of the ADCIRC program. A linear interpolation scheme (described in the report) uses this database to provide tidal constituents at any location within the domain. At the Mud Dump site the M_2 semidiurnal tidal constituent accounts for over 90 percent of the tidal energy (based on the 8-constituent database) as can be seen in the listing of constituent amplitude and local epochs k generated for DRP-WIS Station 304 shown in Table G2. (Constituents were generated at Station 304 instead of the Mud Dump site in order for the tide to correspond to the hydrographs archived at Station 304).

Table G2
Tidal Constituents for DRP-WIS Station 304

Const	h-amp, m	h-k, deg	U-amp, cm/sec	U-k, deg	V-amp, cm/sec	V-k, deg
k_1	0.0867	95.2	0.0049	194.3	0.0061	27.1
O_1	0.0589	100.4	0.0028	193.3	0.0042	43.5
P_1	0.0359	91.0	0.0020	193.5	0.0028	19.7
Q_1	0.0111	98.3	0.0006	202.4	0.0007	19.2
N_2	0.1704	195.6	0.0181	295.6	0.0226	116.0
M_2	0.7744	215.3	0.0837	313.8	0.1012	133.8
S_2	0.1507	254.6	0.0169	355.4	0.0213	173.4
K_2	0.0482	246.6	0.0054	347.2	0.0068	164.9

To account for the four tidal phases, M_2 amplitude A and local epoch phase data k for elevation (h = 0.7744 m, k = 215.3°) and current (U: A = 0.0837 m/sec, k = 313.8°; V: A = 0.1012 m/sec, k = 133.8°) were extracted from the DRP database and used to expand the 16 tropical storms and 16 extratropical season database of storms without tides to a 64 tropical storm database with tides and a 64 extratropical season database with tides. This expanded set of hydrographs represents a combination of the surge hydrograph with the tidal hydrographs generated for the four phases of the tide based on the M_2 tidal constituent.

Wave Field Hydrograph Development

Waves are a critical component of LTFATE input. This section recommends procedures for providing input waves for both tropical and extratropical storms.

Tropical storms

Because LTFATE does not have a storm wave field component, a methodology was adopted from the Shore Protection Manual (SPM) (Headquarters, Department of the Army 1984). The approximation reported in the SPM gives an estimate of the deepwater significant wave height and period at the point of maximum wind for a slowly moving hurricane. A full numerical hindcast of the wave field associated with the historical event would be more accurate than the adopted procedure; however, the SPM approach is expected to be adequate for the purposes of most erosion frequency studies.

The wave height and period are given by the following formulae:

$$H_o = 16.5\, e \frac{R\Delta p}{100}\left[1 + \frac{0.208\alpha V_F}{\sqrt{U_R}}\right] \tag{G1}$$

and

$$T_s = 8.6\, e \frac{R\Delta p}{200}\left[1 + \frac{0.104\alpha V_F}{\sqrt{U_R}}\right] \tag{G2}$$

where

H_o = deepwater significant wave height in feet

T_s = corresponding significant wave period in seconds

R = radius to maximum wind in nautical miles

$Dp = p_n - p_o$, where p_n is the normal pressure of 29.93 in. of mercury and p_o is the central pressure of the hurricane

V_F = forward speed of the hurricane in knots

U_R = maximum sustained windspeed in knots calculated 33 feet above MSL at radius R

α = a coefficient depending on the speed of the hurricane. The suggested value is 1.0 for a slowly moving hurricane

All of the above variables used in Equations G1 and G2 are contained in or can be calculated from the HURDAT database.

Given a maximum wave height and period, a wave field time series for tropical storms was calculated through the following expansion:

$$\left[H(t), T(t)\right] = \left[H_o, T_s\right] e\left(\frac{-9.21}{D}\right)^2 \left(t - \frac{D}{2}\right)^2 \tag{G3}$$

where

t = time in hours starting 51 hr before peak surge (at hour 51) and extending 48 hr after peak surge

D = significant duration of the surge, taken as 24 hr

Given a maximum wave height and period, a wave field time series should be calculated starting 51 hr before peak surge (at hour 51) and extending 48 hr after peak surge. Wave heights and periods described by Equation G3 decay to zero; therefore, minimum values must be prescribed for the time series. These minimum values were specified based on summary tables provided by WIS (Hubertz et al. 1993) for the WIS station location cited in this report (WIS Station 72, which corresponds to DRP #304). The average direction of travel for the 16 tropical events was computed to be approximately 11° clockwise from true north (an azimuth of 191° by WIS convention). According to Hubertz et al. (1993), the largest number of waves at an azimuth of 180° were in the 5.0-6.9 sec band. Therefore, a minimum period of 6.0 sec was selected for the storm-event hydrographs. Maximum mean wave conditions for the months of September and October were reported to be 1.2 and 1.3 m, respectively; therefore, a minimum wave condition was selected to be 1.25 m. Finally, maximum wave heights were limited to the breaking wave criteria of H_b = 0.65*depth based on measurements indicating that storm-generated waves in open water are limited to approximately 0.6-0.7 times the local depth (Resio 1994). Scenarios, to be described below, included mound configurations located at three depths, the minimum of which was 63.0 ft. In order to prescribe wave field boundary conditions that are consistent for all simulations, the minimum depth was used to define maximum wave criteria. Therefore, maximum allowable waves were limited to 0.65*63.0 = 40.95 ft = 12.48 m. This criteria should be used for all simulation scenarios.

Extratropical storms

The wave field input for the extratropical database of events should normally be extracted from the WIS hindcast database unless site-specific wave data from a gauge are available. For the Mud Dump study, the wave field was extracted from the WIS hindcast database for the periods of time corresponding to each of the 1977-1993 storm seasons. These data, available at a 3-hr time step, were obtained from the WIS database and combined with the storm surge elevation and current and tidal elevation and current databases. All hydrographs were generated at a 3-hr time step to be compatible with the WIS database and input requirements of the LTFATE model.

Extratropical Storm Identification

As stated above, first order parameters such as surge elevation and currents or wave heights and periods did not immediately isolate specific extratropical storm events of interest for the Mud Dump site. For example, Figure G5 shows the WIS wave height and period time series for the 1977-79 extratropical storm season. The surface elevation and U,V current hydrographs are similar, i.e., specific storms are difficult to identify. This conclusion is in agreement with the recognized observation that extratropical events are not conducive to parameterization.[1] Because it is not feasible to model the entire season with LTFATE to determine which events impact the Mud Dump site (this would require days on a PC running at 100 MHz), a procedure had to be developed to isolate events of interest.

Developing a systematic procedure to identify and subsequently separate significant storm events from the extratropical storm database required an analysis of combinations of individual parameter components that may provide an indication of impact to east coast sites. Because the storm effect of interest for this example is vertical erosion of a disposal mound located at the Mud Dump site, a methodology for identifying storms with measurable erosional impact was developed by combining available storm-event information into a second order parameter, one which represents some combination of first order parameters such as surge, tide, wave height, etc. This parameter was chosen to be the instantaneous sediment transport magnitude, computed as a function of the storm-induced surge elevation and current, the maximum M_2 tidal amplitude and maximum M_2 tidal velocity magnitude, and the wave height and period.

The transport relationship used is based on the Ackers-White (1973) equations with a modification for additional energy provided by waves suggested by Bijker (1971) used in the LTFATE model. The result of the computation is a transport magnitude hydrograph computed as a function of surge, tide, and wave climate. For the Mud Dump site example, the mean depth was specified as 83 ft

---

[1] Personal Communication, 1994, L. E. Borgman, Professor, University of Wyoming, Laramie, WY.

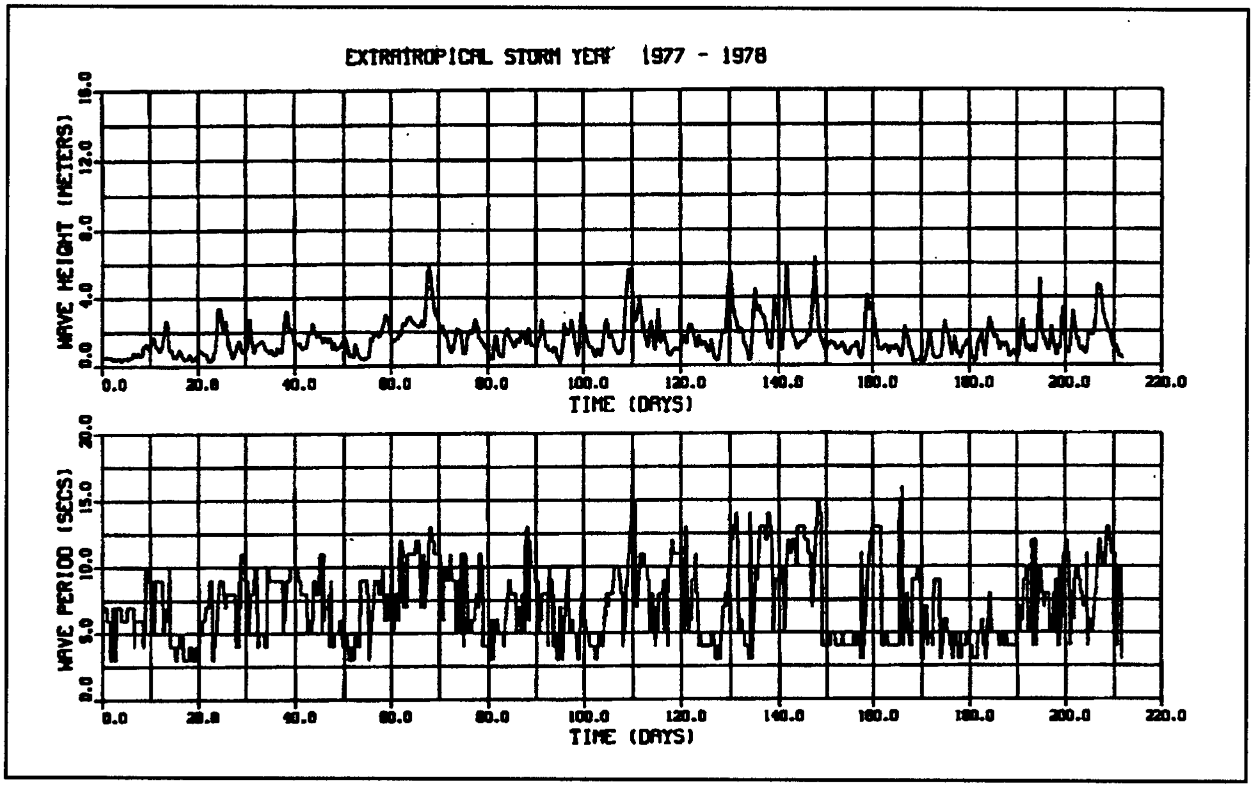


Figure G5. WIS wave height and period time series for 1977-78 extratropical storm season

and mean grain size set at 0.40 mm. The 83 ft depth was the base depth area within the Mud Dump site considered for capping; 0.40 mm sand was the suggested cap material.

The sediment transport hydrograph for the 1977-78 storm season is shown in Figure G6. As evident in the figure, distinct events are now clearly visible in the time series. This approach to event identification is in contrast to the first order parameter time series shown in Figure G5.

Analysis of the 16 seasonal transport hydrographs resulted in the adoption of a threshold value of 30.0×10^{-4} ft^3/sec/ft-width as the basis for selecting events that may cause erosion to the Mud Dump site. This value, selected by trial and error through application of the LTFATE model, will produce a maximum of 0.25 ft of vertical erosion per 24 hr at the corner of mound cap measuring 100 by 100 ft. Table G3 presents a summary of the analysis for the 1977-1993 storm years in the form of the approximate day (measured from 1 September) of occurrence and the magnitude of the peak transport value. The total number of events per season is also tabulated. According to this criteria, the computed average number of events per year that impact the Mud Dump site is 38 events/16 seasons = 2.375 events/year.

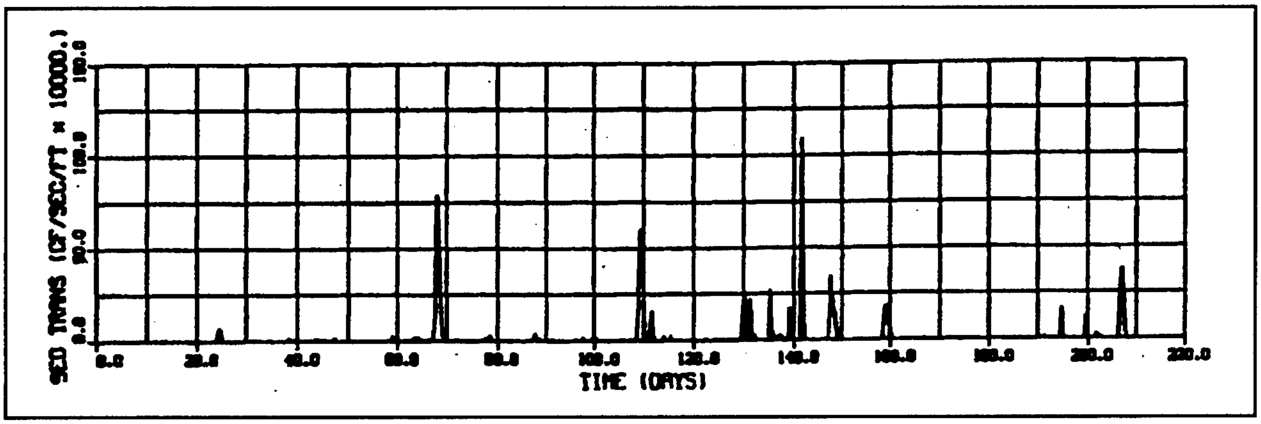


Figure G6. Sediment transport hydrograph for the 1977-78 storm season

Table G3
Summary of Storm Events by Day of Season/Maximum Transport Magnitude in ft^3/sec/ft-width x 10^{-4}

Year	1	2	3	4	5	Total
77-78	68/80	110/65	142/110	207/35	--	4
78-79	146/190	171/50	193/50	205/50	--	4
79-80	132/35	138/35	195/50	--	--	3
80-81	55/125	154/70	163/105	210/30	--	4
81-82	--	--	--	--	--	0
82-83	55/70	164/50	199/50	--	--	3
83-84	41/35	102/110	180/45	210/165	--	4
84-85	43/85	165/180	--	--	--	2
85-86	27/160	65/125	160/30	191/30	200/70	5
86-87	93/190	115/40	123/40	--	--	3
87-88	--	--	--	--	--	0
88-89	--	--	--	--	--	0
89-90	49/33	--	--	--	--	1
90-91	--	--	--	--	--	0
91-92	126/40	--	--	--	--	1
92-93	101/150	165/30	185/120	194/155	--	4

The purpose of selecting specific storms is ultimately to determine frequency-of-occurrence relationships. The specific effect of interest will clearly have a direct bearing on the selection of appropriate storm events. For example, the 10 storm events that cause the most shoreline erosion at a particular location are not necessarily the same 10 events that cause the most vertical erosion of a capped mound in the same area. A separate storm analysis would be required to identify events that cause shoreline/dune recession. However, this second-order parameter approach to storm isolation has been found to be successful in identifying events that cause erosion to a disposal mound. By defining the appropriate parameter, the approach is equally applicable to shoreline processes analyses.

Because vertical erosion is the impact of interest, the transport hydrographs (Figure G6 for 1977-78) were used to identify 38 specific events with a peak transport magnitude greater than the threshold value of 30.0×10^{-4} ft^3/sec/ft-width at the Mud Dump site. These events are listed in Table G3. For each event, surge, tidal, and wave field time series were extracted from the seasonal summary tables to generate hydrographs of total water surface elevation (storm plus tide), total U and V current (storm plus tide), and wave height and period. Each of the 152 hydrographs (38 events with 4 tidal phases) was constructed to be 6 days in duration, centered on the day indicated in Table G3. These hydrographs represent input to the LTFATE model.

LTFATE Model Simulations

After the selected storms have been identified, LTFATE simulations should be used to determine the maximum amount of vertical erosion resulting from each storm for each of the disposal site configurations of interest. As noted earlier, for the Mud Dump site, six combinations of ambient depth, mound height, and crest depth were tested (Table G4). All mound configurations had side slopes of 1:50 with the cap material specified to be noncohesive sand with a d_{50} of 0.40 mm.

Table G4
Mud Dump Mound Configurations

Test Number	Ambient Depth, ft	Mound Height, ft	Crest Depth, ft
1	63	13	50
2	63	8	55
3	73	13	60
4	73	8	65
5	83	13	70
6	83	8	75

LTFATE input file generation

The surge, tidal, and wave field time series must be placed into a format compatible with LTFATE. An example LTFATE input file for hurricane #835 is shown in Table G5. For the Mud Dump study, storm-event input files

Table G5
Example LTFATE Input File

Hurricane: 835 WIS Station: 304	Wave Height, m	Wave Period sec	U-cm/sec	V-cm/sec	Surge, m
219.00	1.250	6.000	9.251	-38.308	1.164
222.00	1.250	6.000	11.406	-39.243	0.071
225.00	1.250	6.000	-3.124	-20.060	0.049
228.00	1.250	6.000	-5.420	-15.662	1.071
231.00	1.250	6.000	9.419	-30.920	1.172
234.00	1.250	6.000	15.334	-35.614	0.077
237.00	1.250	6.000	1.519	-16.542	-0.207
240.00	1.250	6.000	-4.056	-7.843	0.794
243.00	1.250	6.000	9.616	-22.601	1.095
246.00	1.250	6.000	17.646	-30.015	0.074
249.00	1.250	6.000	5.436	-13.767	-0.424
252.00	1.250	6.000	-3.789	-0.846	0.462
255.00	1.748	6.000	7.207	-12.689	1.008
258.00	4.787	6.000	17.136	-24.358	0.165
261.00	9.829	9.460	6.573	-13.044	-0.361
264.00	12.485	14.567	-7.198	-8.491	0.750
267.00	12.485	15.433	-31.538	20.684	3.775
270.00	12.485	14.567	30.319	-121.682	0.077
273.00	9.829	9.460	-28.224	13.077	-1.510
276.00	4.787	6.000	6.797	-4.497	0.262
279.00	1.748	6.000	-0.205	8.166	0.201
282.00	1.250	6.000	5.546	-6.199	0.412
285.00	1.250	6.000	13.366	-12.180	-1.050
288.00	1.250	6.000	-18.947	27.948	-0.298
291.00	1.250	6.000	2.285	1.164	0.663
294.00	1.250	6.000	5.566	-1.685	0.223
297.00	1.250	6.000	9.583	-6.201	-0.647
300.00	1.250	6.000	-6.529	13.946	-0.438
303.00	1.250	6.000	-4.978	15.048	0.544
306.00	1.250	6.000	7.271	0.057	0.589
309.00	1.250	6.000	13.559	-10.128	-0.625
312.00	1.250	6.000	-7.279	14.726	-0.672
315.00	1.250	6.000	-9.291	15.761	0.606

representing the 99-hr time sequences for each of the 16 tropical storm events and the 144-hr time sequences for each of the 38 extratropical storm events were input to LTFATE.

Model simulations

The six Mud Dump ambient depth/mound height combinations were subjected to the 64 tropical storm surge hydrographs (16 storms times four possible tide phases) to evaluate the erosion potential of the configurations shown in Table G4. An identical procedure was followed for the 152 extratropical storm surge hydrographs (38 storms times four possible tide phases). In all six simulations for each type of storm, the maximum vertical erosion experienced at any location on the mound during each of the simulations was archived for use in the EST to develop vertical erosion versus frequency-of-occurrence relationships.

EST Input File Development

As noted earlier, EST is a statistical procedure that uses a limited database of historical occurrences to generate multiple simulated scenarios from which frequency relationships and error estimates can be computed. The EST requires two types of input. The first set represents descriptive storm parameters that define the dynamics of each storm event. These parameters, referred to as input vectors, should be (a) tidal phase, (b) duration of the event measured as the number of hours during which the computed transport magnitude exceeds 10.0×10^{-4} ft^3/sec/ft-width, (c) maximum transport magnitude computed during the storm event, (d) wave height, (e) wave period, and (f) maximum depth-averaged velocity magnitude associated with the maximum transport value.

The second input parameter represents a measure of damage resulting from the passage of the storm event. These parameters are referred to as response vectors. Typical response vectors are storm surge elevation, shoreline erosion, dune recession, flood inundation, or for capping projects, vertical erosion.

Tropical storm vectors

Input and response vectors for hurricanes #296, 327, 748, and 835 for high water after flood (maximum tidal surface elevation) for the site scenario of an 8-ft mound located in 83 ft of water are shown in Table G6.

The EST uses the parameters of Table G6 for all tropical storm events and each of the four tidal phases as a basis for simulating multiple repetitions of multiple years of storm activity. In this application, 100 repetitions of a 200-year sequence of storm activity were simulated for the six scenarios shown in Table G6. As mentioned above, the EST assumes that future storm activity will be similar to past events, i.e., a hurricane such as Camille, which devastated the

Table G6
Tropical Storm Input and Response Vectors for the Mud Dump Site

Hurr. No.	Tide Phase 0-1	Min. Dist. miles	Track Angle deg	Pres. Def., mb	Max. Vel. knots	Forw. Vel. knots	Rad. Max. nm	Vert. Eros., ft
296	1.0	84.85	29.35	25.83	30.68	18.39	43.42	0.20
327	1.0	172.3	10.41	35.31	45.00	20.19	43.42	0.20
748	1.0	17.45	13.46	32.19	67.53	21.81	8.68	0.10
835	1.0	11.32	20.59	56.97	82.04	37.89	36.93	0.80

Gulf coast in 1969, cannot occur in the Bight because historical records indicate that storms of this magnitude have not impacted the Bight. This is probably due to both the exposure of the Bight and the northerly latitude. The second assumption is that the frequency of events is similar to historic activity. In the New York Bight, the frequency used is 16 events per 104 years, i.e., frequency = 0.15385.

Extratropical storm vectors

Input and response vectors for the four events of the 1977-78 extratropical storm season for the zero tidal phase for the site scenario of an 8-ft mound located in 83 ft of water are shown in Table G7.

Table G7
Extratropical Storm Input and Response Vectors for Mud Dump Site

Storm No.	Tidal pH-deg	Dur, hr	Q-Max	H, m	T,sec	V-Max cm/s	E-Max, ft
1	0	21	68.9	5.9	12.0	51.8	0.20
2	0	21	57.6	5.6	12.0	50.8	0.20
3	0	18	50.4	5.6	10.0	51.8	0.20
4	0	15	35.3	4.7	12.0	49.5	0.10

In an identical procedure to the tropical storm simulations, the EST uses the input and response vectors of Table G7 for the selected extratropical storm events and for each of the four tidal phases as a basis for simulating multiple repetitions of multiple years of storm activity. As mentioned above, the EST assumes that future storm activity will be similar to past events. In the New York Bight, the frequency used is 38 events per 16 years, i.e., frequency = 2.375 storms/year.

The EST program generates a 200-year tabulation consisting of the number of storm events that occurred each year and the vertical erosion corresponding to each event. To define an erosion magnitude consistent with the tropical storm analysis, the total summation of erosion magnitudes per year was selected as the parameter of interest. For example, if three storm events were simulated during the first year, the sum of the three vertical erosions would be used to define the parameter for which frequency-of-occurrence relationships would be computed. The computational process is described in the following section.

EST simulation results - vertical erosion versus frequency-of-occurrence

To most effectively use the results from the EST simulations for cap erosion layer thickness design, frequency of vertical erosion curves and tables should be generated from the data. For the Mud Dump site example, vertical erosion versus frequency-of-occurrence relationships were generated for each of the 100 simulations described above for each of the six depth/mound height configurations for both tropical and extratropical storms.

The frequency curves for each simulation are generated by (a) rank-ordering the computed erosion magnitudes, (b) generating a cumulative distribution function (cdf, P(x) versus magnitude), and (c) interpolating an erosion magnitude for an n-year event from the cdf for a probability of occurrence P(x) of the form resulting in an erosion versus frequency curve for each simulation.

Tropical storms. In the analysis of the 100 frequency relationships, an average vertical erosion magnitude is computed relative to each return period. From the EST simulations of tropical storms, an example plot of the 100 recurrence relationships and mean value (indicated by O) for the 8-ft mound located at an 83-ft depth is shown in Figure G7. Note that the spread of data points about the mean demonstrates a reasonable degree of variability, as would be expected of a stochastic process.

Finally, the standard deviation of the 100 events relative to the mean is computed as a measure of variability. Output for design purposes contains only the mean frequency-of-occurrence relationship with a +/- one standard deviation band. An example of this output is shown in Figure G8 for the 8-ft mound at the 83-ft depth shown in Figure G7. Table G8 summarizes the frequency-of-occurrence of vertical erosion from tropical storms for all six mound configurations in the form of a mean value and +/- standard deviation error that can be added to or subtracted from the mean value.

Extratropical storms. A set of analyses identical to those made for tropical storms should be made for the extratropical storms. From the Mud Dump site analysis, an example plot of the 100 recurrence relationships and mean value (indicated by O) for the 8-ft mound located at an 83-ft depth is shown in Figure G9. As for the tropical storms, the spread of data points about the mean demonstrates a reasonable degree of variability, as would be expected of any stochastic process. An example of the mean frequency-of-occurrence relationship with a +/- one standard deviation band is shown in Figure G10 for the 8-ft

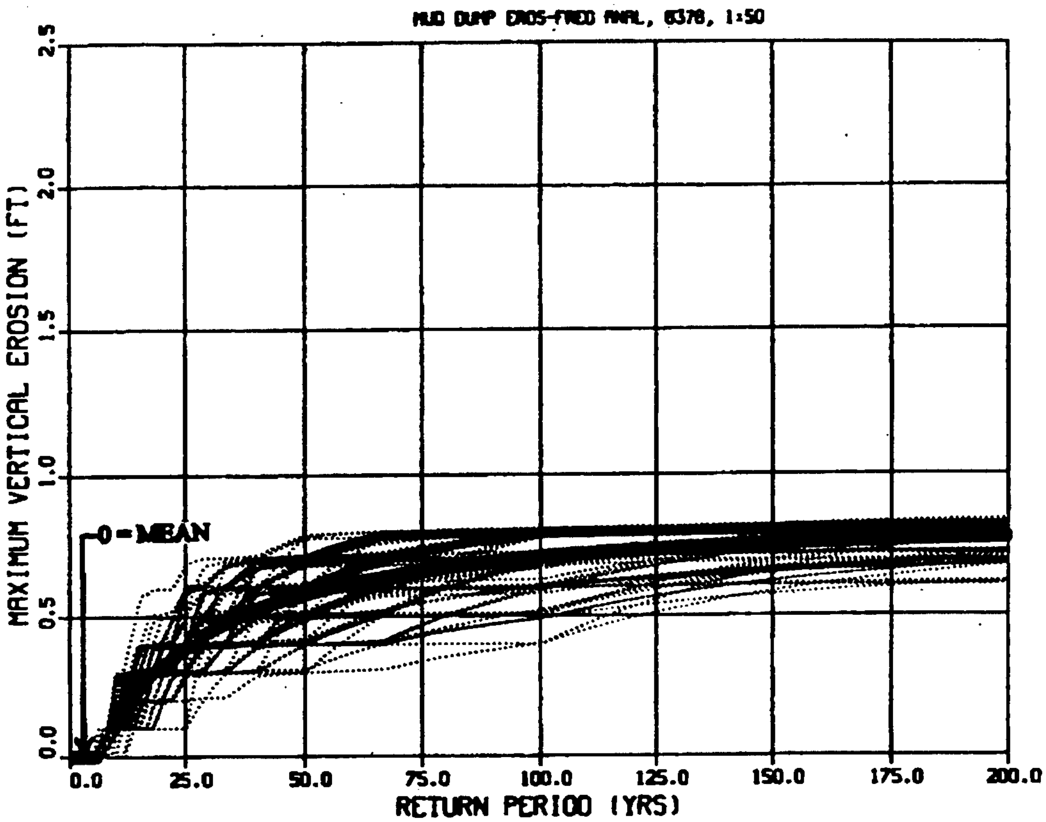


Figure G7. Simulated tropical storm-induced vertical erosion frequency curves for an 8-ft mound located at 83-ft depth, crest depth of 75 ft

Table G8
Mean Value of Vertical Erosion/Frequency-of-Occurrence for Tropical Storms at Mud Dump Site

Test Number/ Ambient Depth - Mound Height/ Crest Depth, ft	25-year mean (± sd), ft	50-year mean (± sd), ft	100-year mean (± sd), ft
1 / (63-13) / 50	1.2 (0.23)	1.6 (0.23)	1.9 (0.26)
2 / (63-8) / 55	0.9 (0.19)	1.3 (0.23)	1.5 (0.19)
3 / (73-13) / 60	0.8 (0.18)	1.2 (0.22)	1.4 (0.20)
4 / (73-8) / 65	0.6 (0.13)	0.8 (0.17)	1.0 (0.16)
5 / (83-13) / 70	0.5 (0.12)	0.8 (0.14)	0.9 (0.15)
6 / (83-8) / 75	0.4 (0.10)	0.6 (0.12)	0.7 (0.10)

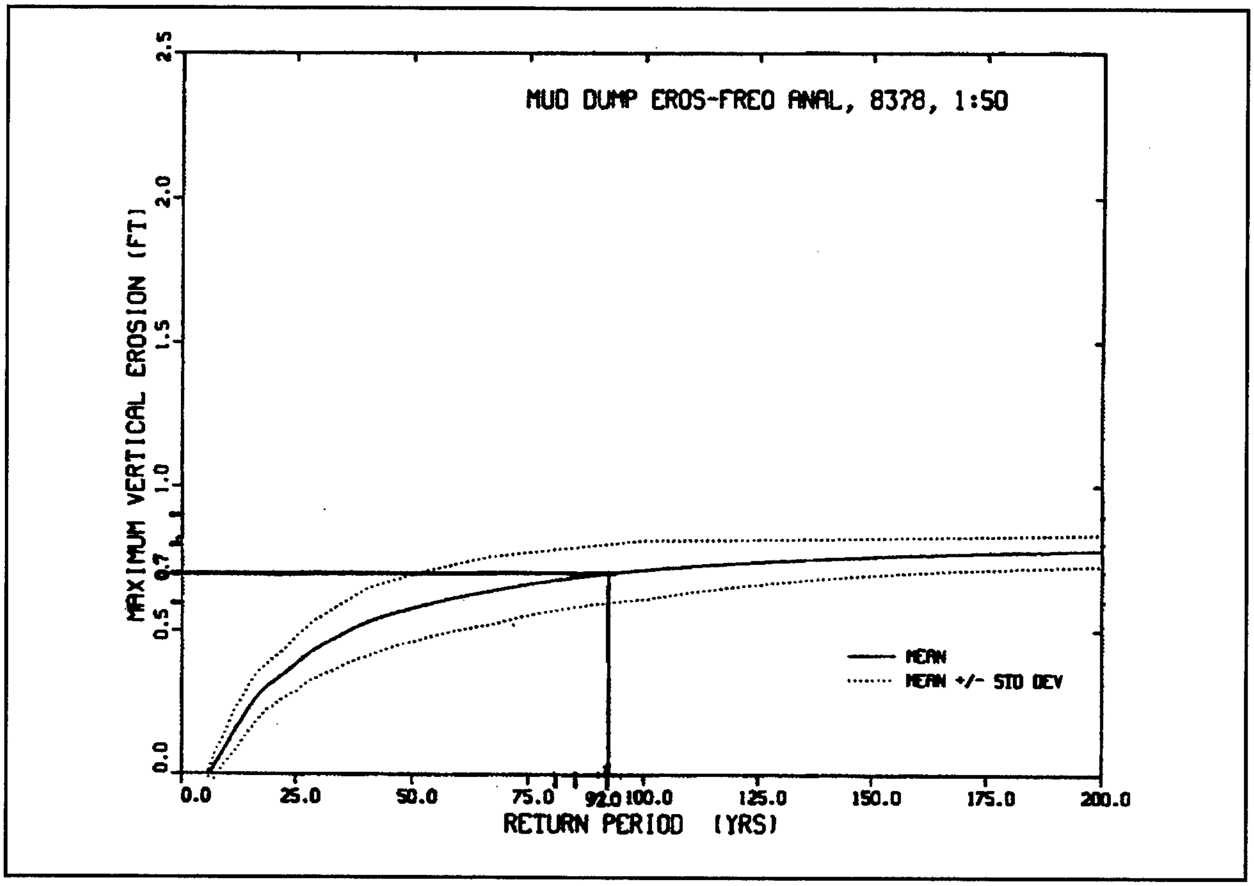


Figure G8. Mean value with error limits for frequency of vertical erosion from tropical storms for 8-ft mound located at 83-ft depth, crest depth of 75 ft

mound at the 83-ft depth. Table G9 summarizes the frequency-of-occurrence of vertical erosion from extratropical storms for all six mound configurations in the form of a mean value and +/- standard deviation error that can be added to or subtracted from the mean value.

Frequency of erosion for the combined impacts of tropical and extratropical storms

For most sites it is probably only practical (and cost effective) to replace any lost cap material due to erosion on a yearly basis. Therefore, for sites that experience both tropical and extratropical storms, the potential for vertical erosion from the combined impacts of both types of storms over a year's time must be considered. Proper design of a cap should consider both the episodic erosion from the less frequently occurring severe storms and the cumulative erosion from normal storm activity (average intensity storms experienced every year) experienced over a period of years. If this is not done, then after say 5 to 20 years of annual erosion, the remaining erosion thickness could fall below the design level (say a 100-year return frequency erosion event).

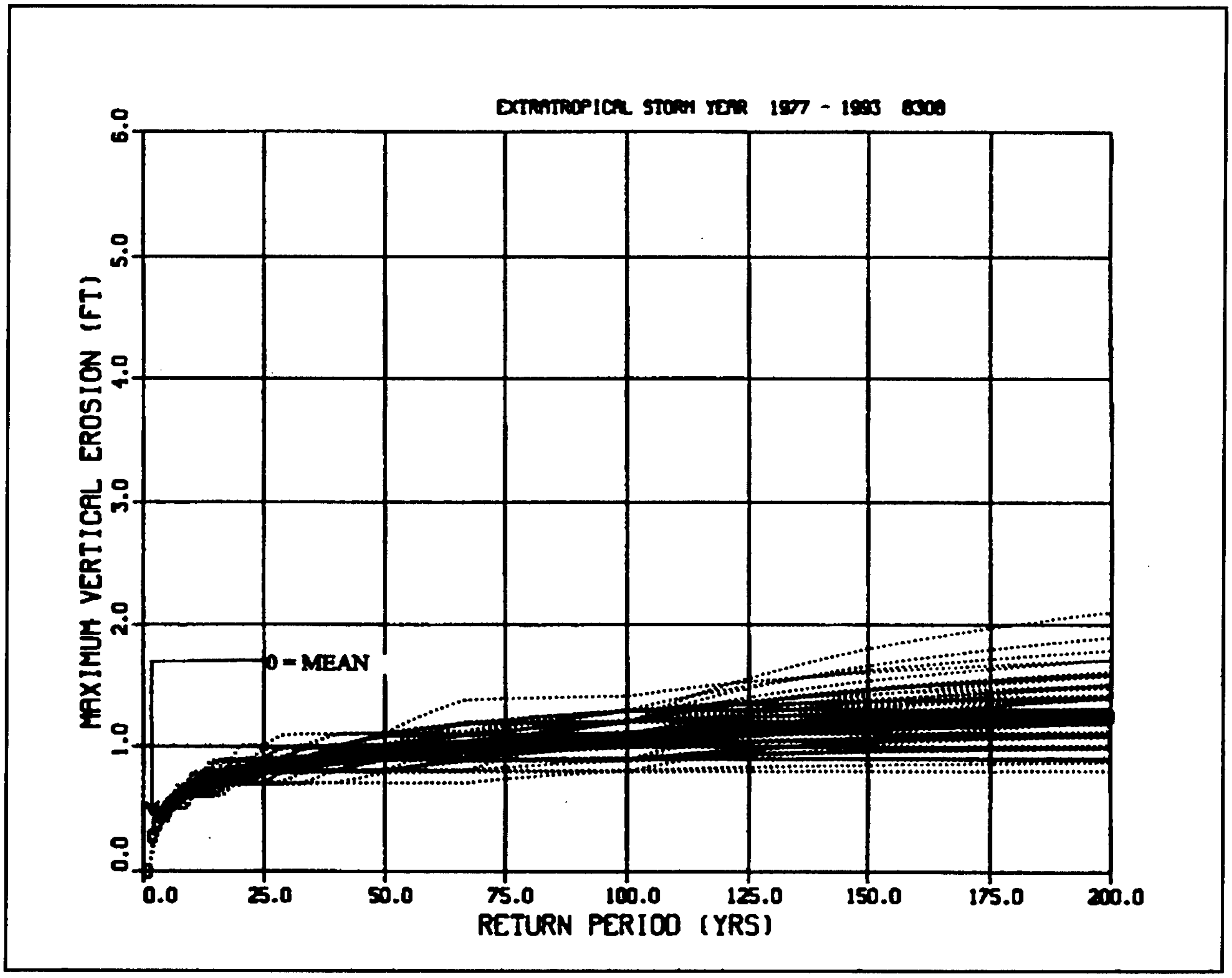


Figure G9. Simulated extratropical storm-induced vertical erosion frequency curves for an 8-ft mound located at 83-ft depth, crest depth of 75 ft

Table G9
Mean Value Erosion/Frequency-of-Occurrence for Extratropical Storms at the Mud Dump Site

Test Number/ Ambient Depth - Mound Height/ Crest Depth, ft	25-year mean (± sd), ft	50-year mean (± sd), ft	100-year mean (± sd), ft
1 / (63-13) / 50	3.0 (0.22)	3.4 (0.30)	3.9 (0.42)
2 / (63-8) / 55	2.1 (0.15)	2.3 (0.2)	2.6 (0.29)
3 / (73-13) / 60	1.8 (0.13)	2.0 (0.17)	2.3 (0.26)
4 / (73-8) / 65	1.3 (0.10)	1.4 (0.13)	1.6 (0.18)
5 / (83-13) / 70	1.1 (0.09)	1.3 (0.12)	1.5 (0.16)
6 / (83-8) / 75	0.8 (0.07)	0.9 (0.09)	1.1 (0.13)

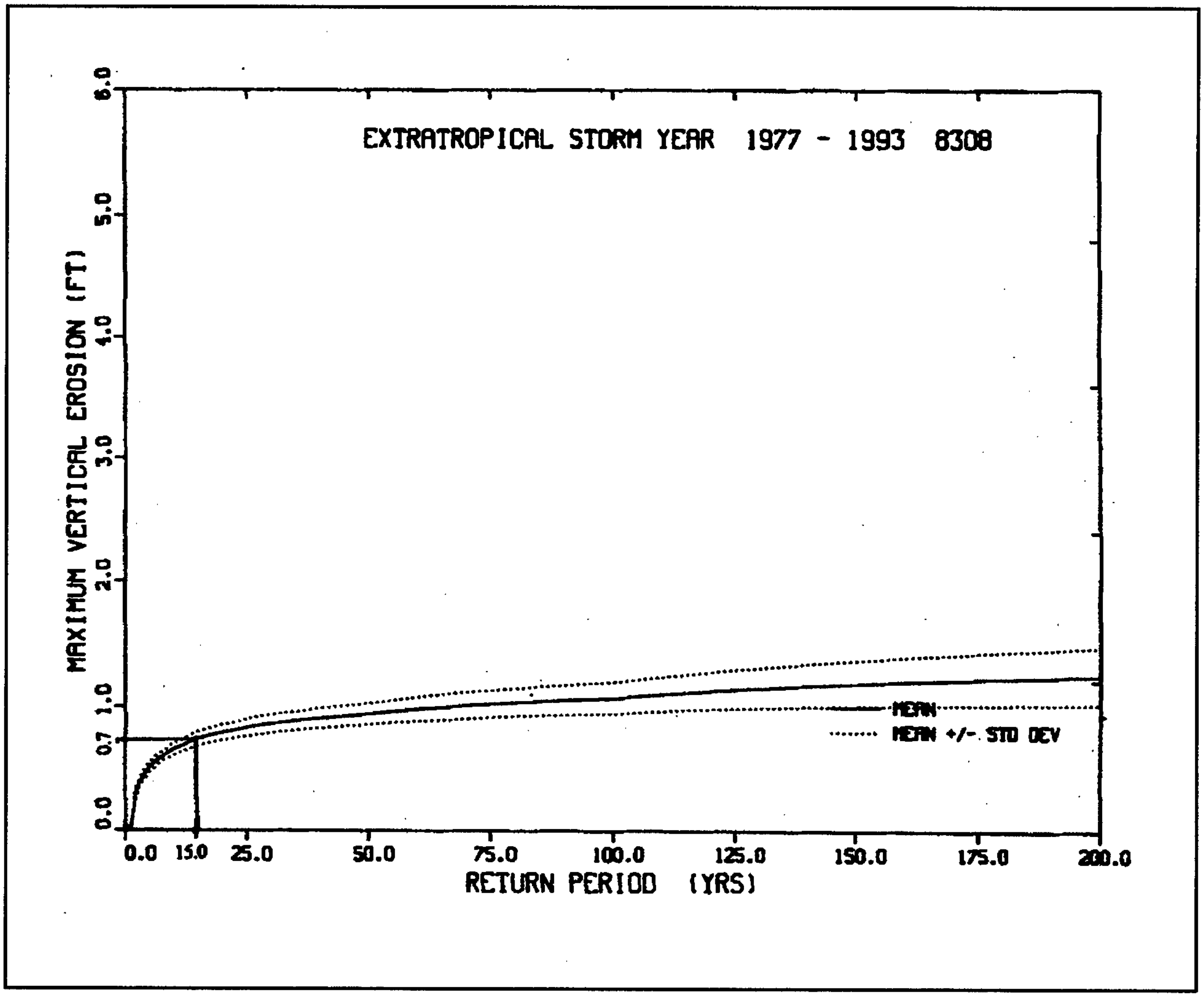


Figure G10. Mean value with error limits for frequency of vertical erosion from extratropical storms for 8-ft mound located at 83-ft depth, crest depth of 75 ft

Therefore, estimates of potential erosion of a disposal mound in the New York Bight require an analysis of both (a) episodic event erosion resulting from tropical and extratropical storms and (b) cumulative erosion. For the Mud Dump site, cumulative erosion would be considered to be due only to average intensity extratropical events. Tropical events are not considered in the average yearly erosion rate because tropical events impact the Bight at a return period of approximately 6.5 years. At more southerly east coast sites and Gulf coast sites, tropical storms may need to be considered for the yearly average erosion computations.

Cumulative erosion. As noted above, cumulative erosion is the vertical erosion expected to occur over intervals of 5 to 20 years due to a normal storm activity, i.e., moderate storms that occur regularly. Because cumulative erosion over periods of 5 to 20 years may consist of a fairly large number of storms, it is important that erosion per storm and the cumulative effects be computed as realistically as practical.

A simple method to compute cumulative erosion is to compute an annual average erosion then multiply that value by the number of years of interest. This can be done by examining the full set of training storms modeled in the erosion frequency analysis, then summing the maximum erosion from each storm and dividing by the number of storms to compute the average maximum erosion per storm. The average annual erosion could then be computed as the average maximum erosion per storm times the average number of storms per year (e.g., 2.375 for the Mud Dump site). This method would likely produce extremely conservative estimates of annual erosion because successive storms would not necessarily produce erosion in the same location. Also as the mound erodes, the elevation decreases, which decreases the erosion rate during future storms. This method also includes the erosion from severe, infrequent storms which would perhaps cause some significant cap erosion such that the cap would have to be repaired.

A correction for the gross annual erosion estimates computed by the above method could be calculated by computing the total mound erosion resulting from a series of low to moderate intensity storms (those with erosion frequencies of less than 5-10 years) applied consecutively (using LTFATE) to a specific mound configuration. The mound geometry from the first storm would be the initial geometry for the second storm and so on. The maximum total erosion at any location on the mound after a series of storms that could normally be experienced in a year (say two to four for the Mud Dump) applied consecutively could then be compared with the maximum total cap erosion of each storm summed individually. The correction factor would then be the ratio of the consecutive total maximum erosion divided by the individual total maximum erosion. Average annual erosion would then be the number of storms per year times the maximum average erosion per storm times the correction factor. Cumulative erosion would then be the corrected average annual erosion times the number of years of interest.

A more sophisticated estimate of cumulative annual erosion values would be to use LTFATE to model erosion for a particular capped mound configuration for a period of 10 to 20 years from which the training storms were selected. The storm-induced capped mound geometry from the initial storm would be, as above, the input geometry for the following storm, with the resulting capped mound geometry from each preceding storm becoming the input geometry for the subsequent storm.

At the end of each year, the maximum erosion, average erosion thickness, and area of erosion (as defined in Figure G11) would be computed. Because of the multiple years of data, running averages of each of the quantities could be computed along with basic statistics such as the average, maximum, and standard deviation. With these values a considerably more realistic estimate of annual and cumulative annual erosion is more likely. Additional research on the application of this suggested approach to actual projects is planned to determine

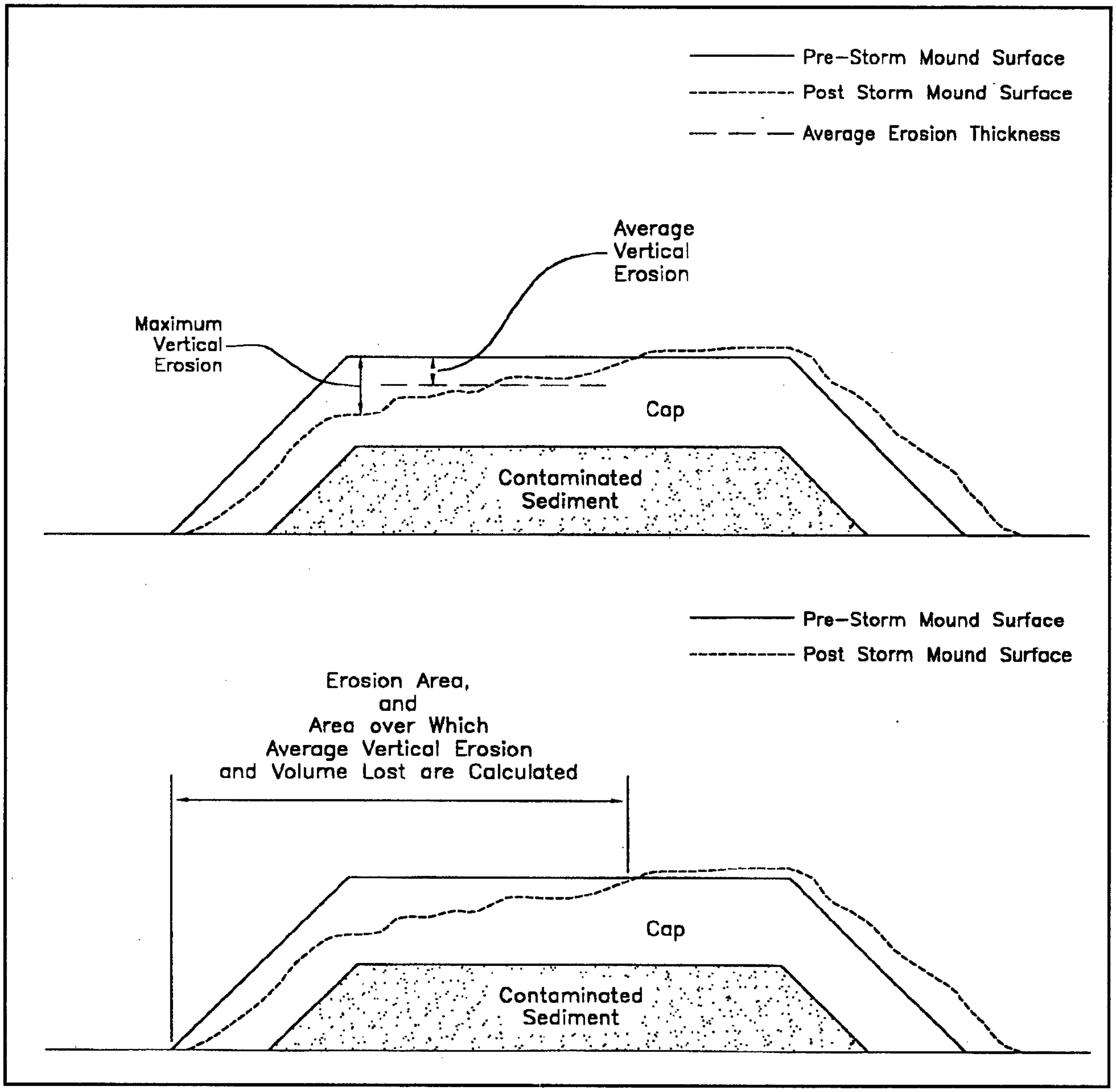


Figure G11. Idealized mound cross sections showing maximum and average vertical erosion and areas over which erosion volume is computed

if in fact, this more complicated method of computing annual and cumulative erosion estimates provides significantly different answers than the simpler methods.

Episodic erosion. Episodic event erosion was individually described for tropical and extratropical events in the prior sections. For tropical events, the curves and tables represent the vertical erosion associated with individual hurricanes. For example, a 100-year erosion value is the erosion associated with a single severe event with a return period of 100 years. However, the curves and tables presented for the extratropical events represent erosion due to multiple events occurring during a single storm season. For example, although an average of only 2.4 events occur per year at the Mud Dump site, results from the program EST generates a simulated 200-year sequence of extratropical storm activity during which it is possible to have eight or nine events in a single season. If eight or nine severe events were to occur during a single winter season, the summation of maximum erosion magnitudes for each event may be large enough for that season to be ranked as a 100-year season.

The erosion versus frequency-of-occurrence relationships for tropical and extratropical events were combined to generate a single curve and table of frequencies for each of the design configurations. The combined frequency-of-occurrence is computed by adding the frequencies associated with tropical and extratropical events for a given magnitude of erosion. For example, consider the 8-ft mound located in 83 ft of water. An erosion of 1.0 ft corresponds to a return period of 83 years for hurricanes but only 10 years for extratropical events. The combined frequency is equal to 1/83 + 1/10 or 0.11, corresponding to a return period of just 9 years. A comparison of the combined event, Table G10, shown below, and Tables G8 and G9, shows that extratropical events are the dominant storm type in the New York Bight. This dominance is evidenced by the fact that the combined event frequency relationships are very similar to the extratropical relationships. This is not surprising considering that on the average, 15 extratropical storms occur for every hurricane. Also, vertical erosion due to extratropical events is generally more severe than for tropical events due to the longer duration of extratropical storms.

Table G10
Mean Maximum Vertical Erosion Frequency due to Tropical and Extratropical Storms Impacting 0.4-mm Sand-Capped Mounds

Mound Configuration Base Depth/Mound Height/Crest Depth, ft	Combined Hurricane/Northeaster Single-Year Erosion Frequency, ft			
	10 year	25 year	50 year	100 year
63/10/50	2.4	3.0	3.4	3.9
63/08/55	1.6	2.0	2.3	2.6
73/13/60	1.5	1.8	2.0	2.3
73/08/65	1.0	1.3	1.5	1.7
83/13/70	0.9	1.2	1.3	1.6
83/08/75	0.7	0.8	0.9	1.1

A summary of results for the Mud Dump site, shown in Table G10, was prepared to provide both episodic and cumulative erosion estimates for each design option. The episodic values are provided at return periods of 10, 25, 50, and 100 years.

For example, the 100-year mean maximum erosion thickness for combined storms for a mound in 73 ft of water that is 8 ft tall with a crest elevation of 65 ft is 1.7 ft.

Use of Table G10 for evaluating disposal site design parameters such as cap thickness or site depth should consider both episodic event erosion and net cumulative erosion. Yearly monitoring of the disposal site should be conducted to ensure that the cap has maintained its integrity, i.e., cap thickness has not been reduced by erosion below the minimum safe level. Even with annual monitoring, the cap should be designed to withstand multiyear erosional events. Therefore, the disposal site should be designed such that the cap will not be compromised by either (a) episodic event (tropical) or episodic season (extra-tropical) erosion of some defined level of intensity such as the 100-year occurrence or (b) several years, 5 for example, of normal storm activity.

Summary

In conclusion, vertical erosion frequency and annual cumulative erosion estimates generated through the techniques described in this appendix can be used as a basis for designing a capped disposal mound. However, it should be emphasized that the erosion magnitudes reported can be considered somewhat conservative for the following reason:

> Single event erosion is calculated as the maximum erosion computed at any location on the cap as a result of the single event. In most cases, this erosion is limited to the edge of a cap at the intersection of the side slope and the crest. If localized erosion of the cap were indicated by annual surveys, maintenance or remedial disposal could easily restore the cap to its design thickness at the appropriate location. The amount of cap material that would be required to restore the cap to its original thickness is roughly estimated at 10 to 25 percent of the original cap volume. Computations of average mound erosion thickness and the area of mound experiencing erosion are recommended to provide additional insight on the potential for cap failure.

The storm-surge frequency analyses described in this study make extensive use of the EST. The approach requires the generation of a database of storm responses that, for this analysis, were selected to be vertical erosion. Because the procedure is a statistical one based on a training set of single-event erosion magnitudes, the above assumptions leading to conservatism cannot be eliminated from the analysis. Therefore, the fact that the estimates are conservative must be considered in the final design.

For specific cap design projects, a comprehensive and rigorous analysis of the cumulative erosion due to the occurrence of multiple events per year is recommended. This could include either computing a gross erosion reduction factor or an LTFATE simulation of multiple years of normal storm activity.

Finally, the procedures recommended in this appendix to generate vertical erosion versus frequency of occurrence utilizes a newly generated database of tropical and extratropical storm surge elevation and current hydrographs. No similar database has ever been available for use in an analysis similar to this. Because the present analysis uses this database in conjunction with thoroughly tested and documented hydrodynamic, sediment transport, and bathymetry change modeling concepts, the approach can be considered to be comprehensive, reasonably accurate, and appropriate for the purpose of developing disposal site design criteria. Future improvements in the algorithms used to compute sediment transport, better values for storm induced processes, and more high quality data on storm-induced erosion of dredged material mounds will provide higher levels of accuracy in the computations and greater confidence in cap design.

Appendix H
Calculation of Required Cap Volumes for Level-Bottom Capping Projects

The primary focus of this appendix is the calculation of the volume of capping material required for level-bottom capping projects, including the influence of various operational considerations on required volumes. The information in this appendix assumes a specific capping project has been identified, a disposal site is available, the contaminated mound geometry (footprint, side-slopes, and elevation) has been estimated, and the cap has been designed with respect to the thickness of capping material required.

Capping Volumes for Circular and Elliptical Mounds

From a plan view, capped mounds typically take either a circular or elliptical/ oval shape (Chapter 10, main text), so required cap volume calculations depend on this shape. For a uniform cap thickness over the entire contaminated mound surface (Figure H1), design must allow for inclusion of the cap volumes of the inner flank, outer flank, and apron in the overall mound cap volume calculation. This will be demonstrated in a generic example. If the cap thickness will be less over the apron (Figure H2), then the cap volume calculation requires isolating different sections of the cap for ease in calculation. For both cases, the volume of cap material included in the apron must also be calculated as constructed projects have shown this volume can be significant. Note that the following relationships are unit independent (i.e., either English or SI may be used as long as consistency is maintained).

For a uniformly thick cap on a circular mound (Figure H1), the following methodology is given to calculate cap volume:

$$V_M = t_c \pi r_M^2$$

$$V_{CA} = \pi (r_{TC}^2 - r_M^2) \frac{1}{2} t_{ta} \qquad \text{(H1)}$$

where

V_M = volume of cap material over dredged material mound

V_{CA} = volume of material in cap apron

t_c = thickness of cap

t_{ta} = thickness of cap at toe of mound apron

r_M = radius of overall dredged material mound

r_{TC} = radius of total capped surface

For a uniformly thick cap on an elliptical mound, the following methodology is given to calculate cap volume:

$$V_M = t_c (\pi r_1 r_2)$$

$$V_{CA} = \pi [(r_1 r_2)_{TC} - (r_1 r_2)_M] \frac{1}{2} t_{ta} \qquad \text{(H2)}$$

where

V_M = volume of cap material over dredged material mound

V_{CA} = volume of material in cap apron

t_c = thickness of cap

t_{ta} = thickness of cap at toe of mound apron

r_1 , r_2 = long, short radius of ellipse

$_M$ = subscript for dredged material mound

$_{TC}$ = subscript for total capped surface

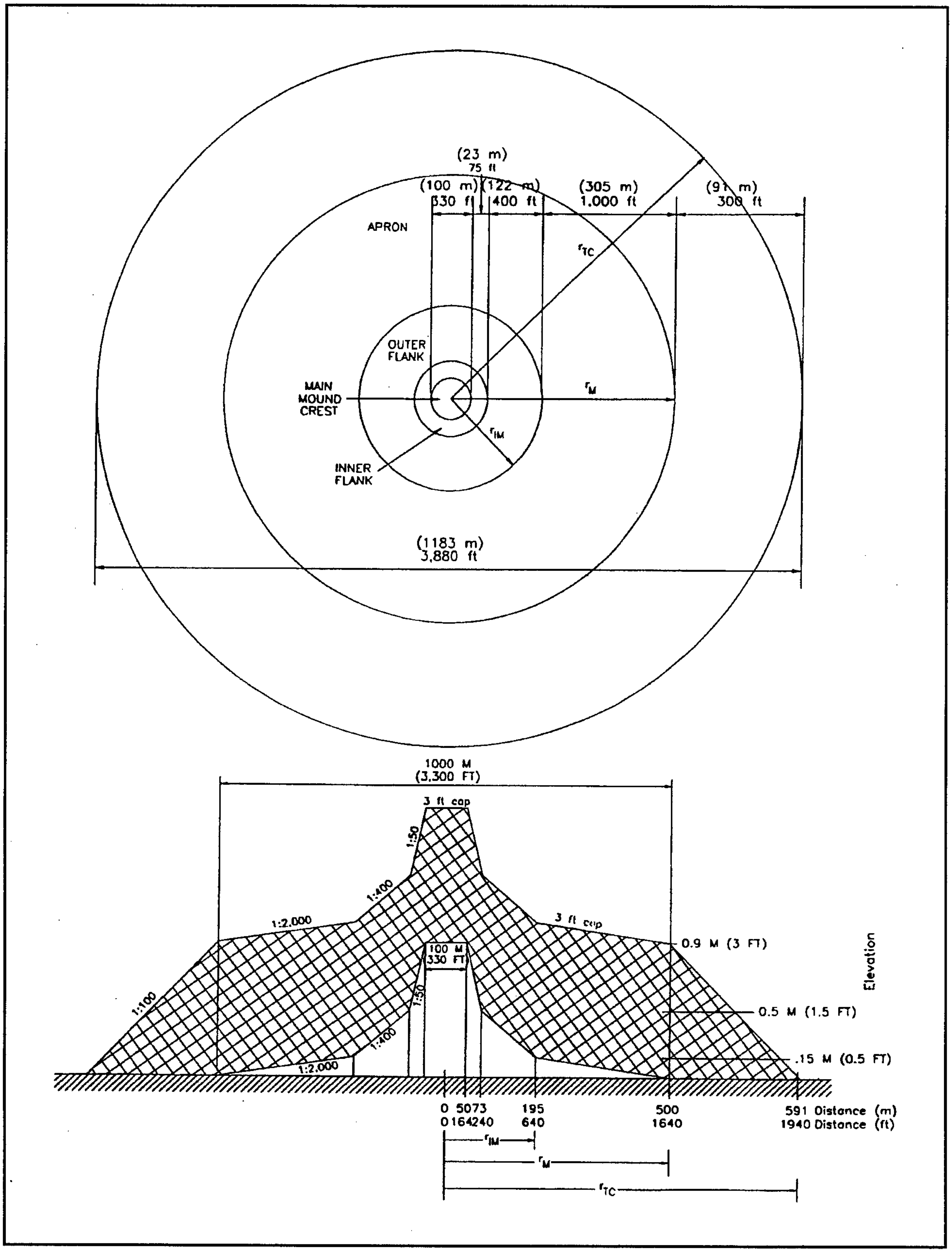


Figure H1. Geometry for a uniform cap thickness over a mound

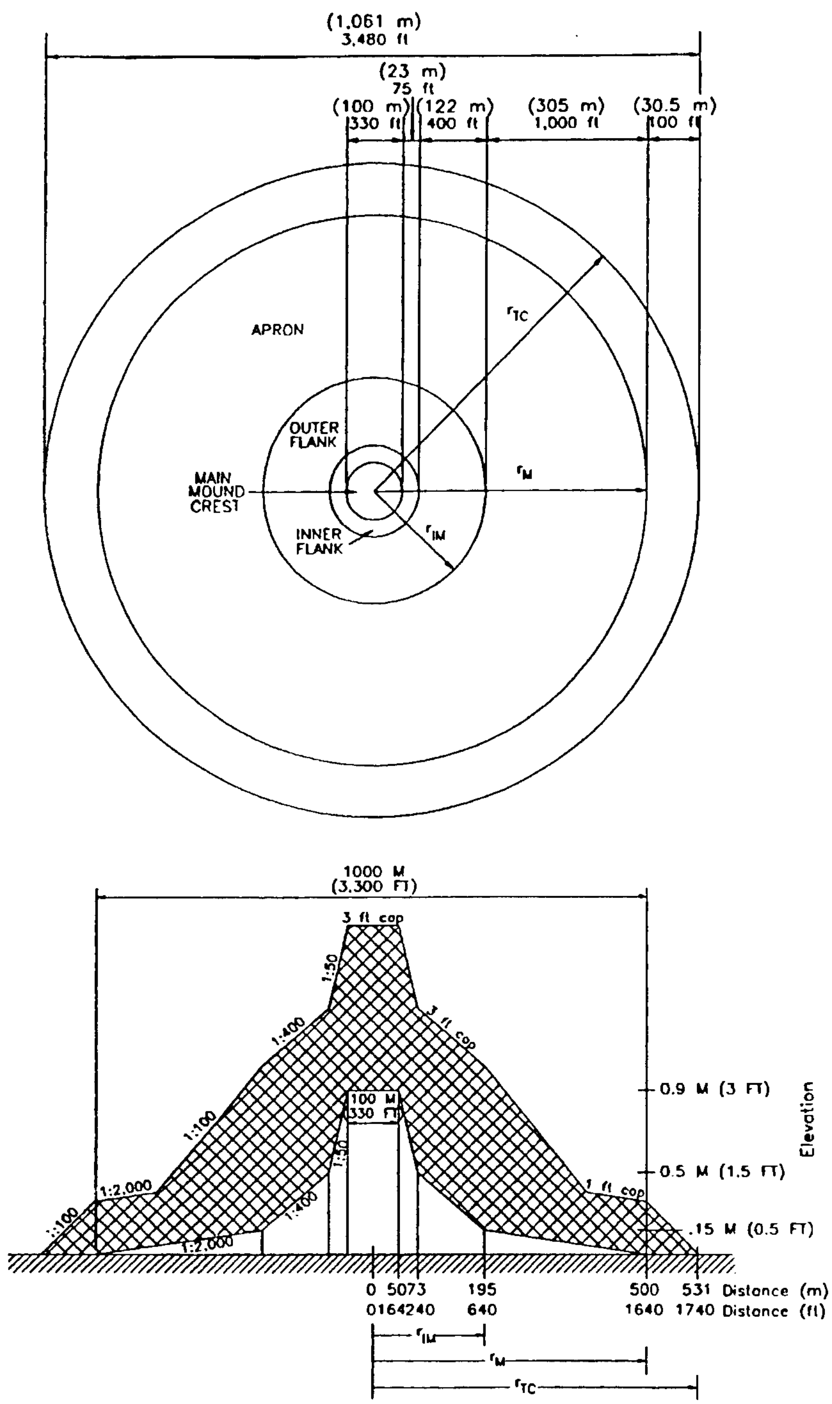


Figure H2. Geometry for a uniform cap with lesser thickness over apron

For a circular mound where the cap thickness is decreased over the apron (Figure H2, the following methodology is given to calculate cap volume:

$$V_M = t_{pc} \pi r_{IM}^2 + 0/00 \Delta t_c \pi \left[\left(r_{IM} + \Delta \frac{t_c}{m} \right)^2 - r_{IM}^2 \right] + \pi t_{ta} (r_M^2 - r_{IM}^2) \tag{H3}$$

$$V_T = V_M + V_{CA}$$

where

V_M = volume of cap material over dredged material mound

V_{CA} = volume of material in cap apron

V_T = total volume of cap material

t_{pc} = thickness of primary cap

t_{ta} = thickness of cap at toe of mound apron

t_c = change in cap thickness over apron (t_{pc} - t_{ta})

r_M = radius of overall dredged material mound

r_{IM} = radius of inner dredged material mound (crest, inner flank and outer flank)

r_{TC} = radius of total capped surface

m = slope of change in cap thickness (i.e., 1:100!m=0.01)

$$V_M = t_{pc} \pi r_1 r_2 + 0/00 \Delta t_c \pi \left[\left(r_{1_{IM}} + \frac{\Delta t_c}{m} \right) \left(r_{2_{IM}} + \frac{\Delta t_c}{m} \right) - (r_1 r_2)_{IM} \right] + \pi t_{ta} \left[(r_1 r_2)_M - (r_1 r_2)_{IM} \right] \tag{H4}$$

For an elliptic mound where the cap thickness is decreased over the apron, the following methodology is given to calculate cap volume:

$$V_T = V_M + V_{CA}$$

$$V_{CA} = \pi [(r_1 r_2)_{TC} - (r_1 r_2)_M] \frac{1}{2} t_{ta} \tag{H5}$$

where

V_M = volume of cap material over dredged material mound

V_{CA} = volume of material in cap apron

V_T = total volume of cap material

t_{pc} = thickness of primary cap

t_{ta} = thickness of cap at toe of mound apron

t_c = change in cap thickness over apron (t_{pc} - t_{ta})

r_1 , r_2 = long, short radius of ellipse

$_M$ = subscript for dredged material mound

$_{IM}$ = subscript for inner dredged material mound (crest, inner flank and outer flank)

$_{TC}$ = subscript for total capped surface

m = slope of change in cap thickness (i.e., 1:100!m=0.01)

The volume of cap material overlying the inner and outer flanks may be calculated as part of the overall dredged material mound cap volume calculations. When there is no change in cap thickness over the mound apron as in Figure H1, the cap volume over the mound apron may also be included in the overall dredged material mound cap volume calculations. To demonstrate, assume a generic circular mound having a relief of 2.1 m (7 ft) with cap 0.9 m (3 ft) thick is created (Figure H3). Approximate average inner flank, outer flank, and apron slopes are 1:50, 1:400, and 1:2000, respectively. Table H1 shows that for this example, the horizontal length and slope length are nearly equal, so use of the horizontal length in cap volume calculation is justified. For steeper slopes and/or higher mound relief, this assumption should be verified.

Table H1
Lengths Associated with Generic-Capped Mound in Figure H3

	Vertical Length		Horizontal Length		Slope Length	
	m	ft	m	ft	m	ft
A - B Inner Flank	0.9	3	46	150	46.009	150.03
B - C Inner Flank	0.9	3	366	1,200	366.0011	1,200.00375
C - D Apron	0.3	1	610	2,000	610.000074	2,000.00025

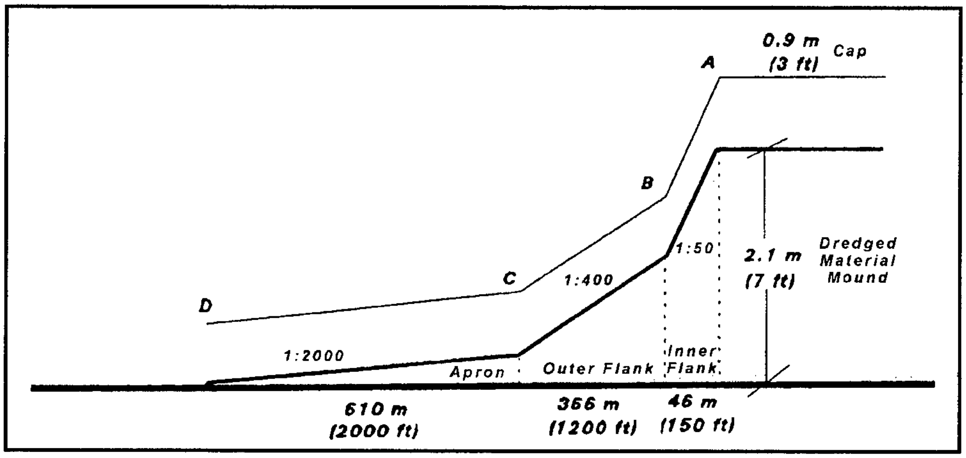


Figure H3. Cap slope length calculation

Effect of Placement Operation on Required Cap Volume

A number of operational factors should be considered in computing required cap volume. These factors include the "full" cap thickness versus "average" cap thickness, the required cap thickness over the apron, and how far beyond the contaminated boundary the cap should be placed. The following paragraphs discuss each of these factors in turn. In general, cap volume to contaminated sediment volume ratios of 1:2 to 1:5 have been used for capping projects. While the following paragraphs describe how to compute specific cap volume requirement, some generalizations can be made. Higher cap to contaminated material ratios will be found for projects that use thin mounds, those consisting of maintenance material that is fine grained with low shear strength, where barges placing contaminated material will not be required to stop, and sites with deeper water. Also, for smaller volume contaminated sediment projects, the apron will tend to occupy an increasingly large percentage of the total area, greatly increasing required cap volume to contaminated sediment volume ratio (particularly if the full cap thickness is required over the entire apron). Lower cap to contaminated sediment volumes can be expected for thicker mounds, those consisting of material with high shear strength, mounds placed in shallow water, where barges come to a complete halt or are moving at low speeds (less than 1/2 to 1 knot).

Achieving full cap thickness over the entire contaminated mound footprint is nearly impossible to accomplish without placing a considerable amount of additional material over that required for a level cap. This is because underwater placement is difficult to precisely control. Depending on the method of cap placement, the cap surface will have greater or lesser amounts of surface relief. For caps that are "sprinkled," this degree of surface relief will probably be less for sprinkled caps than for bottom-dumped caps.

One issue that must be resolved for cap design is whether or not the entire cap area requires the "full cap thickness." While a cap with a constant thickness is assumed for calculations, in reality, the cap thickness is a distribution, with an average value and the actual cap depth in specific cells (say 50 by 50 m) probably following a Gaussian distribution. For example, if a 1-m-thick cap is specified and the standard deviation of cap thickness is 15 cm (6 in.), after 100 percent of the level cap volume has been placed, 99 percent of the contaminated footprint would have 0.55 m of cap, 95 percent would have 0.70 m of cap, 67 percent would have 0.85 m of cap, 50 percent would have 1.0 m of cap, 33 percent would have 1.15 m of cap, 5 percent would have 1.3 m of cap, and 1 percent would have 1.45 m of cap. Should more cap material be placed?

It is recommended that the cap be considered complete if all the contaminated sediment has a minimum thickness equal to thickness required for chemical isolation and bioturbation plus some agreed on thickness, say 5 to 10 cm, to account for elevation variation within a given cell. The reason this procedure is acceptable is that during storms, it is extremely likely that the high spots on the cap will erode first and fill in the low areas. Thus, the requirement to place material in excess of the "level surface cap volume" should be unnecessary.

In addition to the large amount of additional material placed to meet the requirement to achieve 100-percent thickness everywhere over a cap, this requirement will also dictate repeated monitoring, which is also expensive. Finally, the actual placement process becomes less efficient as the vessel placing the cap material attempts to cover a smaller and smaller area. Statistics from the capping effort at the Port Newark/Elizabeth project (Table H2), where the goal was to place 1-m-thick cap over the entire contaminated mound, indicated that an additional 25 percent over the level cap volume was required to achieve full cap thickness coverage at over 90+ percent of the area, resulting in cap thicknesses of over 1.25 m over almost 40 percent of the area.

Table H2
Final Statistics of Cap Thickness from Port Newark/Elizabeth Project (March 1994)

Cap Thickness, m	Percent of Area Covered	Cumulative Coverage, Percent
0.00 - 0.25	0.0	0.0
0.25 - 0.50	0.2	0.2
0.50 - 0.75	2.9	3.1
0.75 - 1.00	16.4	19.5
1.00 - 1.25	42.2	61.7
1.25 - 1.50	30.4	92.1
1.50 - 1.75	6.5	98.6
1.75 - 2.00	1.1	99.7
2.00 - 2.25	0.1	99.8

To calculate required cap volume, it is recommended that the "full cap thickness" volume (i.e., a level cap at full thickness) be computed over the main mound and inner flanks. Up to an additional 10-20 percent of cap material should be identified as possibly being required and should be available.

The required cap thickness over a few centimeters-thick mound apron can become an important issue when one considers the volume (and cost) of cap material required to cover mound aprons. Table H3 compares volumes and dimensions from the Port Elizabeth/Newark project (which required a 1-m cap over the entire contaminated mound) and two generic cap projects based on the mounds shown in Figures H1 (0.9-m cap over the entire mound) and H2 (0.9-m cap over the main mound and a 0.3-m cap over the apron). Volume calculations show that over half (55.6 percent) of the 1,870,000 m^3 (2,446,000 yd^3) of material placed at the Port Elizabeth/Newark mound covered the contaminated mound apron, which contained about 12 percent of the contaminated material volume. Table H3 also shows that in the generic mounds shown in Figures H1 and H2 (identical contaminated mound shapes), the total volume of cap material material required is reduced by nearly 60 percent, from 847,200 m^3 (1,108,100 yd^3) to 347,800 m^3 (454,900 yd^3) when the required cap thickness over the apron is reduced from 1 to 0.3 m. The volume required to cover the contaminated apron reduces from 16.4 to 4.3 percent of total cap volume. The dredging and cap placement over the wide area covered by the apron will, for most projects, significantly increase the project costs. In rare instances where an abundance of cap material is being dredged as part of an authorized dredging project, the cap material can be considered "free." However, the capping project must still cover the additional cost of precisely placing the cap.

For low levels of contaminants, bioturbation-induced mixing of the cap-contaminated material and native sediment may be sufficient to reduce the resulting level of contamination to an acceptable level. McFarland (in preparation)[1] describes procedures that can be used to determine the effects of reduced cap thicknesses over the apron based on bioaccumulation studies. For the sediments used on the Port Newark/Elizabeth 1993 project, McFarland (in preparation) found that a cap thickness to apron thickness ratio of 2:1 was sufficient to reduce bioaccumulation of the contaminant of concern (dioxin) to acceptable levels. The apron thickness for the Port Newark/Elizabeth mound ranged from 1 to 10 cm with a 5 cm averge thickness. Thus using McFarland's results, a cap thickness over the apron of 10 to 20 cm would have been sufficient. Most of the capped mounds created as part of the New England Division's capping program have cap thicknesses over the apron of 20 to 50 cm.

Another issue impacting the amount of cap required is how far beyond the known contaminated mound boundary to place cap material. Because the edge of the cap will normally be located with a sediment profiling camera, the edge of the contaminated material will normally be defined to a precision of about 50 m. Therefore, it seems reasonable to place cap material such that the cap material

---

[1] References cited in this appendix are listed in the References at the end of the main test.

Table H3 Contaminated and Cap Material Volumes and Mound Dimensions					
Project	**Tot Vol, m³ (yd ³)**	**Apron Vol, M³ (yd³)**	**% Total**	**Footprint, m², (acres)**	**Max thick, m (ft)**
			Contaminated		
Port Elizabeth/ Newark	448,000 (586,000)	52,000 (68,000)	11.6	1,470,000 (363)	2.40 (8.0)
Generic No. 1 (Figure H1)	96,600 (126,300)	49,900 (65,300)	51.7	785,400 (194)	0.9 (3.0)
Generic No. 2 (Figure H2)	96,600 (126,300)	49,900 (65,300)	51.7	785,400 (194)	0.9 (3.0)
			Cap		
Port Elizabeth/ Newark (1 m cap over entire project)	1,870,000 (2,445,900)	1,040,000 (1,360,300)	55.6	1,470,000 (363)	1.8 (5.91)
Generic No. 1 (Figure H1) (0.9 m cap over entire project)	847,200 (1,108,100)	140,400 (183,600)	16.6	1,097,000 (271)	0.9 (2.95)
Generic No. 2 (Figure H2) (0.9 m cap over main mound, 0.3 m cap over apron)	347,800 (454,900)	15,100 (19,750)	4.3	885,800 (219)	0.9 (2.95)

extends a distance of 15 to 30 m beyond the expected edge of the contaminated material.

For sites with significant currents (say 30-50 cm/sec and greater) some loss of cap material will probably be experienced. The Seattle District has documented that for small sites (100 to 150 m overall dimensions) this "volume lost," which is a actually cap material that is moved beyond the edge of the contaminated sediment, can be from 10 to 20 percent of the estimated volume required based on a flat cap over the contaminated sediment footprint (Parry 1994).

For a fine-grained cap, the volume lost to consolidation will have to be taken into account for the erosion layer. An estimate of the amount of consolidation over time will be required and the additional thickness added to account for potential erosion. Note that the reduced cap thickness from consolidation may not be a problem from a chemical isolation standpoint due to advection of contaminants. The reduced cap thickness from consolidation is somewhat compensated for by the reduced void ratio and permeability, creating more tortuous paths for the contaminants to diffuse through.

However, the reduction in cap thickness due to consolidation should be considered from the standpoint of advection of pore water. Consolidation will reduce the void ratio and thus will force pore water further out into the cap.

Effect on Volume Due to Change in Void Ratio

The volume of material to be dredged for the cap must be calculated to determine if potential sources of capping material, say from an available maintenance dredging project, will be adequate. The potential changes in volume due to dredging and placement must be considered. The required volume of capping material (in situ in the channel) can be calculated as follows:

$$V_{ci} = V_c \left(\left[\frac{(e_o - e_i)}{(1 = e_i)} \right] + 1 \right) \tag{H6}$$

where

V_{ci} = volume of cap material in situ in channel

V_c = volume of cap material initially placed

e_o = average void ratio of cap material initially placed

e_i = average void ratio of cap material in situ in channel

For projects in which the capping material is hydraulically placed, the value of e_o can be determined in the same way as that used in design of confined disposal facilities (USACE 1987, EM 1110-2-5027). For mechanically dredged sediments, an approach to determine the minimum cap volume required is to assume no difference in e_o and e_i (i.e., $V_{ci} = V_c$). It is recommended that those with experience dredging a particular project (USACE District Operations Division staff, dredging contractors, etc.) be contacted for suggestions on bulking factors. SAIC (1995) reports that the assumption of no difference in e_o and e_i is reasonable.

Options if Required Volume is Too Large

The information from the prior section along with the information in Chapter 6 (main text) on expected contaminated mound footprint should be used to compute required cap volume. If the estimated cap volume is too large, either because insufficient cap material is available or the cost is too high, the following options are available. As noted earlier, the most obvious is to reduce the volume of contaminated material. A second option may be to delay dredging until additional cap material becomes available, perhaps combining several small projects that collectively can afford the cap required. Other options involve creating a contained aquatic disposal (CAD) site, either by creating berms from clean material (perhaps dredged from the disposal site creating additional capacity) or potentially using geotextile fabric containers. Use of geosynthetic fabric containers (GFCs) to contain the contaminated sediments is also an option to reduce the amount of cap required. However, this is a fairly recent development, and specific guidelines for this application are not yet available. Clausner et al. (1996) summarize the present state of knowledge and critical issues for geotextile container use with contaminated dredged material.

Good advance planning can be used to create a "natural" CAD site. As described in Chapter 6, over a several-year time period, the New England Division created a series of capped mounds in a circle. The de facto CAD site in the center was then used for a rather large project. This technique greatly reduced the potential spread of the contaminants and allowed a low cap volume to contaminated sediment volume ratio. Fredette (1994) describes this project in detail.

Appendix I
Consolidation Testing

Consolidation Testing Procedures

Consolidation analysis of soft dredged material requires that laboratory compressiblity data be obtained across the entire, wide range of void ratios that are commonly encountered in these soft materials as they consolidate. Void ratios in dredged materials can vary much more than those of normal soils. In typical (nonsediment) soils in the natural state, void ratios normally vary between 0.25 and 2.0, with some soft organic clays reaching 3.0. Recently deposited in situ sediments often have void ratios as high as 5 or 6, double or triple the values of most soils. When dredged by hopper or hydraulic dredges, the initial void ratios after disposal may reach as high as 10 to 12; in a few clayey sediments; the maximum values may reach even higher. Mechanical dredging does not dramatically alter the void ratio of the mass of dredged material; however, there will be clumps of material at about the in situ void ratio with much softer (slurry consistency) material between the clumps.

Laboratory consolidation testing of soft materials often requires use of at least two types of consolidation tests. Both a modified version of the standard oedometer consolidation test and a self-weight consolidation test must normally be conducted; these tests provide data for the low and high ends of the anticipated range of void ratios, respectively. However, on relatively firm dredged materials that are mechanically dredged, use of oedometer testing alone may suffice.

Several additional consolidation test devices and procedures have been developed and evaluated in recent years, but none are currently available or recommended for routine dredged material testing. Some of these devices were intended to supplement the self-weight and oedometer test by providing more continuous void ratio-effective stress (e-σ) and void ratio-permeability (e-k) throughout the middle ranges of interest, while some devices were intended to provide all of the necessary data, thus eliminating the need for any other tests (e.g., Poindexter 1988). Because of continued widespread interest in slurry consolidation in the dredging, mining, and phosphate industries, it is anticipated that the American Society for Testing and Materials (ASTM) will develop a standard (or standards) for consolidation testing of very soft materials in the near future.

The modified oedometer test procedure is outlined in Appendix D of EM 1110-2-5027 (U.S. Army Corps of Engineers (USACE) 1987). The self-weight consolidation test and its interpretation and use have been described by Poindexter (1988) and Poindexter-Rollings (1990). Both of these consolidation tests will be briefly discussed below. For additional information and exact testing procedures, the reader is referred to the following documents: ASTM D 2435, USACE (1986), USACE (1987), Cargill (1986).

Standard Oedometer Test

The standard oedometer (consolidometer) test can be used to conduct consolidation tests on dredged materials and foundation soils, as shown in Figure I1 (USACE 1986). Due to the soft, often fluidlike consistency of the sediment samples normally tested, the fixed ring consolidometer should be used, instead of the floating ring device, since extrusion of the sample from the device will be less likely in the fixed ring consolidometer. Sample preparation and loading method constitute the only modifications necessary for testing of dredged material in this device. Consolidation test procedures for use with soft dredged materials are outlined below; more detailed procedures are provided in USACE (1987), Poindexter (1988), Poindexter-Rollings (1990), and Palermo, Montgomery, and Poindexter (1978), and troubleshooting tips are provided in Rollings and Rollings (1996). Although the foundation soils under dredged

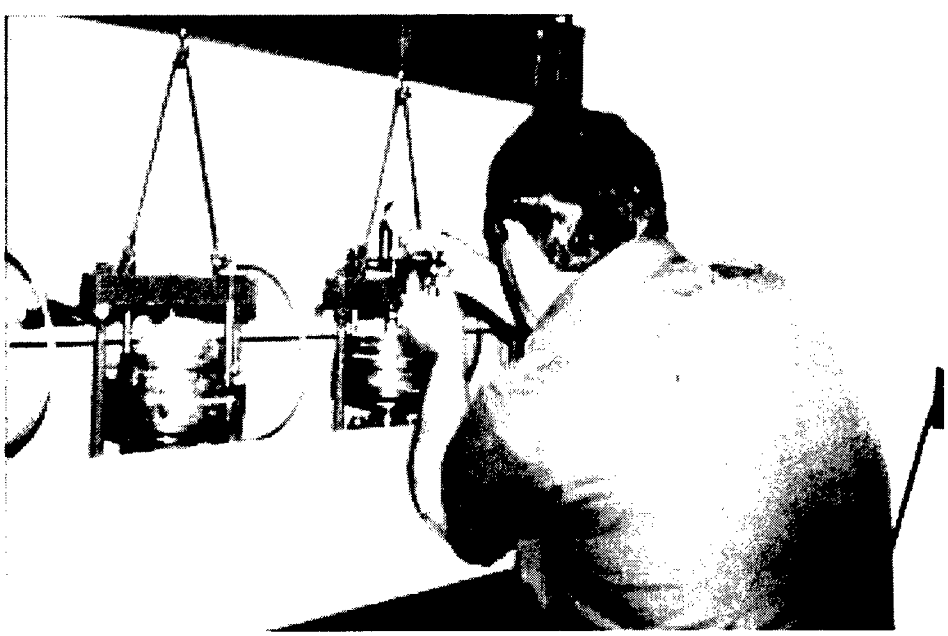


Figure I1. Standard oedometer testing device material mounds are generally stiffer than dredged sediments, they are usually still categorized as soft soils within the geotechnical community. Therefore, it is prudent to test the foundation soils in the fixed ring device, although the standard loading sequence may be used.

A representative sample of the fine-grained (minus No. 40 sieve) portion of sediments to be dredged should be used for the standard oedometer test. Since sediments have typically been remolded during the dredging process and any internal structure existing in situ in the channel has been destroyed, a remolded sample can be used for this test. The samples of foundation soils for consolidation testing, however, should be undisturbed.

When soft disturbed sediment samples are used, they are often spooned into the consolidation device. In this case, the dredged material must be placed carefully into the consolidometer to prevent inclusion of air bubbles that would invalidate the test results. After the sample is placed in the consolidation ring in the oedometer, the initial load is applied. The seating load consisting of the porous stone, loading plate, and ball bearings plus the compression load caused by the dial indicator is considered as the initial load increment for the test. This load should not exceed 0.005 tsf. If the sample consistency is extremely fluid-like, a lower initial load may be necessary to prevent extrusion of the soft material from the consolidation ring.

Succeeding load increments may be placed using the normal beam and weight or pneumatic loading devices. The following loading schedule is typically used for dredged material testing: 0.005, 0.01, 0.02, 0.05, 0.10, 0.25, 0.50, and 1.0 tsf. A maximum load of 1.0 tsf should be adequate for most applications. However, the maximum effective stress anticipated to occur at the bottom of the dredged material deposit during its existence should be estimated and the loading sequence extended, if necessary, to cover the full range of potential effective stresses.

Time-consolidation data should be examined while the test is in progress to ensure that 100-percent primary consolidation is reached for each load increment. In some cases, it may be necessary to allow each load increment to remain for a period of several days. Rebound loadings are not normally required since the dredged material will not typically be excavated after placement at a disposal site (USACE 1987).

Self-Weight Consolidation Test

A test device and testing procedure were developed by Cargill (1985 and 1986) to allow determination of the compressibility characteristics of dredged material at high void ratios. This test represents a modification to a testing procedure developed by Bromwell and Carrier (1979) for use in analyzing phosphate mining wastes. It is used to supplement the standard consolidation test in order to provide e-σ' and e-k data over the full range of anticipated void ratios and is especially useful for hopper or hydraulically dredged materials.

This test is useful for determining the upper portion of the void ratio-effective stress and void ratio-permeability relationships; it is presently the only method available to determine this needed information.

The self-weight testing device is shown in Figure I2. This device consists of an outer plexiglass cylinder that encircles a second plexiglass column composed of either 0.25- or 0.50-in.-thick rings. The device allows consolidation testing and subsequent incremental sampling of a specimen 6 in. in diameter and up to 12 in. high. The material tested in this device should consist of only the fine-grained portion of the sediment, i.e., that portion passing the No. 40 sieve. Use of only minus No. 40 material is necessary to prevent, or minimize, segregation of the coarser fraction from the high void ratio slurry being tested.

The sediment is mixed with water from the dredging site to form a slurry. In order to develop the entire e-σ' relationship, this slurry should always be at a void ratio greater than the void ratio at zero effective stress, e_{00}, which is the void ratio of the dredged material after sedimentation and before consolidation. The initial void ratios usually used in this test range from approximately 10.0 to 16.0.

The slurry is placed in the consolidometer, and it is allowed to undergo self-weight consolidation. Deformation versus time data are collected during the consolidation process. After the completion of primary consolidation, the test device is disassembled and the specimen is sampled at 0.25- or 0.50-in. intervals throughout its depth to obtain the necessary data to calculate void ratio, effective stress, and permeability values for the upper portion of the e-σ' and e-k curves.

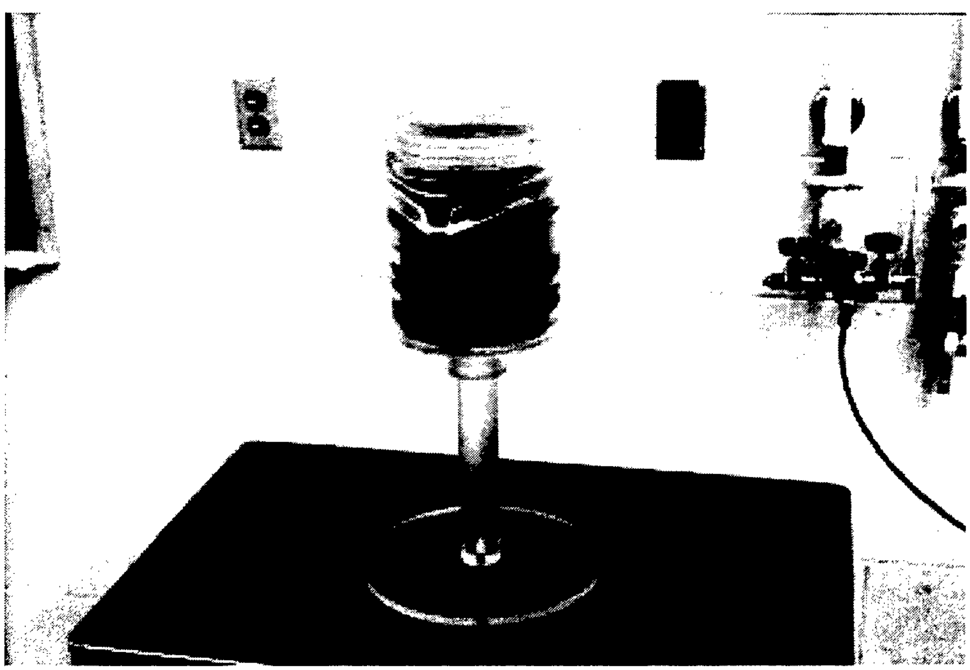


Figure I2. Self-weight consolidation test device

(Only one average value of k is obtained from this test.) Typical void ratios encountered in the specimen after completion of this test range from 5 to 12 (from bottom to top of specimen).

The self-weight consolidation test was developed to provide compressibility and permeability data for material that had been hydraulically dredged and placed in the disposal site as a slurry; thus the initial void ratios used in this test were required to be greater than the zero effective stress void ratio. Despite the fact that dredging methods other than hydraulic dredging will commonly be used for material placement at subaqueous disposal sites, continued use of this procedure will ensure that the e-σ' and e-k relationships developed for a particular material will cover the entire possible range of conditions.

Test Results

Both void ratio-effective stress and void ratio-permeability relationships must be developed from laboratory test results for each material (cap, contaminated dredged material, and foundation soil). These relationships should extend across the entire range of void ratios that may exist in each material. For dredged material, results obtained from the self-weight and oedometer tests (described in the previous section) must be combined to yield composite e-σ' and e-k relationships. For the stiffer foundation soils and some mechanically dredged materials, standard oedometer tests will typically provide adequate data. Tests needed for capping material will depend upon the type of material and its consistency; if sand is used for capping, no consolidation test will be required. Example compressibility and permeability curves are shown in Figures I3 through I8.

References

Bromwell, L. G., and Carrier, W. D., III. (1979). "Consolidation of fine-grained mining wastes," *Proceedings of the Sixth Pan American Conference on Soil Mechanics and Foundation Engineering, Lima, Peru.*

Cargill, K. W. (1985). "Mathematical model of the consolidation/desiccation process in dredged material," Technical Report D-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cargill, K. W. (1986). "The large strain, controlled rate of strain (LSCRS) device for consolidation testing of soft, fine-grained soils," Technical Report GL-86-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Gibson, R. E., England, G. L., and Hussey, M. J. L. (1967). "The theory of one-dimensional consolidation of saturated clays, I. Finite, non-linear consolidation of thin homogeneous layers," *Geotechnique* 17, 261-273.

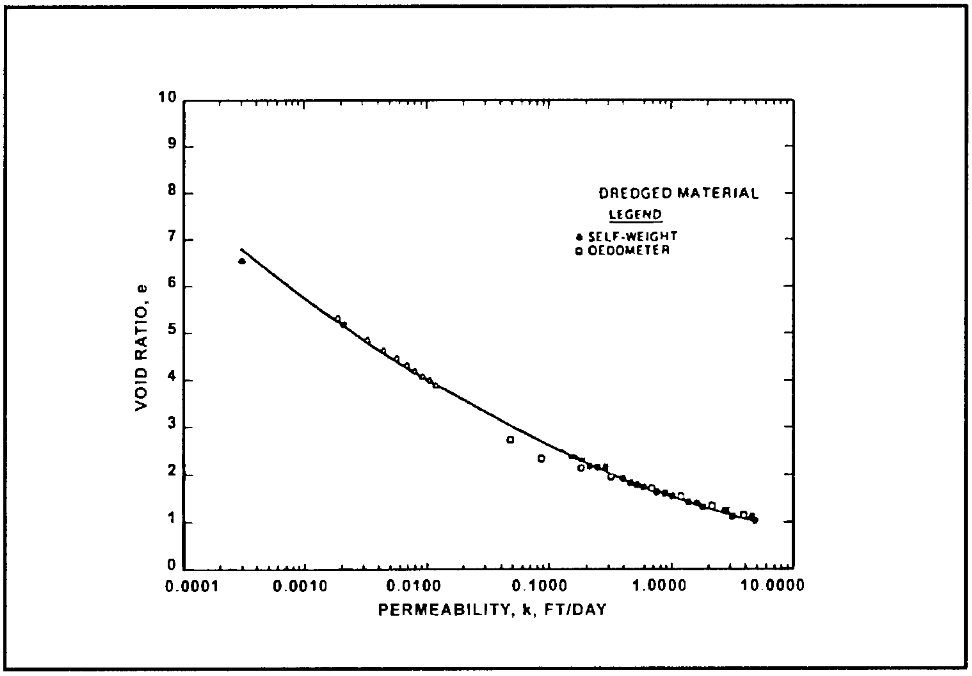


Figure I3. Void ratio-effective stress relationship for contaminated dredged material

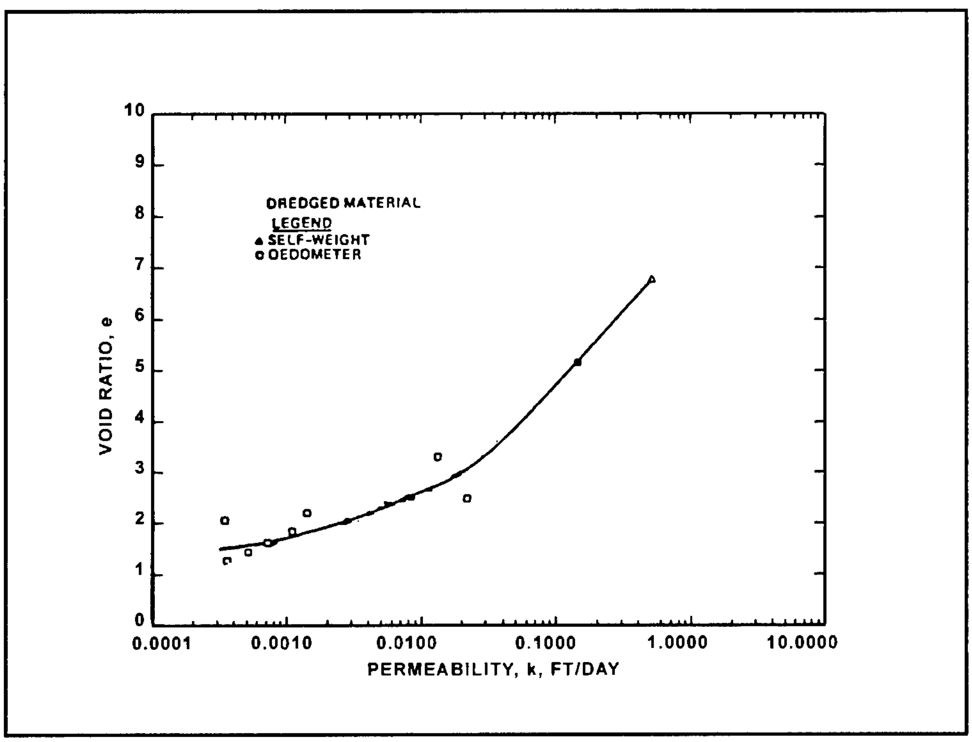


Figure I4. Void ratio-permeability relationship for contaminated dredged material

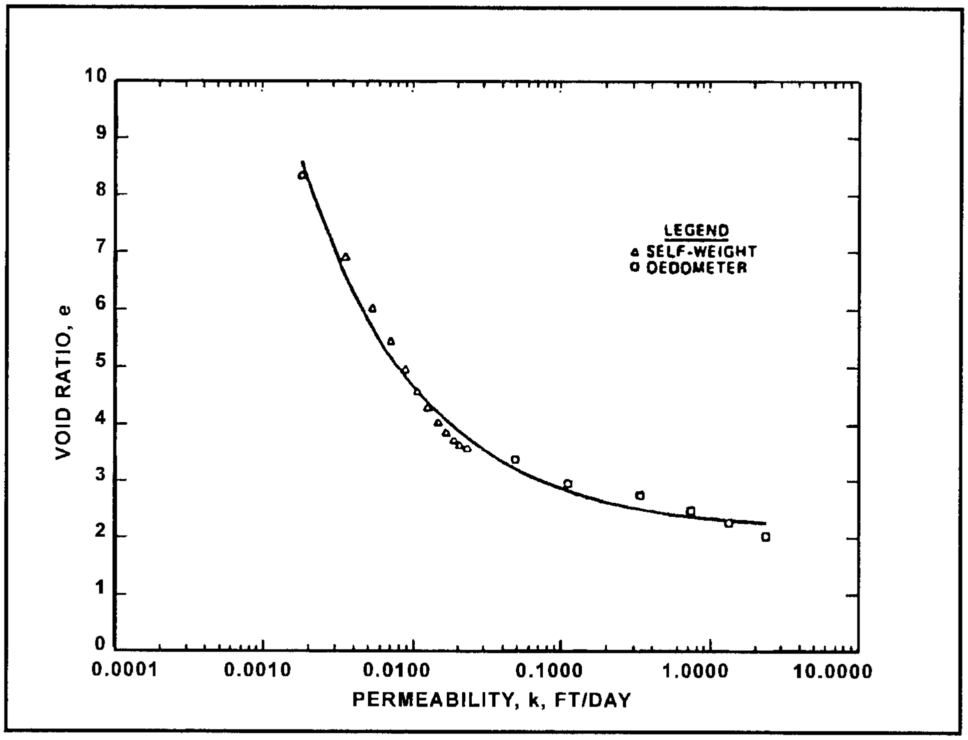


Figure I5. Void ratio-effective stress relationship for capping material

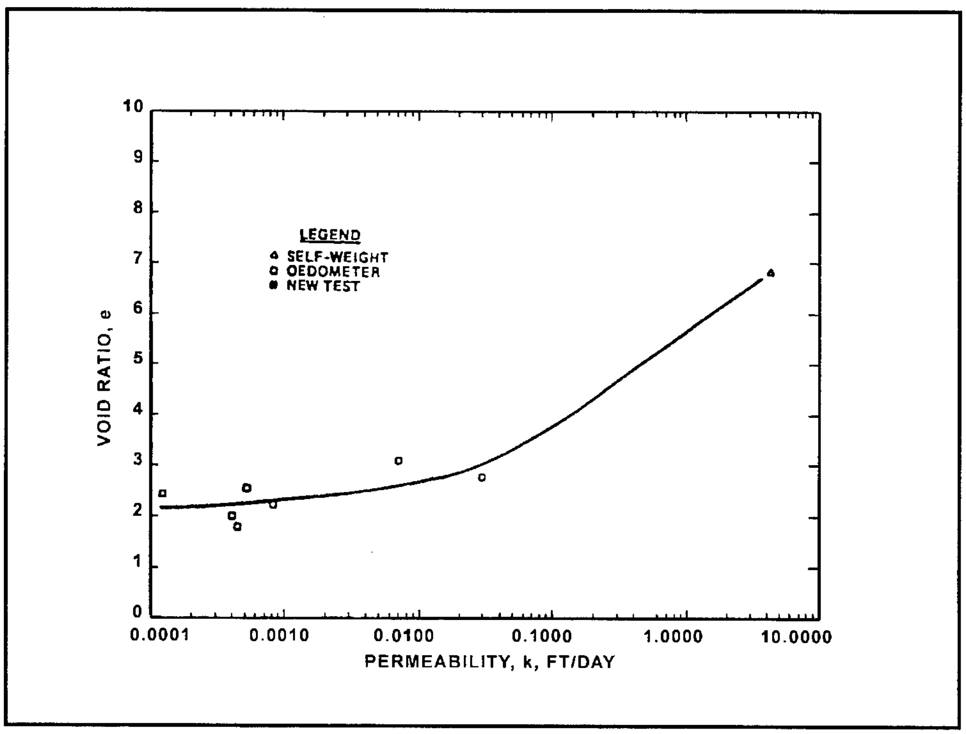


Figure I6. Void ratio-permeability relationship for capping material

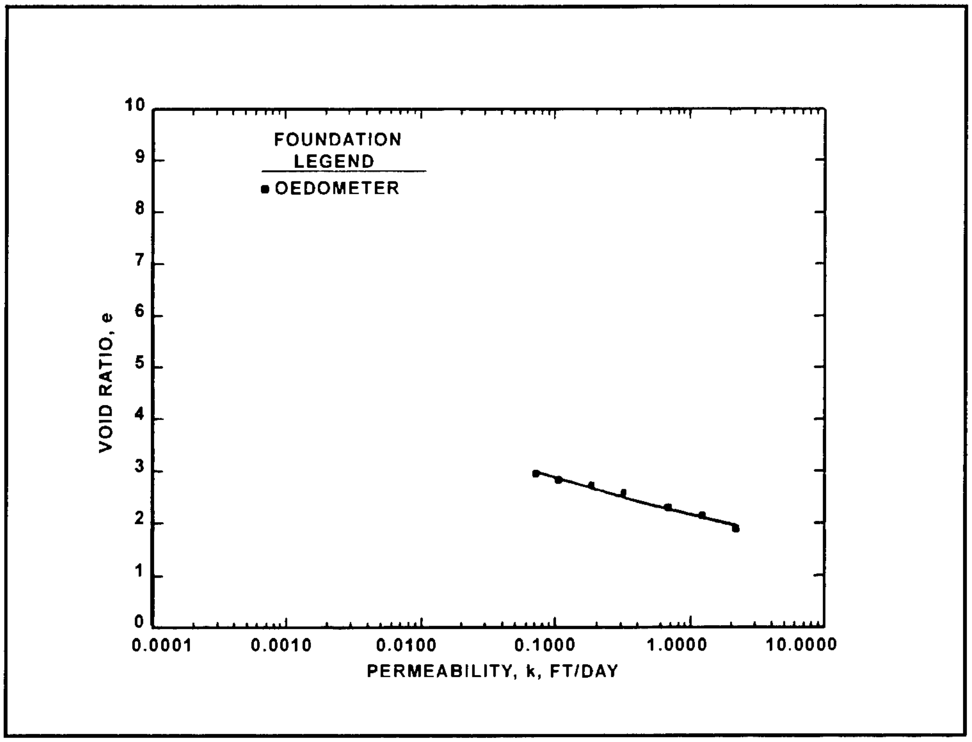


Figure I7. Void ratio-effective stress relationship for foundation soil

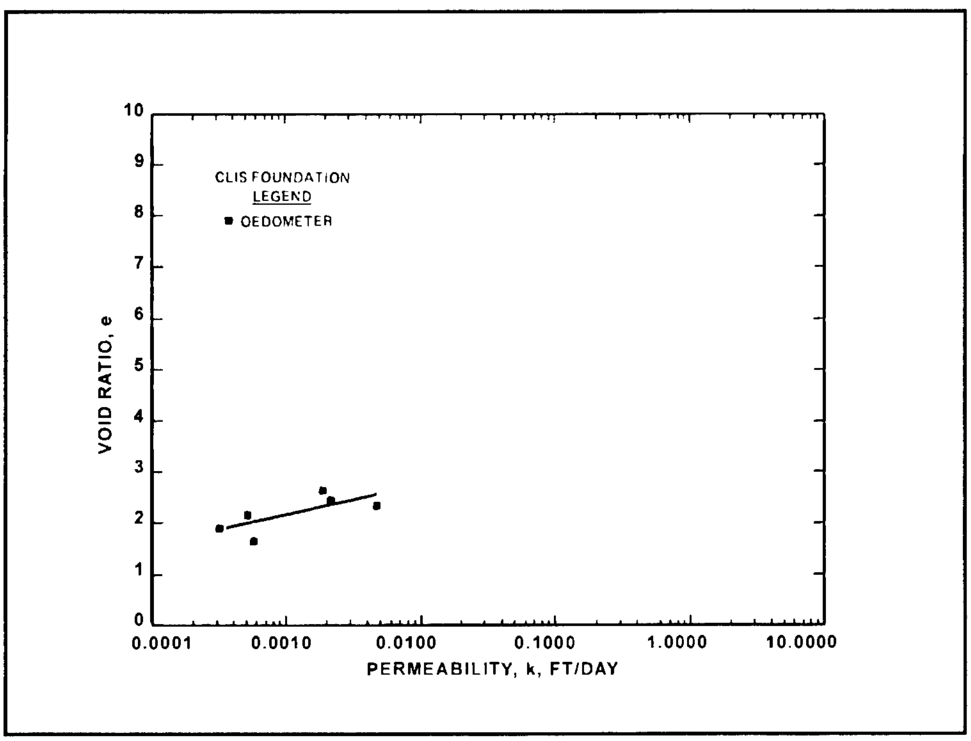


Figure I8. Void ratio-permeability relationship for foundation soil

Gibson, R. E., Schiffman, R. L., and Cargill, K. W. (1981). "The theory of one-dimensional consolidation of saturated clays, II. Finite, non-linear consolidation of thick homogeneous layers," *Canadian Geotechnical Journal* 8, 280-293.

Palermo, M. R., Montgomery, R. L., and Poindexter, M. E. (1978). "Guidelines for designing, operating, and managing dredged material containment areas," Technical Report DS-78-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Poindexter, M. E. (1988). "Behavior of subaqueous sediment mounds: Effect on disposal site capacity," Ph.D. Diss., Texas A&M University, College Station, TX.

Poindexter-Rollings, M. E. (1990). "Methodology for analysis of subaqueous sediment mounds," Technical Report D-90-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Rollings and Rollings. (1996). *Geotechnical materials in construction.* McGraw-Hill, New York.

Townsend, F. C. (1987). "Clay waste pond reclamation by sand/clay mix or capping," *ASCE Journal of Geotechnical Engineering* 115(11), New York.

Townsend, F. C., and McVay, M. C. (1990). "State-of-the-art: Large strain consolidation predictions," *ASCE Journal of Geotechnical Engineering* 116(2), New York.

U.S. Army Corps of Engineers. (1986). "Laboratory soils testing," Engineer Manual 1110-2-1906, Washington, DC.

__________. (1987). "Confined disposal of dredged material," Engineer Manual 1110-2-5027, Washington, DC.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY ***(Leave blank)***

2. REPORT DATE
June 1998

3. REPORT TYPE AND DATES COVERED
Final report

4. TITLE AND SUBTITLE
Guidance for Subaqueous Dredged Material Capping

5. FUNDING NUMBERS

6. AUTHOR(S)
Michael R. Palermo, James E. Clausner, Marian P. Rollings, Gregory L. Williams, Tommy E. Myers, Thomas J. Fredette, Robert E. Randall

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
See reverse.

8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report DOER-1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

When dredged materials proposed for open-water placement are found to require isolation form the benthic environment due to the presence of contaminants, capping may be appropriate for consideration as a management action. This report is intended to provide technical guidance for evaluation of capping projects. From a technical perspective, this guidance is applicable to dredged material capping projects in ocean waters as well as inland and near-coastal waters.

Subaqueous dredged material capping is the controlled, accurate placement of contaminated dredged material at an appropriately selected open-water placement site, followed by a covering or cap of suitable isolating material. A number of capping operations under a variety of placement conditions have been accomplished. Conventional placement equipment and techniques are frequently used for a capping project, but these practices must be controlled more precisely than for conventional placement. Level bottom capping (LBC) is defined as the placement of a contaminated material in a mounded configuration and the subsequent covering of the mound with clean sediment. Contained aquatic disposal is similar to LBC but with the additional provision of some form of lateral confinement (e.g., placement in natural bottom depressions, constructed subaqueous pits, or behind subaqueous berms) to minimize spread of the materials on the bottom.

(Continued)

14. SUBJECT TERMS
Capping
Contaminated sediments
Dredged material
Dredging
Open-water disposal

15. NUMBER OF PAGES
302

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
UNCLASSIFIED

18. SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

7. (Concluded).

U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, MS 39180-6199;
U.S. Army Engineer District, New England
696 Virginia Road, Concord, MA 01742-2751;
Texas A&M University, College Station, TX 77843

13. (Concluded).

The main body of this report describes specific procedures for all aspects of capping project evaluation and design. A recommended sequence of design activities is presented, and specific design steps are organized into flowcharts as necessary. A number of appendixes are also included in this report that provide detailed information on specific testing procedures, predictive models, etc.

A capping operation must be treated as an engineered project with carefully considered design, construction, and monitoring to ensure that the design is adequate. There is a strong interdependence between all components of the design for a capping project. By following an efficient sequence of activities for design, unnecessary data collection and evaluations can be avoided, and a fully integrated design is obtained. The major components of the project design and evaluation process include site selection, equipment and placement techniques, geotechnical considerations, mixing and dispersion during placement, required capping sediment thickness, material spread and mounding during placement, cap stability, and monitoring. Processes influencing the cap design include bioturbation, consolidation, erosion, and potential for advection or diffusion of contaminants. The basic criterion for a successful capping operation is simply that the cap thickness required to isolate the contaminated material from the environment be successfully placed and maintained.

The cost of capping is generally lower than alternatives involving confined (diked) disposal facilities. The geochemical environment for subaqueous capping favors long-term stability of contaminants as compared with the upland environment where geochemical changes may favor increased mobility of contaminants. Capping is therefore an attractive alternative for disposal of contaminated sediments from both economic and environmental standpoints.

EXHIBIT 3

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

October 7, 2022

Mandy Revell
California Coastal Commission
South Coast Area Office
301 East Ocean Blvd Suite 300
Long Beach, CA 90802-4302
(562) 590-5071

Dear Commissioners and Staff,

This comment letter is a continuation of previous comments, objections, and concerns expressed about the City of Newport Beach proposal to stockpile contaminants in the middle of Newport Bay. Several significant and irrefutable shortcomings of this project have been raised by the Friends of Newport Harbor LLC, myself individually, and other concerned citizens, NGOs, and environmental groups who have been following this effort since the first CEQA public meetings.

Ever since the early days of this effort, there was a consistent glossing over of very key components of testing and analysis, and the alternatives analysis conducted for the CAD plan. Personally, as a marine science practitioner, I have been very adamant that a singular consultant should not be allowed to plan, design, sample, and then also singularly conduct the CEQA analysis, particularly when that Consultant has and will charge millions of dollars in what can only be perceived as an extreme conflict of interest trying to permit their own idea. But, there is not regulation with the City that requires a conflict of interest check on these efforts, but it hasn't gone unnoticed by those following this process.

Also clear, is that no tangible or documented process for a comprehensive alternatives evaluation was presented, besides a CEQA analysis that included options like a CAD here, a CAD there, and two other smaller CADs in other places. The obvious lack of alternatives caused people, who were without any classic scientific or engineering background, to question the thoroughness of the alternatives analyzed, questions the City summarily dismissed. The City has not looked at additional sediment management alternatives besides dumping contaminated material next to people's homes, a first in the Nation.

Also dismissed by the City was any suggestion that there had not been enough sediment testing and analysis conducted, and specifically on the contaminated material identified for CAD placement.

As described in the City EIR and associated response(s) to comments from the City, these areas of unsuitability have been determined based on one or two archived core samples collected in 2019, and through statistical interpolation (i.e., Kriging), the sediment within these areas mathematically was determined unsuitable by the City, and approved by the agencies.

The City and their consultants have been successful at convincing regulators to accept that a single sample input into a water quality model can accurately be used to estimate the potential effects near people's homes, and that their 'rigorous and robust' testing approach provided enough assurance that kids playing on the beach will not be exposed to dissolved contaminants.

A large part of the reason the City plan has gotten this far is thanks to the USACE, in this case a construction company masquerading as a federal agency, and them exerting behind the scenes pressure for this effort. Even going so far as to hold the federal dredging as hostage, stating in their EA that if is there is no CAD, they will take their dredge project and go home.

But the option to not dredge and maintain the federal channels is not a decision for planners and scientists who are employed by the LA District; rather, it is national mandate, and a required part of the USACE mission. So, the federal channels in Newport will get dredged. When and how that maintenance happens is the real question, which can only be answered with field collected data and a sustained commitment to find the most beneficial and least deleterious ways to dredge the federal channels.

Well, shame on the City for not performing the adequate analysis, listening to the concerns of their constituents, consulting the right regulatory documents, and engaging in the due diligence necessary for placing and storing contaminated material in a REC-1 system. And due to the City's lack of analysis and cursory review approach to this project, the City is asking the Coastal Commission to approve a really bad project, and bow to the collective weight of regulatory approvals which all are based on a faulty premise that everything has been done to address the multitude of environmental concerns from contaminated sediment disposal in the middle of Lower Newport Bay, adjacent to homes, an MPA, and the site of a variety of contract recreation activities that make Newport, well, Newport.

It is possible to send the City back to the drawing board, and based on the information presented further in my comment letter, the Coastal Commission has the responsibility to do so.

The primary concerns expressed about the City environmental data analysis have included:

- Potential sediment contaminant concentration heterogeneity within areas of contaminated material. As the City has resisted any suggestion of retesting the unsuitable areas, the sediment dataset for sediment testing consists of roughly one core sample every 400 ft., and only 1 to 2 cores in the contaminated areas. In most cases, 1 sample within the contaminated areas are being described as being representative of over 20,000 cubic yards of material to be placed in the CAD.
- Lack of vertical characterization. Core data was not split along strata or section of the dredge depths (dredge vs over dredge) to identify where in the sediment column the contaminants exist. This data is critical to the understanding of the source of contamination and if it is from recent or historical activities in the Bay. Split analysis also helps identify potential disposal alternatives through dual management options which may be realized only after sampling the areas of unsuitability.
- Lack of sediment data on the newly exposed bottom surface layer (i.e., Z-layer). As these negotiated areas represent areas of contamination and have overlying material that is too 'dirty' to be disposed of offshore, more information on what is being exposed by dredging needed to be collected and analyzed by the City. While samples of the Z-layer were taken in 2019, they were never analyzed as part of this project, even after a determination of unsuitability was made. Questions as to the quality of the sediment to be dredged still remain unanswered. The decision to not test the Z-layer samples was singularly made by the City.
- Estimates of water quality impacts from the contaminated material have not been fully evaluated. STFate numerical modeling and open-ocean bioassay elutriate analysis is not the appropriate analysis nor representative of the potential impacts to water quality from the contaminated material.

So, on 27 September 2022 we engaged in an opportunistic sediment sampling event to further characterize the areas of unsuitability. These areas of unsuitable sediment are presented in the City EIR as being above the 1.5 mg/kg concentration of mercury negotiated by the City with the DMMT, and are therefore scheduled to be disposal of in the proposed Lower Newport Bay CAD. As our questions were not being answered by the public agency entrusted to protect the health of the environment and citizens of Newport Bay with respect to the need for additional testing data, we were bound by intellectual curiosity and the protection of all who enjoy Newport Bay to use all the tools at our disposal to help understand environmental impacts to the Bay from this project. Even if the City wouldn't.

The sediment data collected and described herein were collected exclusively within the negotiated contaminated areas above the 1.5 mg/kg concentration of mercury. This included the unsuitable areas of the Main Channel North 1 (MCN1) and Main Channel North 2 (MCN2) dredge units, and Newport Channel 1 (NC) (Figure 1).

These contaminated areas collectively account for approximately 87,000 cubic yards (CY) of the 106,000 CY of sediment to be disposed of in the CAD during the first fill event and covered for at least 2 years with a 1-foot sand layer, with the source yet to be identified.

The sediment samples were sampled from our scientific grade research vessel, using an electrically powered vibracore, the preferred type of equipment for this type of sediment collection. All cores sampled from the surface of the sediment to the bottom of the dredge design, including the 2-ft over dredge allowance. In the main channel areas the total depth of collection was -22 ft MLLW (-20-ft + -2-ft over dredge), and in the NC1 dredge area, -17 Ft MLLW (-15 ft+ -2 ft over dredge).

Core samples were collected from two locations within each area of unsuitability for a total of six cores. Recovered core samples were sub-sampled to analyze the dredge material and over dredge material separately. A process not conducted by the City.

Laboratory testing was completed by Eurofins-Calscience, in Tustin, CA. Eurofins-Calscience is a state certified laboratory who specializes in the testing of marine sediment samples. Laboratory analysis included mercury testing only, using EPA method 7471. Dry weight sediment testing results are provided in Table 1. The laboratory results of the mercury analysis are also attached to the end of this comment letter.

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

Figure 1. September 2022 Sediment Sampling Locations

Table 1. Dry Weight Mercury Results

Dredge Unit	Material Type	Sample ID	Sample Depth (ft below surface)	Mercury (mg/kg)
Newport Channel 1	Dredge	NC1	0-2	**2.91**
	Dredge		2-3.2	**5.81**
	Over Dredge		3.2-3.8	**3.69**
	Dredge	NC1-2	0-3	**4.91**
	Over Dredge		3-4.6	0.0398J
Main Channel 1	Dredge	MC1-1	0-2.5	0.703
	Over Dredge		2.5-5.0	**9.32**
	Dredge	MC1-2	0-3.5	0.782
	Over Dredge		3.5-5.5	**3.6**
Main Channel 2	Dredge	MC2-1	0-2.5	0.402
	Over Dredge		2.5-5.0	**1.52**
	Dredge	MC2-2	0-2	0.275
	Over Dredge		2-4	**2.03**

J= sample results were above the Method Detection Limit (MDL), but below the Reporting Limit (RL), estimated
Bold values are above 1.5 mg/kg
Maximum concentration measured

Main Channel North Areas 1 and 2 Results

The results of main channel sediment testing within the contaminated areas, are suggestive that much of the material above the federal maintenance dredge depths would meet the project open-water disposal concentration of 1.5 mg/kg of mercury. This indicates that if unsuitable material was retested with higher resolution sampling approach, there could be a significant volume reduction from both of these areas, which collectively adds 40,000 CY to the CAD storage volume, as our team has argued repeatedly.

The exploratory sediment investigation further indicates that in the main channel areas, mercury concentrations are significantly higher in the over dredge material than the material above the dredge depth. The highest concentration measured was 9.32 mg/kg at station MC1-1, found at a depth between 2.5 and 5 ft, below the depth required for safe navigation. Each of the over dredge samples collected within the main channel areas exceeds the mercury concentration of 1.5 mg/kg.

Being that the over dredge material has such high levels of mercury at depth, the contamination is likely from legacy contaminants, and not recent deposition. This data indicates that the newly exposed bay bottom after dredging, or Z-layer, has concentrations of contaminants that far exceed the surface level concentrations that are being dredged, and is not consistent with the 1 core sample the City analyzed as part of their rigorous and robust analytic process. The potential Z-layer concentrations, if exposed, would negate any perceived benefits from stockpiling contaminants in the middle of Newport Bay, putting benthic animals, fish, and birds back at risk from contaminates buried decades ago.

Further, as mercury was used only as an indicator chemical for this exploratory sampling event, it is possible that other chemicals of concern like PCBs and DDX are co-located with mercury and also pose a similar risk to the Bay from exposure via dredging. Without resampling, this obvious signature of contamination is not immediately apparent because when the City homogenized (uniformly mixed) the entire length of the core during their 1 sampling event, and then mixed again (composited) with clean material, they diluted the test sample for both chemical and bioassay testing with substantial portions of suitable material.

Newport Channel 1

The Newport Channel 1 area also exhibited higher than 1.5 mg/kg concentrations of mercury at all depths at station NC1, the closest sample to the Rhine Channel. This result is not surprising, since the Rhine channel was historically used for all sorts of commercial marine activities, including military boat building during World War II. All strata tested at NC1 exceeded City sampling results collected as part of the 2019 event. Highlighting the need for additional characterization.

Within the same dredge unit, station NC1-2 had a very distinct transition from silt and clay to poorly graded sand (Figure 2). As would be expected, the concentration of mercury in the dredge material also transitioned from 4.91 mg/kg in the dredge material, and in the over dredge part of the core, 0.0389J mg/kg, the lowest mercury concentration measured.

We have long argued that a dual management option in this area may be possible, given the proximity to the beach and likelihood of sand somewhere within the sediment column. The current sampling results confirm this comment, and that in some parts of the Newport Channel 1 area, dredge and over dredge material could be managed separately to reduce volumes and offer additional beneficial reuse alternatives for some of the material.

The results of exploratory sediment investigation have confirmed many of the questions we have posed to the City, and present a very different picture of these contaminated areas.

The sediment testing results highlight the heterogeneity within the mathematically derived unsuitable areas, and the limits of resolution that exist within the City's data characterization, with respect to Z-layer concentrations, the representativeness by only having a single sample for analysis in many cases, and the spatial and vertical distribution of contaminates.

With additional DMMT approved sampling and analysis, the City could not only develop a better understanding of the contaminant concentrations in the dredge material management areas, but also ensure they have performed the proper due diligence when opting for in bay disposal in a Rec-1 system a few hundred feet from people's homes and play beaches.

Figure 2. Station NC1-2 Sediment Core Photo

Based on the results of our September 2022 testing and analysis, there are several potential volume reduction options that could be explored with additional data from these contaminated areas, if evaluated for a specific disposal alternative and through a creative approach to dredge material management.

Also, based on our split core sampling approach, that singularly looked at the chemistry from the unsuitable areas and within the dredge and over dredge material, dredging has a high degree of certainty to expose deleterious concentrations of contaminants, more than what is in the surface sediment currently.

The data collected supports previous assertions that additional testing and analysis is needed within the contaminated areas before a CAD should be considered as an alternative for placement.

Potential for Water Quality Impacts

As mentioned previously, a critical suitability component for the CAD material has not been addressed by the City's EIR, and the potential for water quality impacts from just the unsuitable material has been improperly evaluated.

There is existing national testing and engineering guidance on the matter of CAD construction, called the Guidance for Subaqueous Capping of Dredged Material, promulgated by the USACE. The manual states clearly on page 2, '*The technical guidance in this report is intended for use by USACE and EPA personnel, State regulatory personnel, as well as dredging permit applicants and others (e.g., scientists, engineers, managers, and other involved or concerned individuals).'*

The guidance goes on to state*, 'Chemical characterization of contaminated sediment may include a sediment chemical inventory and standard elutriate test results. The chemical sediment inventory is useful in determining contaminants of concern and in the development of appropriate chemical elements of a monitoring program to determine capping effectiveness. Elutriate data are used in estimating the potential effects on water quality due to placement of the contaminated material*.'

The guidance goes on to reference other sections of the document for additional information on sediment dispersion during placement for the assessment of potential water quality impacts, and states unequivocally, '*The contaminant release is predicted by an elutriate test, and results are compared with applicable water-quality criteria or standards as appropriate.'*

The City has argued that they have the discretion to substitute the bioassay elutriate and STFATE modeling for the elutriate testing requirement in this manual, and that other guidance designed for inland or open water placement is how they met the testing requirements of this Capping guidance, while never referring to it as a testing manual for suitability. However, this is erroneous and inconsistent with the federal guidance that covers projects like the CAD for two significant reasons*:*

1- The bioassay elutriate samples are based on composite sediment tests and therefore include a significant portion of 'clean' material. Because of this, the resulting concentrations of the composite bioassay elutriate is not representative of the 9% of unsuitable material actually going to the CAD. As per the Capping guidance: *If water column effects during placement of the contaminated material are of concern, an evaluation of the suitability of the material from the standpoint of water column effects* ***must*** *be performed.* And goes on to state that, '*Elutriate data are used in estimating the potential effects on water quality due to placement of the contaminated material.'*

2- The second reason the bioassays elutriate results are not a substitute here, is because the guidance specifically states you cannot substitute other testing for the evaluation of the potential water quality effects. More specifically, '*Capping as a control measure is normally considered only after sediment to be dredged is found to be contaminated. In*

> *order to make such a determination, some chemical and biological characterization of the contaminated sediment is normally performed as a part of the overall evaluation for suitability for open-water placement (EPA/USACE 1991; EPA/USACE 1998). It should be noted that even though capping is being considered because of a determination of potentially unsuitable benthic effects, the data necessary for evaluation of potential water column effects are still required.*

Another talking point by the City is that the testing fully complies with the USACE guidance, however, to further evaluate water column impacts during placement, a USACE developed model (i.e., STFATE) was also used to predict compliance with applicable water quality criteria.

The question of the STFATE model applicability was never whether the sediment spreading estimates were accurate or not, but whether the STFATE model was the appropriate measure of potential water quality impacts. Particularly when disposing of contaminated materials near children play beaches and homes.

As per the Capping manual, which requires elutriate testing in the event of possible water quality impacts, it also includes a discussion of the STFATE model right below the discussion of elutriate testing.

As a point of fact, there is no language or provision within the Capping technical guidance which allows for, or implies substitution of the STFATE model for elutriate analysis within the sediment disbursement section of the guidance. It does, however, recommend the STFATE model for spreading and loss estimates, consistent with the ERDC response.

We also believe the STFATE model results were calculated incorrectly for this project. As described in the Capping manual appendix relevant to the STFATE, there are two critical pieces of information needed for properly running the STFATE model: the sediment chemistry data, and the elutriate concentration (Figure 3). The significant question as to the representativeness of a single archived core sample used for modeling notwithstanding, as confirmed by the EPA, the elutriate data is based on the bioassay elutriate, which includes a significant proportion of clean material as part of the testing. As described earlier, the city sediment testing approach diluted the composite testing results through homogenizing the length of the core, and also by compositing with other clean material.

What this really means, is that the elutriate data used for model input is not the elutriate concentrations related to the contaminated material only. Rather, the elutriate is from a mixed sample, and that is inconsistent with the guidance which requires the testing of the contaminated material only, which as of the time of this comment letter, has still not been analyzed by the City as part of this project.

That said, even if the STFATE model was identified as an allowable substitution by the Capping manual (which it is not), the modeling would need to be completed on unsuitable material only.

Using contaminated core chemistry and composite elutriate results is an improper use of the STFATE model.

In pragmatic terms, the STFATE modeling comes after the standard elutriate testing of the contaminated material, not before. But the City didn't follow the proper guidance, because their 'expert's knew more that the national guidance on the matter. And have caused the entire regulatory process, to have egg on its face. A diagram of the testing and analytical process that should have been followed by this project had they addressed the correct technical guidance, included as Figure 4.

Table D1
STFATE Model Input Parameters

Parameter	Disposal Operation Types[1]	Units	Options[2]
Contaminant Selection Data			
Solids concentration of dredged material		g/L	
Contaminant concentration in the bulk sediment		μg/kg	
Contaminant concentration in the elutriate		μg/L	
Contaminant background concentration at disposal site		μg/L	
Contaminant water quality standards		μg/L	
Site Description			
Number of grid points (left to right)	H, B		
Number of grid points (top to bottom)	H, B		

Figure 3. STFate Model Parameters

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

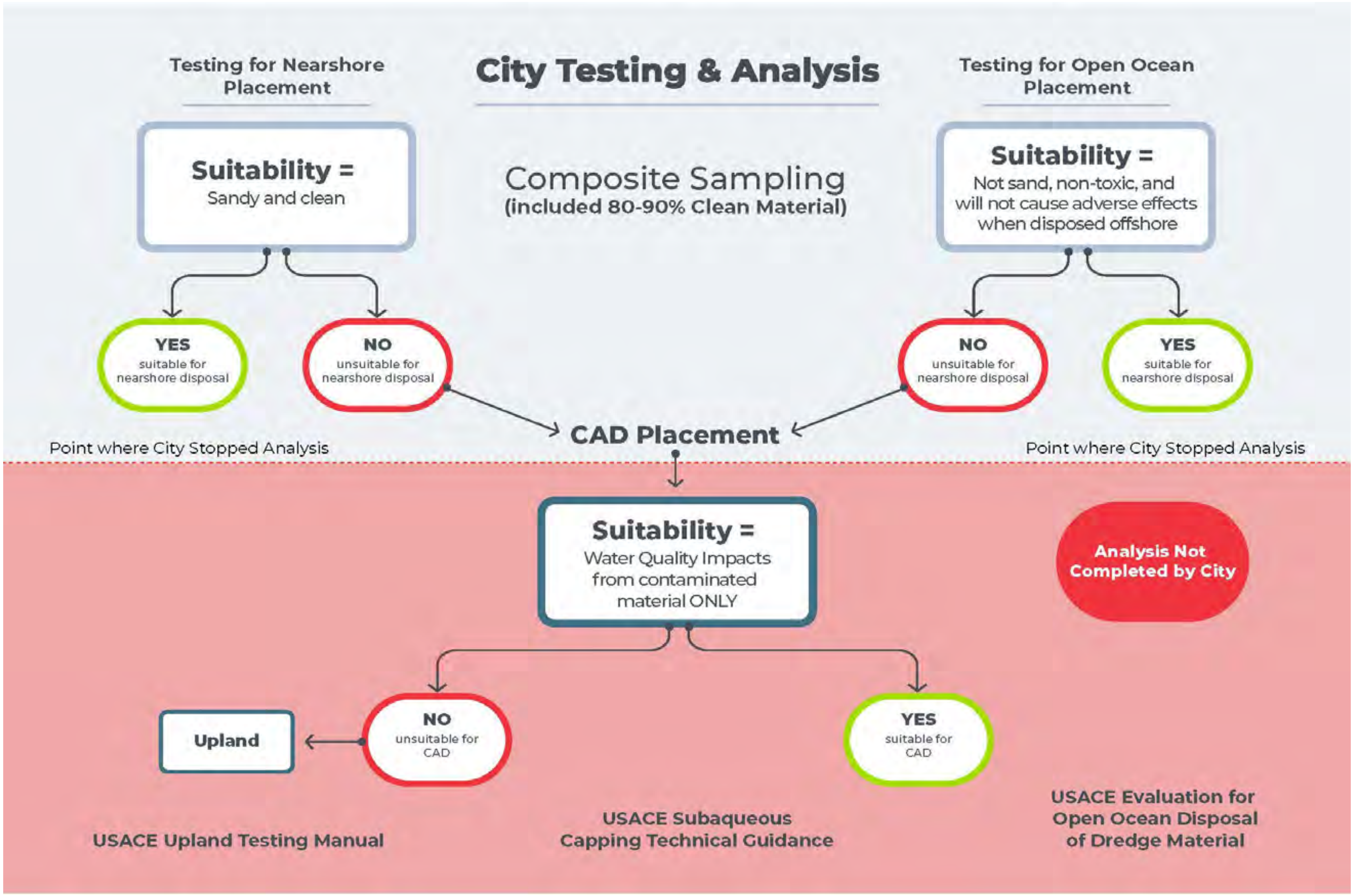


Figure 4. Testing and Analysis Flow Chart for Permitting A CAD

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

As I mentioned earlier, I am a practitioner, a life-long marine scientist, and genuinely concerned for my industry and the regulatory process based on what I have seen transpire on this project, the collusion within agencies, the gorilla-type force that can and will be exerted by Federal agencies when they don't get their way, and the finger pointing that creates of a round robin of approvals.

As a scientist, I believe that data is where the rubber meets the road. And in this case, more data needs to be evaluated to guide the decision-making process and ensure that the thoroughness in project planning results in effective implementation and the preservation of beneficial uses in Newport Bay.

Without the proper data to support a suitability determination a project cannot be permitted. Just as a suitability determination for dredge material identified to go to the nearshore area could not be permitted without grain size analysis, the disposal of contaminants within a CAD have to meet the required elutriate water quality testing and suitability analysis conducted according to the relevant federal guidance.

It is not the residents or users of the Bay who have not addressed the required technical guidance and analysis, but they will be the ones at risk when the untested material starts to leech into the receiving waters, around their homes and beaches.

There is no stop work requirement in any of the permits attached to this project. So, once the process of digging the CAD and filling it with contaminated material has begun, <u>there is no stopping it. Even if/when water quality samples are found in exceedance of established numerical objectives, the polluting of the bay will continue, 6 days a week for months.</u>

The City analysis (or lack thereof) and our own sediment characterization data suggest a very real scenario for this project, where this project is releasing dissolved contaminants at a much higher concertation than predicted by the composite testing and the unallowable modeling of 'clean' and 'dirty' material, which will be coupled with the re-exposure of legacy contaminates in the bottom layers of the dredge areas, which have significantly higher concentrations that what the singular sample used for analysis suggests.

This project could set the environmental clock back in Newport Beach 25 years!!

As a purely common-sense plea, please help the residents, contact recreation users, and concerned NGOs who advocate for sustainable resource management, protect and preserve the beneficial uses of the Newport Bay. There are clearly enough data uncertainties here to require the City to retest and reanalyze the contaminated areas of this project with respect to CAD suitability.

As a matter of fact, if the City had listened to the residents and retested these areas of contaminated material when the original objections were raised, the project would not be in this position, and maybe more importantly, neither would the Coastal Commission. But the City has dug their heels in, and has decided under no circumstances are they going to retest the material, or reanalyze or revisit any of their previous decisions or testing, in spite of the relevant technical guidance and commons sense screaming they should.

Please don’t make the hundreds of thousands of users of Newport Bay pay the price for inadequate testing and analysis, and City egos. This project has failed to meet the even the bare minimum testing requirements to attain a suitability determination for the material going to the CAD, much less the thoroughness and high standard of testing and analysis that would support the due diligence required by such a plan, so close to people’s homes.

Thank you for your time, and again, please deny this application in the name of common sense, science-based decision making, and the protection and preservation of Newport Bay.

Respectfully,

Brent Mardian
Senior Marine Scientist
Pi Environmental, LLC

eurofins

Environment Testing America

ANALYTICAL REPORT

Eurofins Calscience
2841 Dow Avenue, Suite 100
Tustin, CA 92780
Tel: (714)895-5494

Laboratory Job ID: 570-111306-1
Client Project/Site: Privileged and Confidential: FONH Newport Bay

For:
Pi Environmental
426 Palm Road
San Marcos, California 92069

Attn: Brent Mardian

Authorized for release by:
10/3/2022 2:44:29 PM

Carla Hollowell, Project Manager I
(714)895-5494
Carla.Hollowell@et.eurofinsus.com

LINKS

Review your project results through myEOL

Have a Question? Ask The Expert

Visit us at: www.eurofinsus.com/Env

The test results in this report meet all 2003 NELAC, 2009 TNI, and 2016 TNI requirements for accredited parameters, exceptions are noted in this report. This report may not be reproduced except in full, and with written approval from the laboratory. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

Table of Contents

Definitions/Glossary

Client: Pi Environmental | Job ID: 570-111306-1
Project/Site: Privileged and Confidential: FONH Newport Bay

Qualifiers

Metals

Qualifier	Qualifier Description
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Job ID: 570-111306-1

Laboratory: Eurofins Calscience

Narrative

Job Narrative
570-111306-1

Comments
No additional comments.

Receipt
The samples were received on 9/27/2022 7:15 PM. Unless otherwise noted below, the samples arrived in good condition, and where required, properly preserved and on ice. The temperature of the cooler at receipt was 1.9º C.

Metals
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

General Chemistry
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Method: 7471A - Mercury (CVAA)

Client Sample ID: NC1-2 3-4.6 OD
Lab Sample ID: 570-111306-5
Date Collected: 09/27/22 10:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.0318	J	0.0989	0.0160	mg/Kg	☼	09/29/22 21:45	09/30/22 13:14	1

Client Sample ID: MC1-1 0-2.5
Lab Sample ID: 570-111306-6
Date Collected: 09/27/22 11:00
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.703		0.201	0.0326	mg/Kg	☼	09/29/22 21:45	09/30/22 13:16	1

Client Sample ID: MC1-2 0-3.5
Lab Sample ID: 570-111306-8
Date Collected: 09/27/22 12:00
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.782		0.195	0.0315	mg/Kg	☼	09/29/22 21:45	09/30/22 13:20	1

Client Sample ID: MC1-2 3.5-5 OD
Lab Sample ID: 570-111306-9
Date Collected: 09/27/22 12:00
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	3.60		0.661	0.107	mg/Kg	☼	09/29/22 21:45	09/30/22 13:54	5

Client Sample ID: MC2-1 0-2.5
Lab Sample ID: 570-111306-10
Date Collected: 09/27/22 13:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.402		0.174	0.0281	mg/Kg	☼	09/29/22 21:45	09/30/22 13:23	1

Client Sample ID: MC2-1 2.5-4.5 OD
Lab Sample ID: 570-111306-11
Date Collected: 09/27/22 13:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	1.52		0.157	0.0255	mg/Kg	☼	09/29/22 21:45	09/30/22 13:25	1

Client Sample ID: MC2-2 0-2
Lab Sample ID: 570-111306-12
Date Collected: 09/27/22 14:45
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.275		0.182	0.0295	mg/Kg	☼	09/30/22 16:00	09/30/22 18:03	1

Client Sample ID: MC2-2 2-4 OD
Lab Sample ID: 570-111306-13
Date Collected: 09/27/22 14:45
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	2.03		0.173	0.0281	mg/Kg	☼	09/30/22 16:00	09/30/22 18:09	1

Method: 7471A - Mercury (CVAA) - DL

Client Sample ID: NC1 0-2
Date Collected: 09/27/22 09:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-1
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	2.91		0.958	0.155	mg/Kg	☼	09/29/22 21:45	09/30/22 13:45	5

Client Sample ID: NC1 2-3
Date Collected: 09/27/22 09:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-2
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	5.81		0.905	0.147	mg/Kg	☼	09/29/22 21:45	09/30/22 13:47	5

Client Sample ID: NC1 3.2-3.8 OD
Date Collected: 09/27/22 09:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-3
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	3.68		0.631	0.102	mg/Kg	☼	09/29/22 21:45	09/30/22 13:49	5

Client Sample ID: NC1-2 0-3
Date Collected: 09/27/22 10:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-4
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	4.91		0.895	0.145	mg/Kg	☼	09/29/22 21:45	09/30/22 13:50	5

Client Sample ID: MC1-1 2.5-5 OD
Date Collected: 09/27/22 11:00
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-7
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	9.32		1.57	0.255	mg/Kg	☼	09/29/22 21:45	09/30/22 13:52	10

General Chemistry

Client Sample ID: NC1 0-2
Date Collected: 09/27/22 09:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-1
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	44.4		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: NC1 2-3
Date Collected: 09/27/22 09:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-2
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	47.0		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: NC1 3.2-3.8 OD
Date Collected: 09/27/22 09:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-3
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	66.0		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: NC1-2 0-3
Date Collected: 09/27/22 10:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-4
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	45.6		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: NC1-2 3-4.6 OD
Date Collected: 09/27/22 10:30
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-5
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	86.0		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: MC1-1 0-2.5
Date Collected: 09/27/22 11:00
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-6
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	42.3		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC1-1 2.5-5 OD
Date Collected: 09/27/22 11:00
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-7
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	50.9		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC1-2 0-3.5
Date Collected: 09/27/22 12:00
Date Received: 09/27/22 19:15
Lab Sample ID: 570-111306-8
Matrix: Sediment

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	42.8		0.1	0.1	%			09/30/22 15:54	1

General Chemistry

Client Sample ID: MC1-2 3.5-5 OD
Lab Sample ID: 570-111306-9
Date Collected: 09/27/22 12:00
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	60.6		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: MC2-1 0-2.5
Lab Sample ID: 570-111306-10
Date Collected: 09/27/22 13:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	47.0		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC2-1 2.5-4.5 OD
Lab Sample ID: 570-111306-11
Date Collected: 09/27/22 13:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	52.0		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC2-2 0-2
Lab Sample ID: 570-111306-12
Date Collected: 09/27/22 14:45
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	46.7		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC2-2 2-4 OD
Lab Sample ID: 570-111306-13
Date Collected: 09/27/22 14:45
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	50.1		0.1	0.1	%			09/30/22 15:54	1

Client: Pi Environmental
Job ID: 570-111306-1
Project/Site: Privileged and Confidential: FONH Newport Bay

Method: 7471A - Mercury (CVAA)

Lab Sample ID: MB 570-268657/1-A
Client Sample ID: Method Blank
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268657

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.0868	0.0141	mg/Kg		09/29/22 21:45	09/30/22 12:34	1

Lab Sample ID: LCS 570-268657/2-A
Client Sample ID: Lab Control Sample
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268657

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	0.400	0.3792		mg/Kg		95	80 - 120

Lab Sample ID: LCSD 570-268657/3-A
Client Sample ID: Lab Control Sample Dup
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268657

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Mercury	0.417	0.3909		mg/Kg		94	80 - 120	3	10

Lab Sample ID: MB 570-268696/1-A
Client Sample ID: Method Blank
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.0868	0.0141	mg/Kg		09/30/22 16:00	09/30/22 17:58	1

Lab Sample ID: LCS 570-268696/2-A
Client Sample ID: Lab Control Sample
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	0.417	0.4402		mg/Kg		106	80 - 120

Lab Sample ID: LCSD 570-268696/3-A
Client Sample ID: Lab Control Sample Dup
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Mercury	0.408	0.4339		mg/Kg		106	80 - 120	1	10

Lab Sample ID: 570-111306-12 MS
Client Sample ID: MC2-2 0-2
Matrix: Sediment
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	0.275		0.856	1.179		mg/Kg	☼	106	80 - 120

Lab Sample ID: 570-111306-12 MSD
Client Sample ID: MC2-2 0-2
Matrix: Sediment
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Mercury	0.275		0.892	1.192		mg/Kg	☼	103	80 - 120	1	20

Method: Moisture - Percent Moisture

Lab Sample ID: 570-111306-5 DU
Client Sample ID: NC1-2 3-4.6 OD
Matrix: Sediment
Prep Type: Total/NA
Analysis Batch: 268928

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Percent Solids	86.0		85.9		%		0.1	10

Lab Sample ID: 570-111306-8 DU
Client Sample ID: MC1-2 0-3.5
Matrix: Sediment
Prep Type: Total/NA
Analysis Batch: 268937

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Percent Solids	42.8		42.7		%		0.3	10

Laboratory: Eurofins Calscience

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
California	State	3082	07-31-23

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
Homogenization		Sediment	Sample Homogenized
Moisture		Sediment	Percent Solids

Method	Method Description	Protocol	Laboratory
7471A	Mercury (CVAA)	SW846	EET CAL 4
Homogenization	Homogenization	None	EET CAL 4
Moisture	Percent Moisture	EPA	EET CAL 4
7471A	Preparation, Mercury	SW846	EET CAL 4

Protocol References:

EPA = US Environmental Protection Agency

None = None

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

EET CAL 4 = Eurofins Calscience Tustin, 2841 Dow Avenue, Tustin, CA 92780, TEL (714)895-5494

Sample Summary

Client: Pi Environmental
Job ID: 570-111306-1
Project/Site: Privileged and Confidential: FONH Newport Bay

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
570-111306-1	NC1 0-2	Sediment	09/27/22 09:30	09/27/22 19:15
570-111306-2	NC1 2-3	Sediment	09/27/22 09:30	09/27/22 19:15
570-111306-3	NC1 3.2-3.8 OD	Sediment	09/27/22 09:30	09/27/22 19:15
570-111306-4	NC1-2 0-3	Sediment	09/27/22 10:30	09/27/22 19:15
570-111306-5	NC1-2 3-4.6 OD	Sediment	09/27/22 10:30	09/27/22 19:15
570-111306-6	MC1-1 0-2.5	Sediment	09/27/22 11:00	09/27/22 19:15
570-111306-7	MC1-1 2.5-5 OD	Sediment	09/27/22 11:00	09/27/22 19:15
570-111306-8	MC1-2 0-3.5	Sediment	09/27/22 12:00	09/27/22 19:15
570-111306-9	MC1-2 3.5-5 OD	Sediment	09/27/22 12:00	09/27/22 19:15
570-111306-10	MC2-1 0-2.5	Sediment	09/27/22 13:30	09/27/22 19:15
570-111306-11	MC2-1 2.5-4.5 OD	Sediment	09/27/22 13:30	09/27/22 19:15
570-111306-12	MC2-2 0-2	Sediment	09/27/22 14:45	09/27/22 19:15
570-111306-13	MC2-2 2-4 OD	Sediment	09/27/22 14:45	09/27/22 19:15

Chain of Custody Record

557228

eurofins Environment Testing TestAmerica

111306

Address

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other

TAL-8210

Client Contact	
Company Name	P. Environmental
Address	426 Palm Rd
City/State/Zip	San Marcos CA
Phone	760 593-3141
Fax	
Project Name	FONH
Site	Newport Bay
P O #	

Project Manager:
Tel/Email:
Site Contact:
Lab Contact:
Date:
Carrier:
COC No
____ of ____ COCs
Sampler

Analysis Turnaround Time

☐ CALENDAR DAYS ☐ WORKING DAYS

TAT if different from Below ASAP

☐ 2 weeks
☐ 1 week
☒ 2 days
☐ 1 day

For Lab Use Only:
Walk-in Client
Lab Sampling
Job / SDG No

570-111306 Chain of Custody

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)	Hold - TPH-D	Sample Specific Notes
NC1 0-2	9/27	09:30	core	sed	1			X	1
NC1 2-3		09:30						X	2
NC1 3.2-3.8 OD		09:30						X	3
NC1-2 0-3		10:30						X	4
NC1-2 3-4.6 OD		10.30						X	5
MC1-1 0-2.5		11.00						X	6
MC1-1 2.5-5 OD		11 00						X	7
MC1-2 0-3.5		12 00						X	8
MC1-2 3.5-5 OD		12.00						X	9
MC2-1 0-2.5		13:30						X	10
MC2-1 2.5-4.5 OD		13 30						X	11
								X	

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample

☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☒ Disposal by Lab ☐ Archive for ____ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☐ No
Custody Seal No
Cooler Temp (°C) Obs'd ____ Corr'd ____ Therm ID No ____

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
[signature]	P	15:00 9/27	William Rivera	EC	9/27/22 1500
William Rivera	EC	9/27/22 1915	Olga Orrelus	EC	9/27/22 1915
			Received in Laboratory by		

1.6/1.9 SC11

Chain of Custody Record

557229

eurofins | Environment Testing TestAmerica

111306

Address ____________

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

TAL-8210

Client Contact		Project Manager:	Site Contact:	Date:	COC No
Company Name	P. Environmental	Tel/Email:	Lab Contact:	Carrier:	____ of ____ COCs
Address	426 Palm Rd				Sampler:
City/State/Zip	San Marcos, CA				
Phone	960-593-3141				
Fax.					
Project Name					
Site					
P O #					

Analysis Turnaround Time

☐ CALENDAR DAYS ☒ WORKING DAYS

TAT if different from Below ASAP

☐ 2 weeks
☐ 1 week
☒ 2 days
☐ 1 day

For Lab Use Only:
Walk-in Client:
Lab Sampling
Job / SDG No

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)	4474-HD	Sample Specific Notes
MC2-2 0-2	9/27	1415	Core	Sol	1			X	12
MC2-2 2-4 OD	↓	↓	Core	Sol	1			X	13

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ____________

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample

☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☒ Disposal by Lab ☐ Archive for ________ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☐ No | Custody Seal No | Cooler Temp (°C) Obs'd ________ Corr'd ________ | Therm ID No ________

Relinquished by:	Company:	Date/Time:	Received by	Company:	Date/Time
[signature]	P.	1500/9-27	William Rivera	EC	9/27/22 1500
William Rivera	EC	9/27/22 1915	Olga Onukas	FC	9/27/22 1915
			Received in Laboratory by:		

1.6°/1.9° SC11

Login Sample Receipt Checklist

Client: Pi Environmental | Job Number: 570-111306-1

Login Number: 111306 | **List Source: Eurofins Calscience**
List Number: 1
Creator: Patel, Jayesh

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

EXHIBIT 4


LINDA ISLAND
HARBOR ISLAND
LIDO ISLE
BALBOA ISLAND
BAY ISLAND
BALBOA PENINSULA
PROPOSED LOCATION OF CONFINED
AQUATIC DISPOSAL FACILITY
1000'
1250'
770'
510'
1450'
600'
600'
370'

EXHIBIT 5

CAD Research Sources:

Arega, Feleke, and Hayter, Earl (2008) Coupled consolidation and contaminant transport model for simulating migration of contaminants through the sediment and a cap. Applied Mathematical Modelling 32, 2413–2428

Cappellino, S. et al. (2009), PORT HUENEME CONFINED AQUATIC DISPOSAL CELL DESIGN AND CONSTRUCTION, https://www.westerndredging.org/phocadownload/ConferencePresentations/2009_Tempe/Session3B-EnvironmentalAspectsOfDredging/4%20-%20Cappellino%20-%20Port%20Hueneme%20Confined%20Aquatic%20Disposal%20Cell%20Design%20and%20Construction%E2%80%93Port%20Hueneme,%20California.pdf

Contaminated Sediments at Navy Facilities: Cleanup Alternatives (2002). NAVFAC, TDS-2092-ENV, 6 pp.

Fredette, T.J., and French, G.T. (2004) Understanding the physical and environmental consequences of dredged material disposal: history in New England and current perspectives, Marine Pollution Bulletin 49 (2004) 93–102

Fredette, Thomas J. (2005) Why Confined Aquatic Disposal Cells Often Make Sense, Integrated Environmental Assessment and Management — Volume 2, Number 1—pp. 35–38

Gregory A. Kiker , Todd S. Bridges & Jongbum Kim (2008) Integrating Comparative Risk Assessment with Multi-Criteria Decision Analysis to Manage Contaminated Sediments: An Example for the New York/New Jersey Harbor, Human and Ecological Risk Assessment, 14:3, 495-511,

Kim, et al. (2009), Multicriteria Decision Analysis To Assess Options forManaging Contaminated Sediments: Application toSouthern Busan Harbor, South Korea, Integrated Environmental Assessment and Management — Volume 6, Number 1—pp. 61–71

One, Amy, et al. (2017) Monitoring chemical and biological recovery at a confined aquatic disposal site Oslofjord, Norway, Environmental Toxicology and Chemistry 36(9)

Pantazidou, Marina, et al. (2009), Evaluating Management Options for the Disposal of Dredged Sediments, Journal of ASTM International, Vol. 6, No. 6

Sparrevik, Magnus, et al. (2011), Evaluation of Factors Affecting Stakeholder Risk Perception of Contaminated Sediment Disposal in Oslo Harbor, Environ. Sci. Technol. 2011, 45, 1, 118–124.

Vogt, Craig (2009) International Review of Practices and Policies for Disposal in Ocean and Coastal/Estuarine Waters of Contaminated Dredged Material. March 30, 2009

Wolf, Steven & Greenblatt, Marcia & Fredette, Thomas & Kelly, Stephanie & Diaz, Robert & Neubert, Pamela & Williams, Isabelle & Ryther, John & Carey, Drew. (2006). STABILITY AND RECOVERY OF CAPPED IN-CHANNEL CAD CELLS: BOSTON HARBOR, MASSACHUSETTS

Zeller, Craig and Cushing, Bradford (2006), Panel Discussion: Remedy Effectiveness: What Works,What Doesn't? Integrated Environmental Assessment and Management — Volume 2, Number 1—pp. 75–79

Zhang, H.; Yang, H., and Jeng, D.-S., 2015. Contaminant transport in capped deformable partially saturated sediments. Journal of Coastal Research, 31(6), 1489–1501.

Vidgren, H. et al. (2015), Sand Cap Placement and Cap ThicknessMonitoring: A Case Study at a ConfinedDisposal Facility, RemediationDOI: 10.1002/rem

EXHIBIT 6

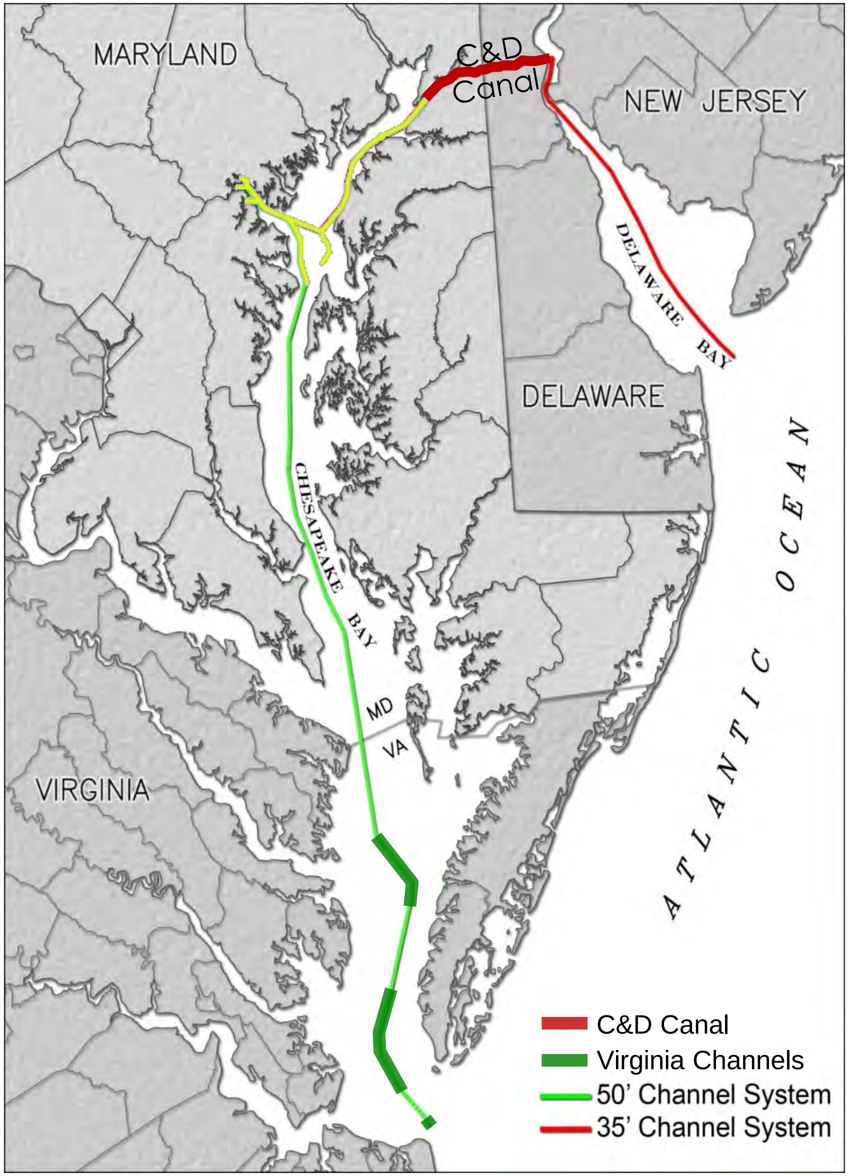
Baltimore Harbor Confined Aquatic Disposal (CAD) Pilot Project

Maryland Department of Transportation
Maryland Port Administration
June 2019

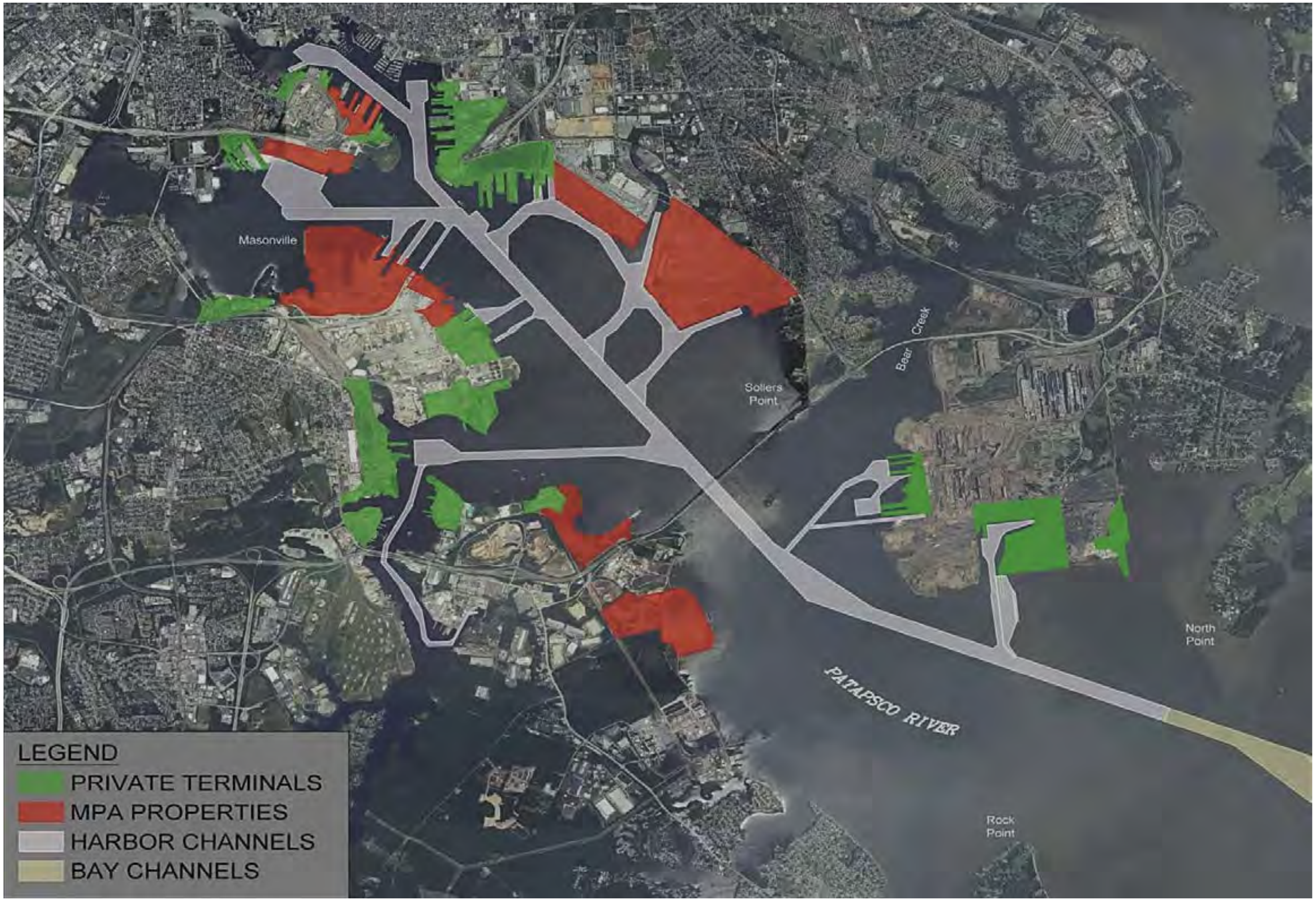
ANCHOR QEA
MARYLAND ENVIRONMENTAL SERVICE
MDOT MARYLAND DEPARTMENT OF TRANSPORTATION
MARYLAND PORT ADMINISTRATION

Port of Baltimore Channel System

- Annual Baltimore Harbor maintenance dredging about 1.5 mcy
- Legislation requires Baltimore Harbor material be *confined* or *beneficially / innovatively reused*
- Maintaining cost-effective, environmentally sensitive, and community-supported dredging program is ongoing challenge:
  - Less expensive options are exhausted
  - Future placement sites limited
  - Existing placement sites have limited capacity
  - Obstacles to implementing the beneficial use / innovative use program



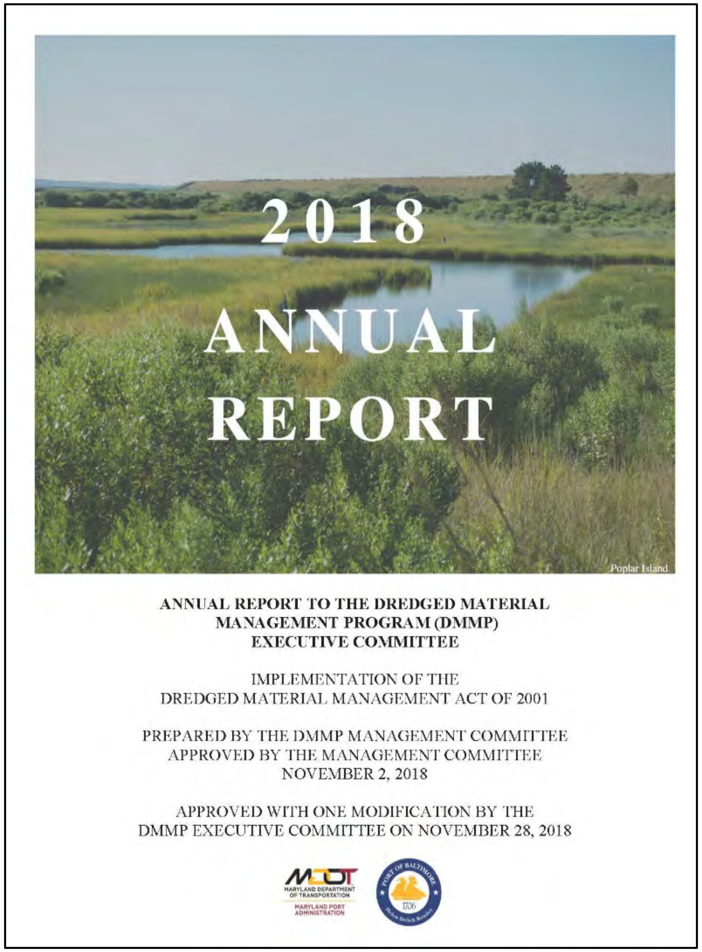
Port of Baltimore Terminals



ANCHOR QEA · MARYLAND ENVIRONMENTAL SERVICE · MDOT MARYLAND DEPARTMENT OF TRANSPORTATION MARYLAND PORT ADMINISTRATION

Baltimore Harbor Dredged Material Management Program

- 20-year plan for managing dredged material capacity
- Harbor dredged material is managed using two dredged material containment facilities (DMCFs)
- Confined aquatic disposal (CAD) is an additional option for dredged material management within the Harbor
- Would provide flexibility in the program → maximize DMCF capacity and life cycle


2018 ANNUAL REPORT

Poplar Island

ANNUAL REPORT TO THE DREDGED MATERIAL MANAGEMENT PROGRAM (DMMP) EXECUTIVE COMMITTEE

IMPLEMENTATION OF THE DREDGED MATERIAL MANAGEMENT ACT OF 2001

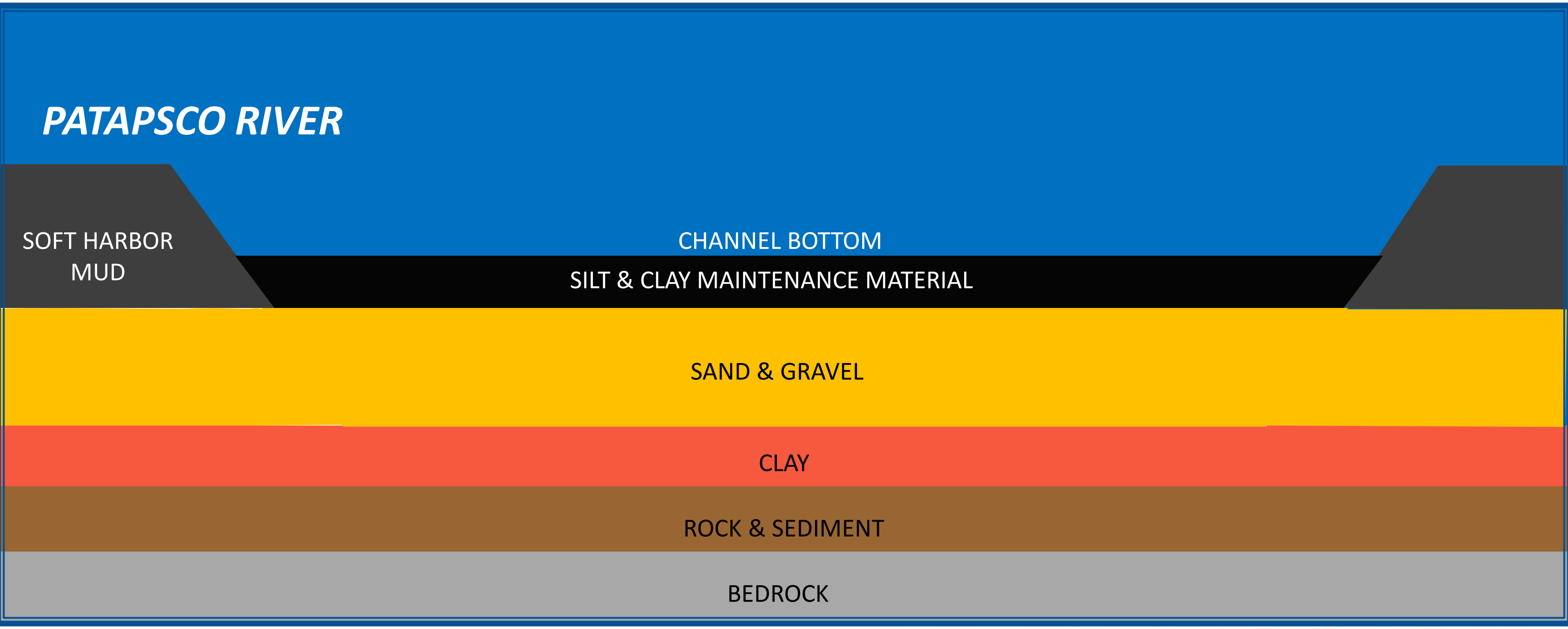
PREPARED BY THE DMMP MANAGEMENT COMMITTEE
APPROVED BY THE MANAGEMENT COMMITTEE
NOVEMBER 2, 2018

APPROVED WITH ONE MODIFICATION BY THE DMMP EXECUTIVE COMMITTEE ON NOVEMBER 28, 2018

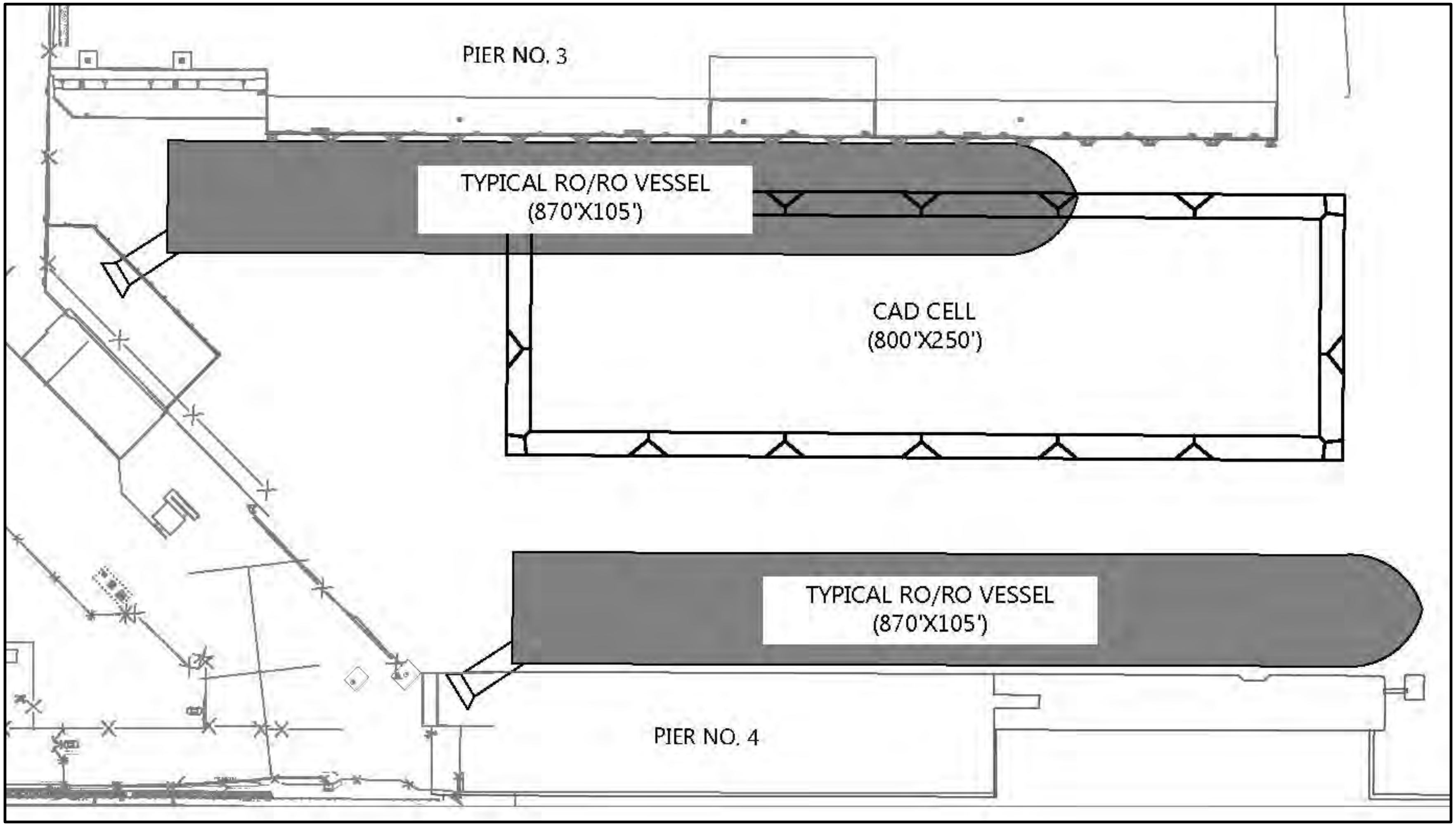
Baltimore Harbor CAD Site

- Pilot project evaluated potential to implement CAD as part of the overall DMMP
- Constructed between Pier 3 and Pier 4 within an active berth at the Masonville/Fairfield Marine Terminal
- Coordinated with USACE's annual maintenance dredging
- Two simultaneous goals:
  - Beneficial use of sandy material removed during construction
  - Placement site for maintenance material from Federal navigation channels

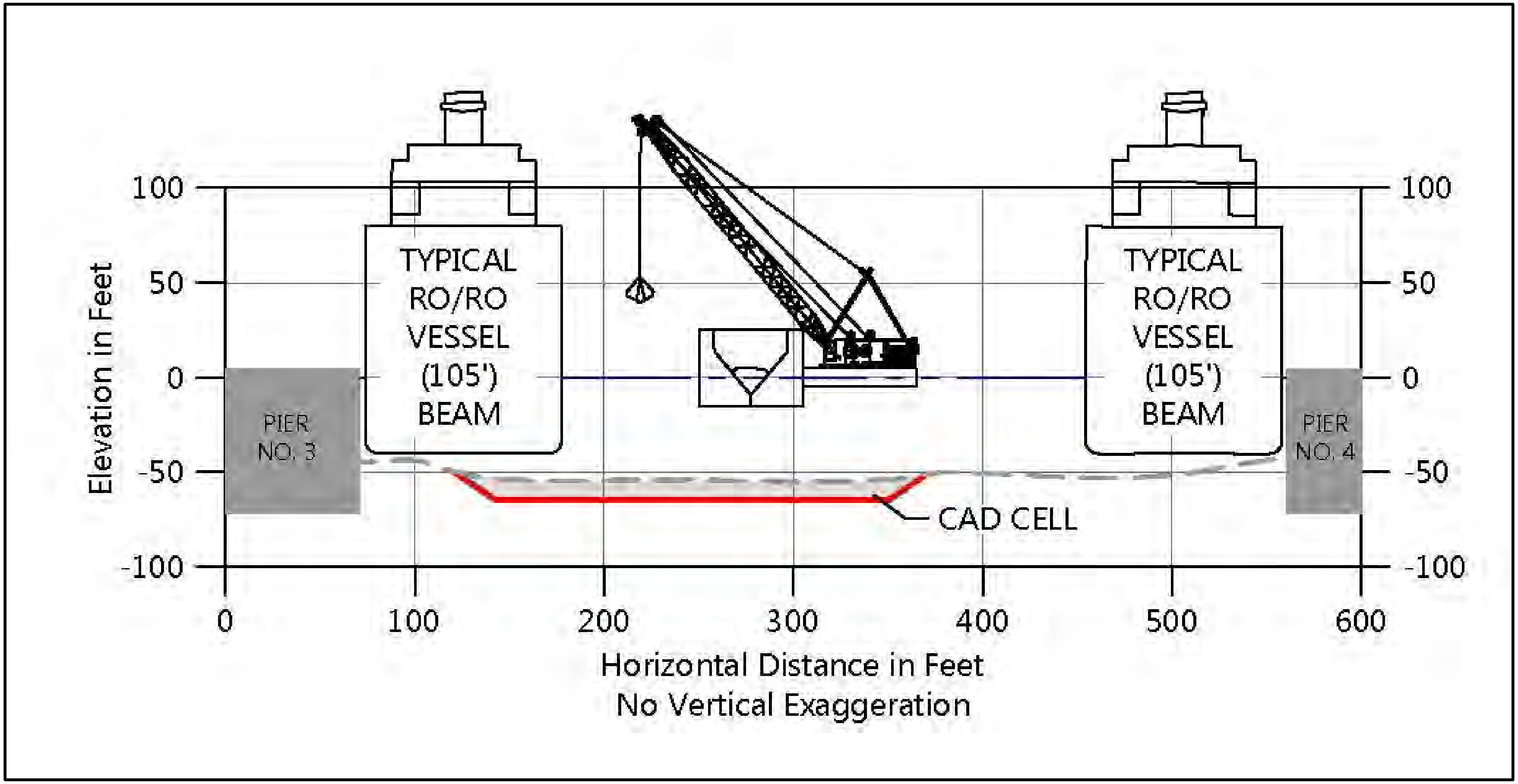
How Confined Aquatic Disposal Works



CAD Site Location – Plan View



CAD Site Location – Section View



CAD Site Construction

- CAD constructed in September and October 2016
- Approximately 130,000 cy of sandy material placed at Masonville
- CAD placement occurred in February 2017
- Approximately 62,000 cy of maintenance material from the Ferry Bar channel placed into the CAD.
- Developed a multi-phased monitoring plan for the project.

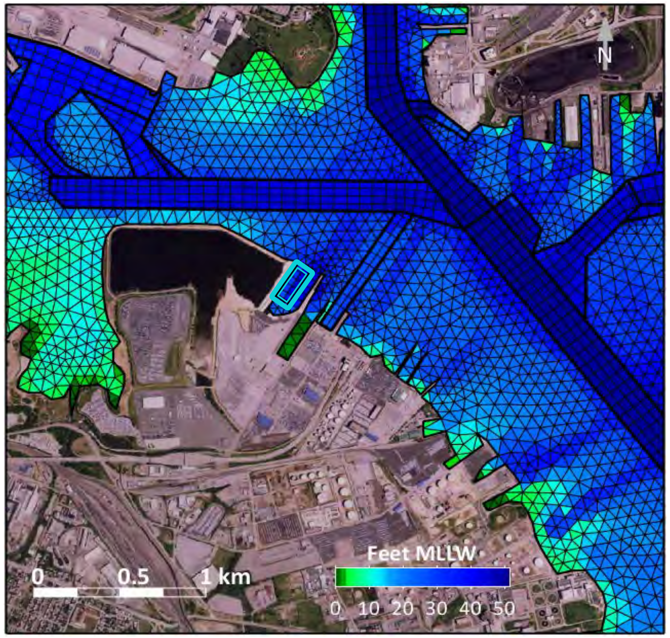
Inflow at Masonville DMCF (2016)

Maintenance Dredging in Ferry Bar Channel (2017)

ANCHOR QEA
MARYLAND ENVIRONMENTAL SERVICE
MDOT MARYLAND DEPARTMENT OF TRANSPORTATION MARYLAND PORT ADMINISTRATION

Regulatory and Stakeholder Coordination

- Nutrient monitoring (total nitrogen and total phosphorus) during dredged material placement because of the Chesapeake Bay TMDL
  - Conducted a baseline nutrient study to establish existing conditions so the influence of the project, if any, could be identified
  - Performed 3-D hydrodynamic modeling to predict nutrient concentrations over time

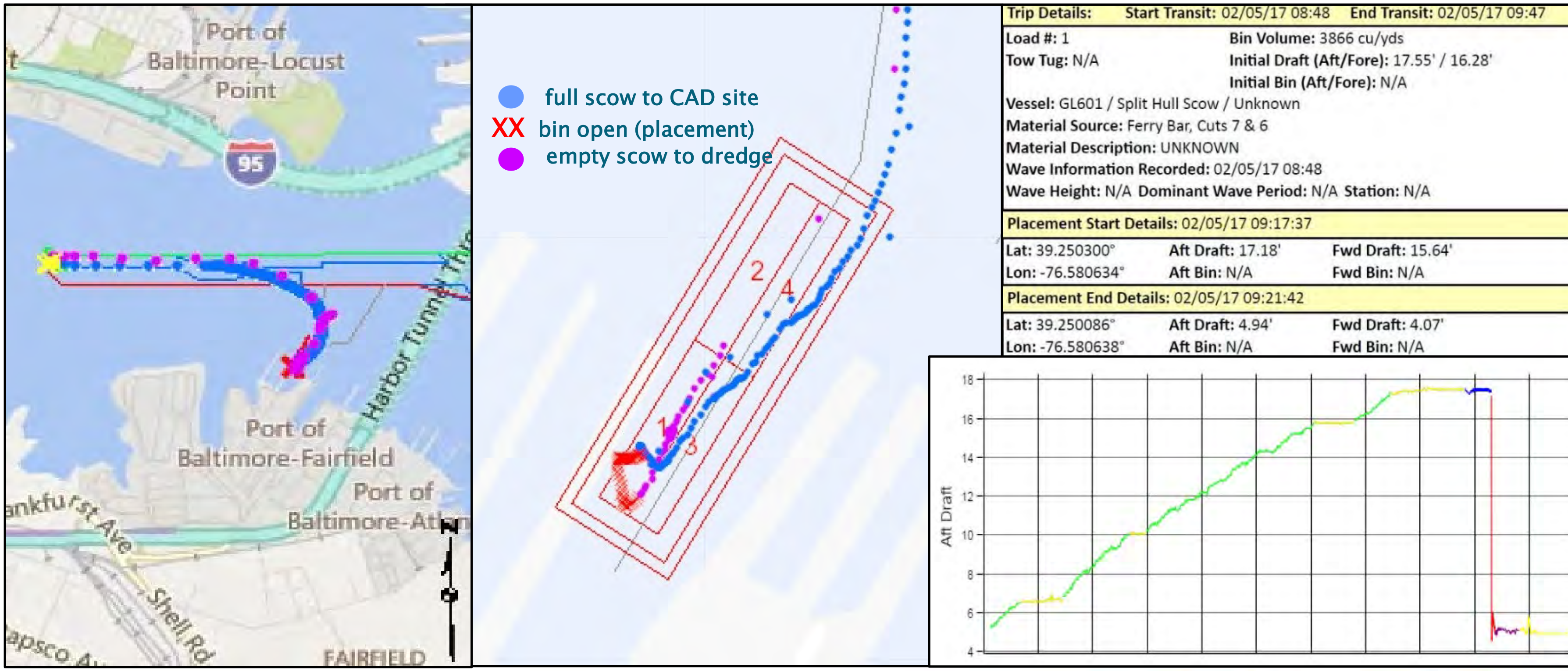


- Stakeholder questions about the dredged material quality and potential for remobilization
  - Sediment testing to confirm material quality
  - Post-placement surveys to evaluate dredged material consolidation

Water Quality Monitoring

Dredged Material Placement

- Each scow and placement event tracked: timing, placement location, draft, estimated quantity
- Monitoring started right after scow emptied



Water Quality Monitoring Locations

Water Quality Monitoring Program

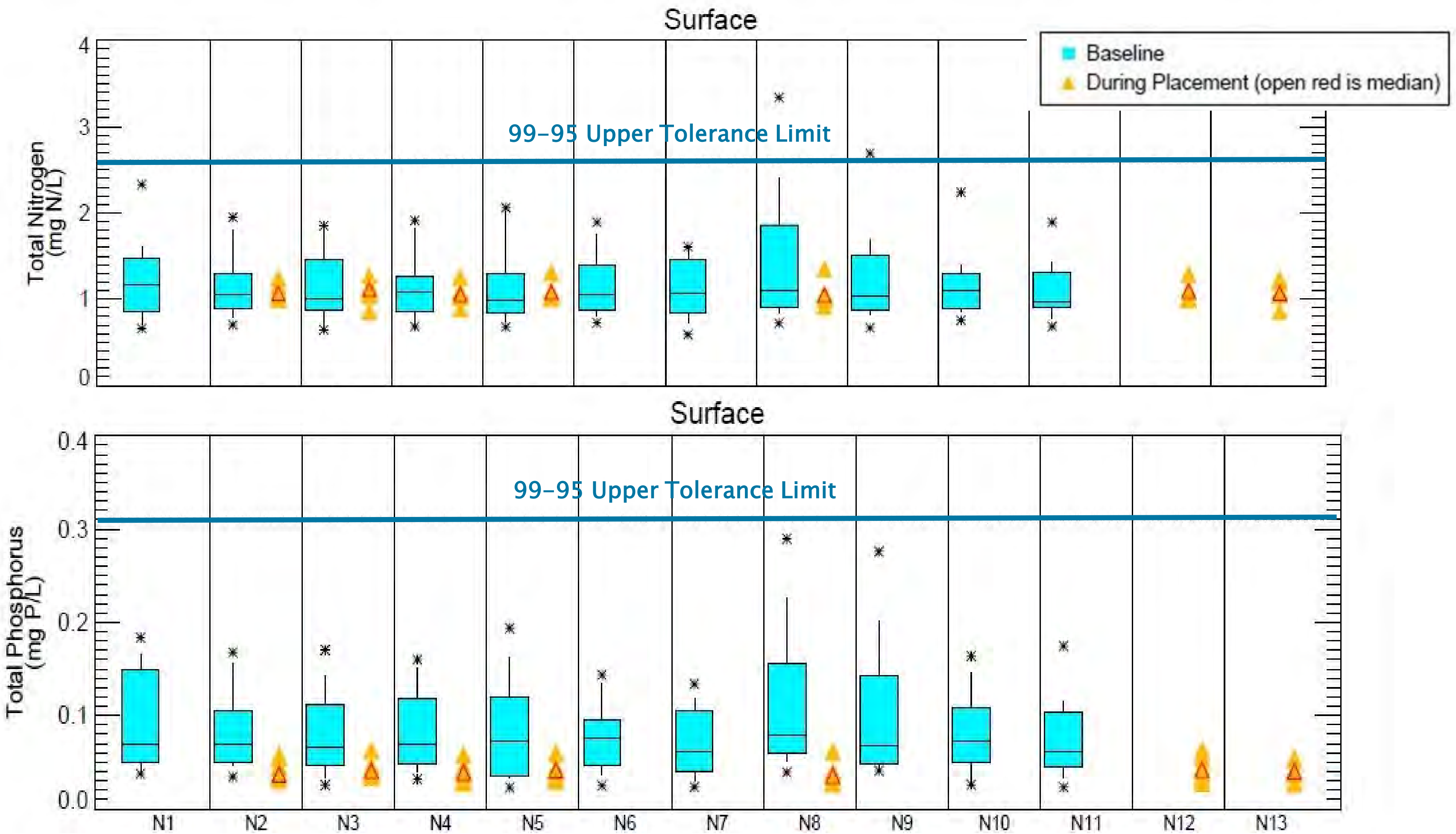
- Conducted during dredged material placement
- Daily monitoring →7 events total
- 7 locations sampled during each sampling event
  - 4 near field
  - 2 far field
  - 1 background
- Turbidity measured at 5-ft depth increments
- Nutrient data collected at surface and mid-depth

Fully Loaded Scow

Dredged Material Placement

Empty Scow

Nutrient Monitoring Results



- Horizontal green lines indicate 99-95 Upper Tolerance Limits from baseline data
- Boxes show median (horizontal central line) and outliers (stars)
- Baseline and "During Placement" data consist of 14 and 7 points, respectively

Post-Placement Bathymetric Monitoring

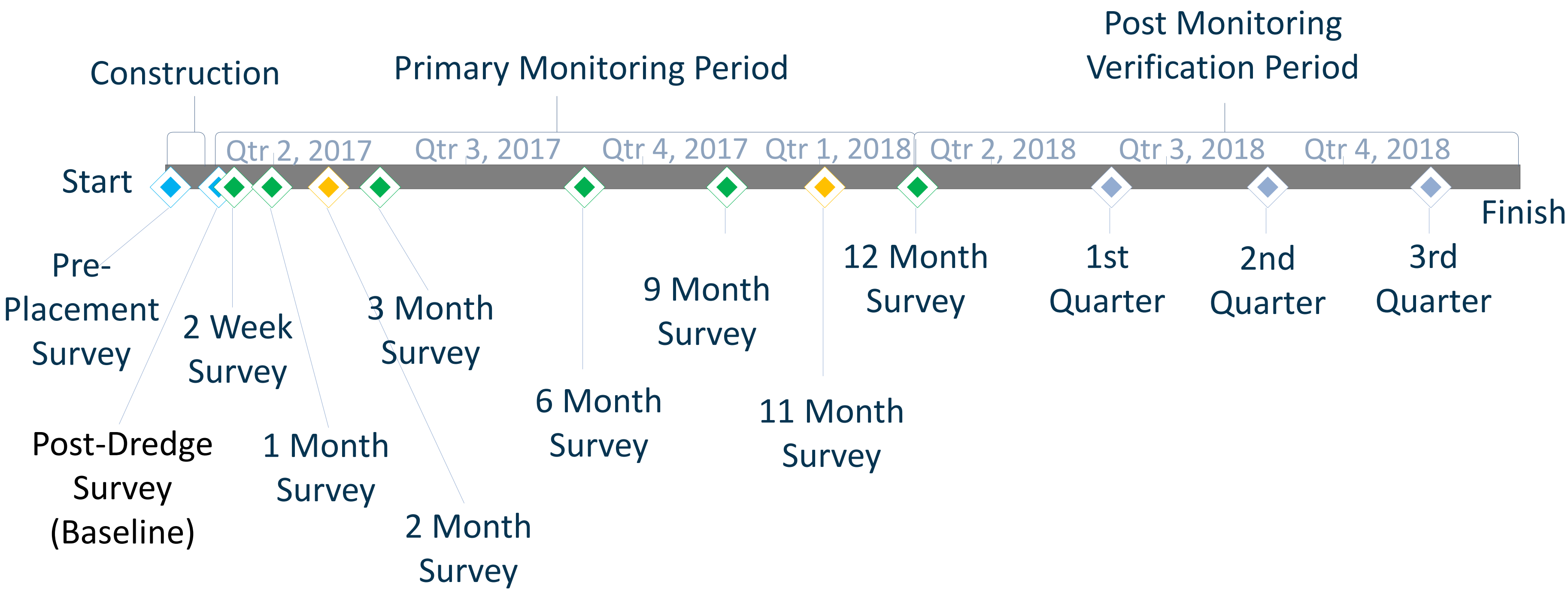
ANCHOR QEA

MARYLAND ENVIRONMENTAL SERVICE

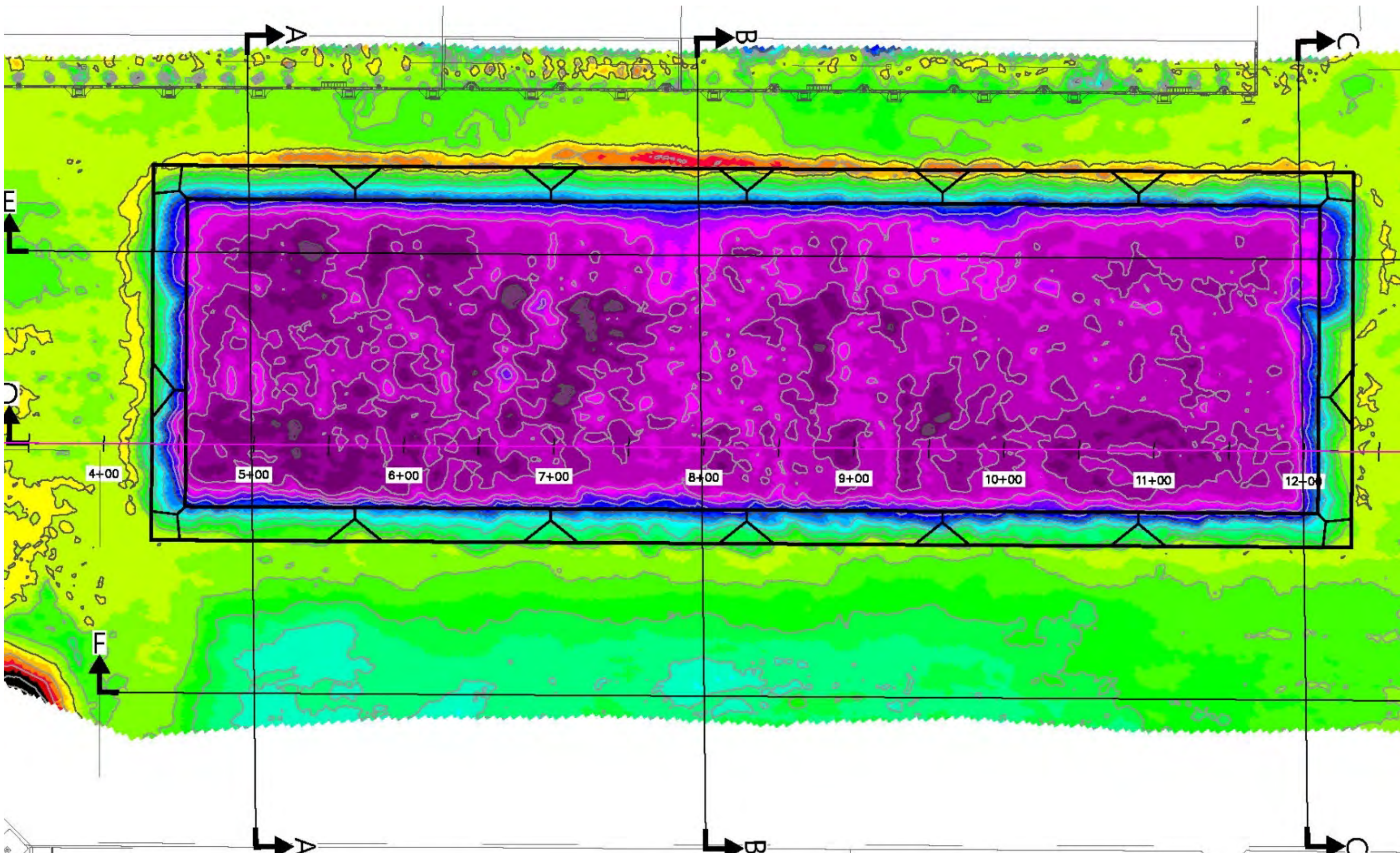
MARYLAND DEPARTMENT OF TRANSPORTATION

MARYLAND PORT ADMINISTRATION

Post Placement Monitoring Schedule and Additional Monitoring



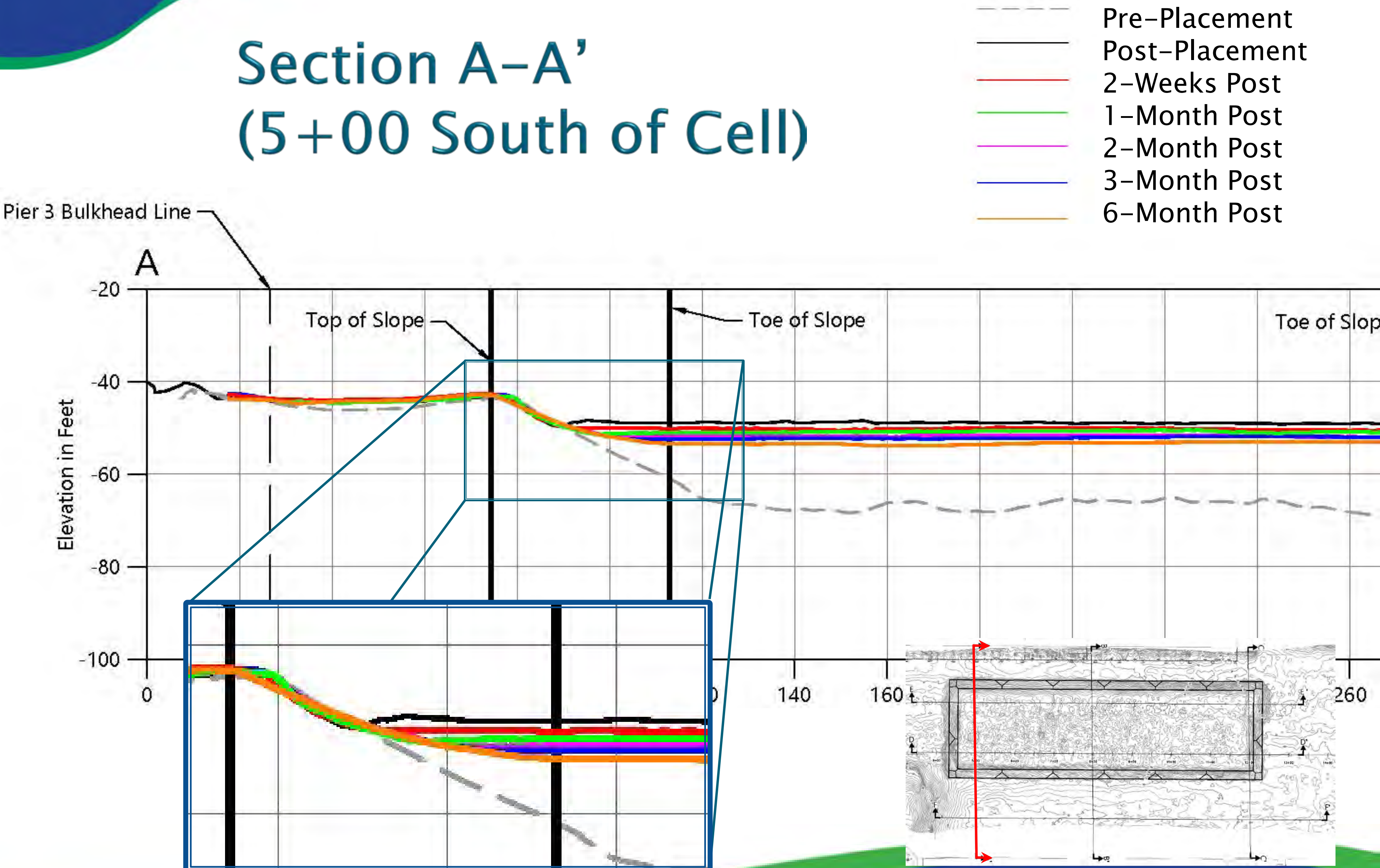
Change in Elevations (Pre-Placement to Post-Placement)



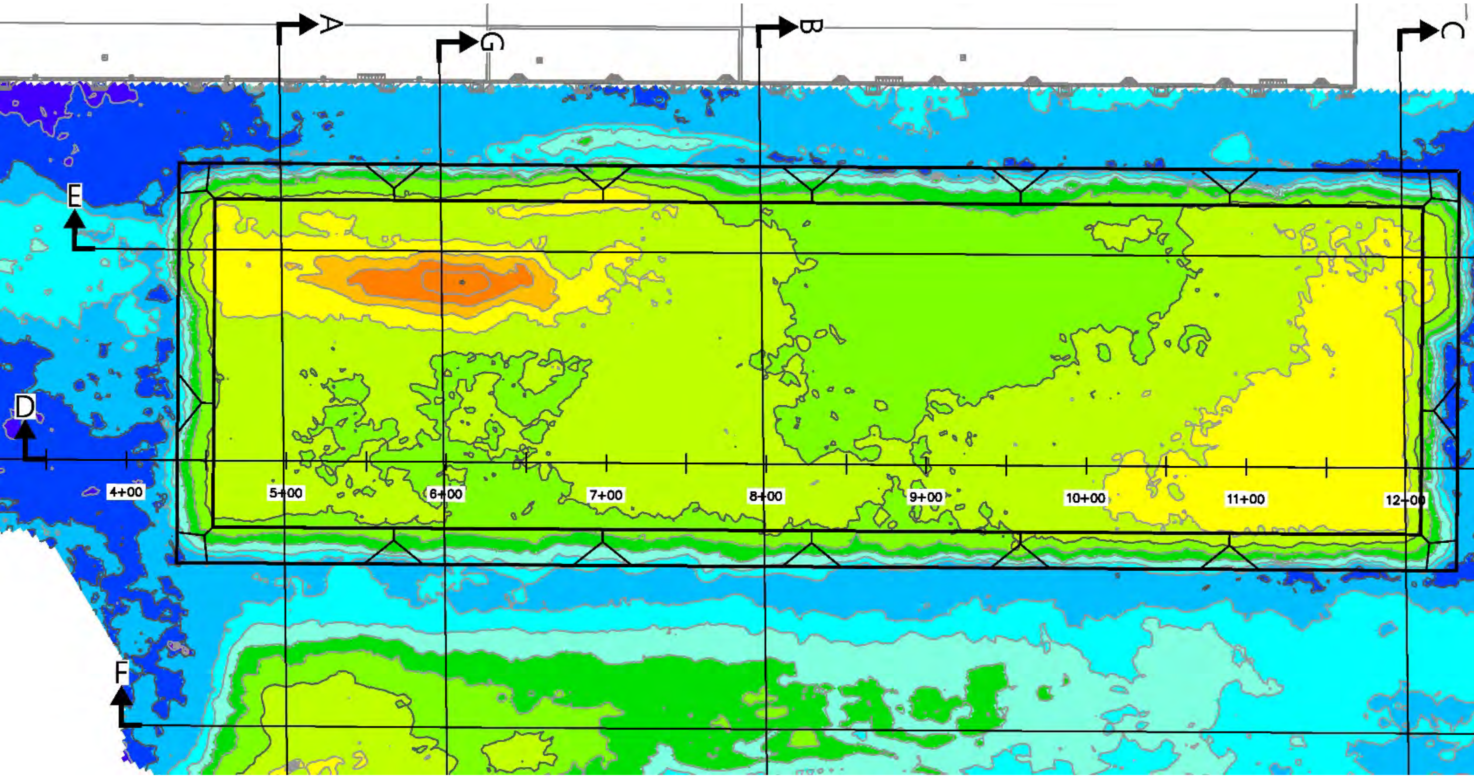
DIFFERENCE BETWEEN PRE-PLACEMENT AND POST-PLACEMENT ELEVATION		
ELEVATION DIFFERENCE (FT)	COLOR	AREA (SF)
-5.00 to -4.00		191
-4.00 to -3.00		771
-3.00 to -2.00		2990
-2.00 to -1.00		5227
-1.00 to 0.00		51468
0.00 to 1.00		238798
1.00 to 2.00		84201
2.00 to 3.00		56161
3.00 to 4.00		25700
4.00 to 5.00		19847
5.00 to 6.00		25507
6.00 to 7.00		11376
7.00 to 8.00		4316
8.00 to 9.00		4138
9.00 to 10.00		4114
10.00 to 11.00		4088
11.00 to 12.00		4040
12.00 to 13.00		4021
13.00 to 14.00		4548
14.00 to 15.00		5948
15.00 to 16.00		10675
16.00 to 17.00		25587
17.00 to 18.00		54203
18.00 to 19.00		35100
19.00 to 20.00		11574
20.00 to 21.00		911

ANCHOR QEA
MARYLAND ENVIRONMENTAL SERVICE
MDOT MARYLAND DEPARTMENT OF TRANSPORTATION MARYLAND PORT ADMINISTRATION

Section A–A' (5+00 South of Cell)

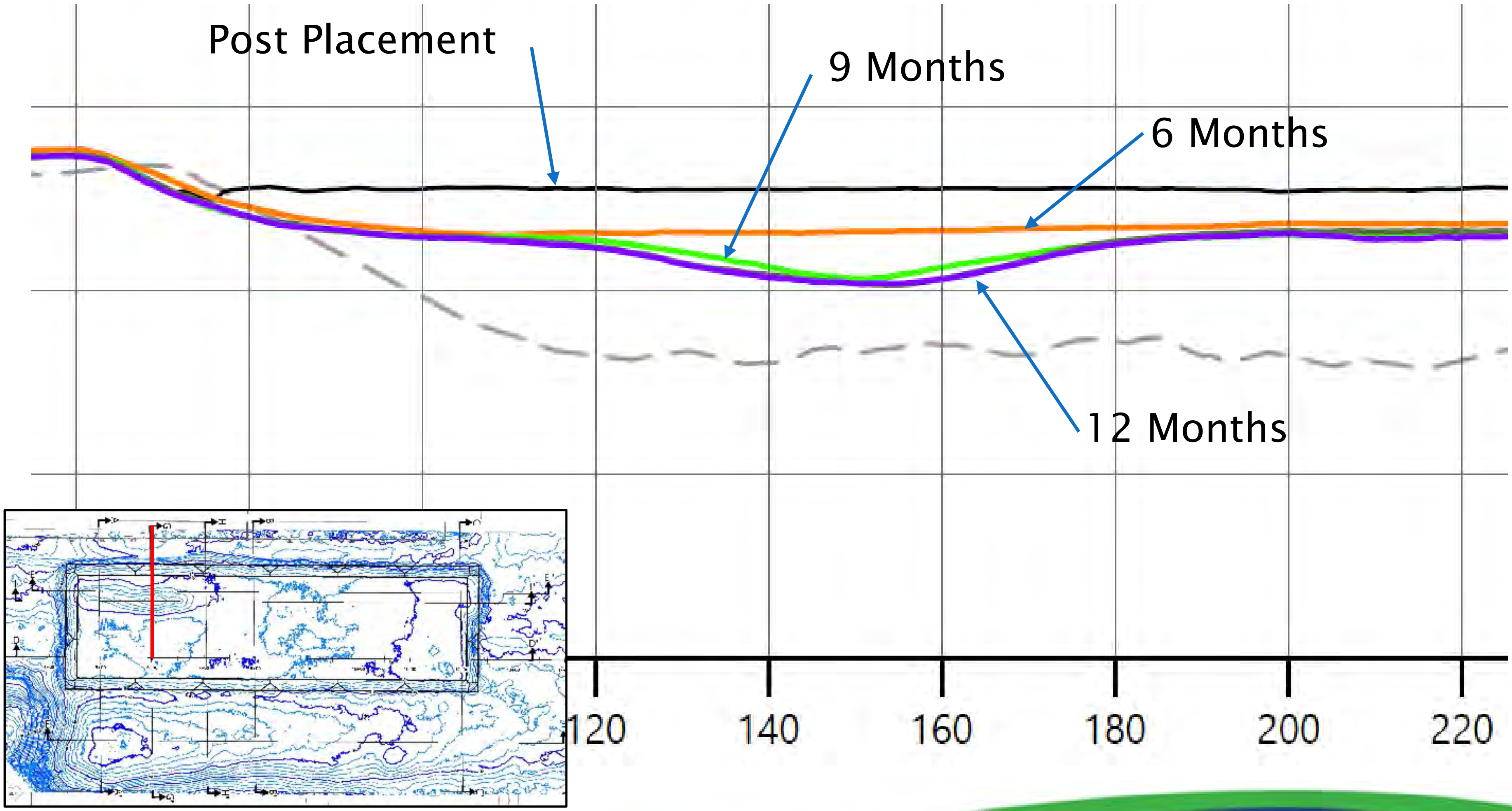


Post Placement Changes Over 9 Months

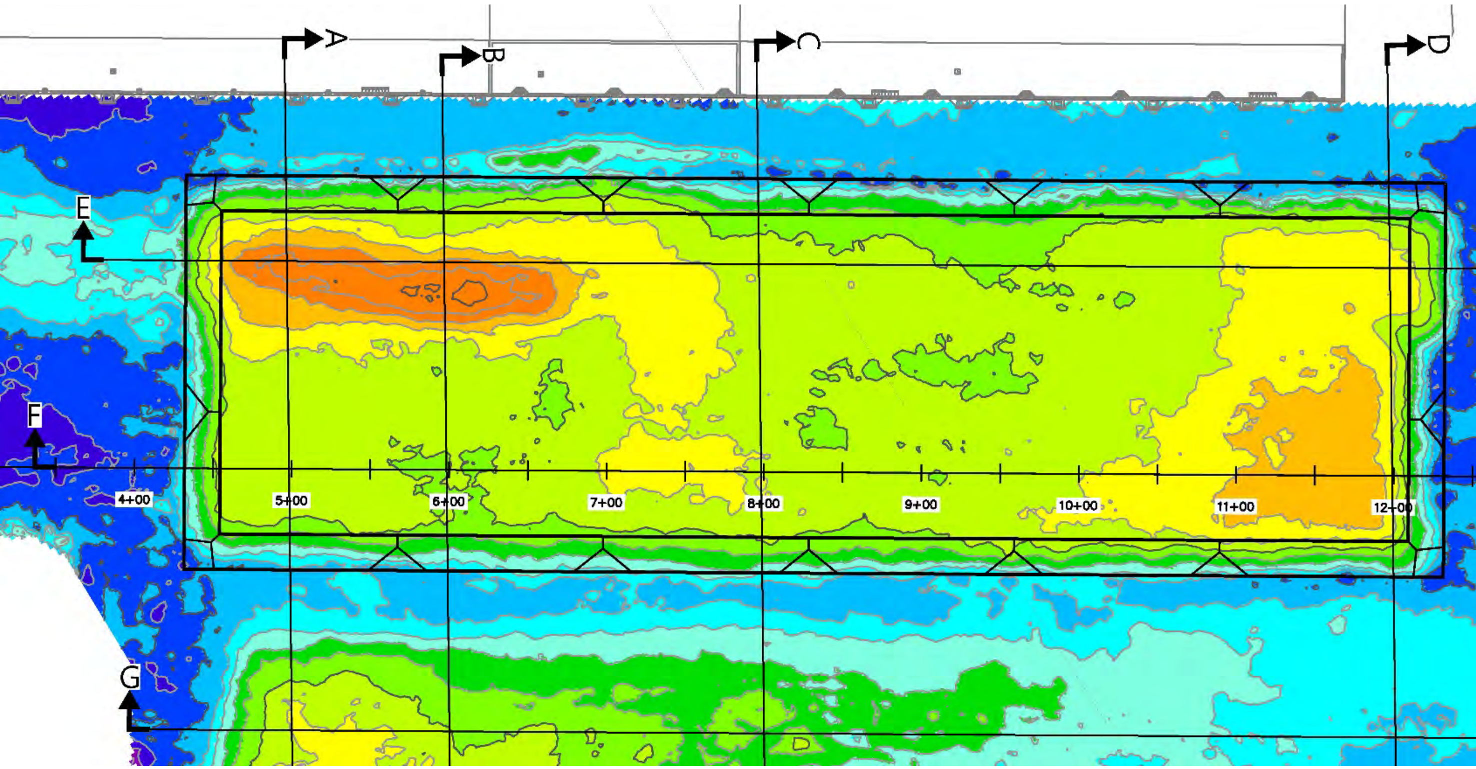


ELEVATION DIFFERENCE (FT)	COLOR
< -8.00	
-8.00 to -7.00	
-7.00 to -6.00	
-6.00 to -5.00	
-5.00 to -4.00	
-4.00 to -3.00	
-3.00 to -2.00	
-2.00 to -1.00	
-1.00 to 0.00	
0.00 to 1.00	
1.00 to 2.00	
2.00 <	

Cross Section B
(Rear of CAD Cell)



Post Placement Changes Over 21 Months



ELEVATION DIFFERENCE (FT)	COLOR
-8.10 to -8.00	
-8.00 to -7.00	
-7.00 to -6.00	
-6.00 to -5.00	
-5.00 to -4.00	
-4.00 to -3.00	
-3.00 to -2.00	
-2.00 to -1.00	
-1.00 to 0.00	
0.00 to 1.00	
1.00 to 2.00	
2.00 to 2.50	

CAD Pilot Project Findings

- Construction and dredged material placement were successful
  - Collaboration with USACE to incorporate CAD into annual maintenance dredging program
- Challenges working in a busy, high traffic berth
  - Coordinating with the dredging contractors and Harbor Pilots, construction sequencing, and monitoring operations were all key
- Nutrient monitoring to evaluate project under Chesapeake Bay TMDL framework was successful
  - Developed site-specific approach so potential project impacts could be identified
- Localized scour was observed but area has stabilized
  - Importance of site selection criteria and planning studies

CAD is an effective strategy and may be an option for future dredged management in Baltimore Harbor

Questions?

For additional information:

Holly Miller
Maryland Port Administration
hmiller2@marylandports.com

EXHIBIT 7

CITY OF
NEWPORT BEACH
City Council Staff Report

July 26, 2022
Agenda Item No. 8

TO:	HONORABLE MAYOR AND MEMBERS OF THE CITY COUNCIL
FROM:	David A. Webb, Public Works Director - 949-644-3311, dawebb@newportbeachca.gov
PREPARED BY: **PHONE:**	Chris Miller, Administrative Manager, cmiller@newportbeachca.gov, 949-644-3043
TITLE:	Lower Bay Dredging: Memorandum of Agreement with the US Army Corps of Engineers for City Contributed Funds

ABSTRACT:

The US Army Corps of Engineers (USACE) is planning to dredge the federal navigation channels in Newport Harbor this fall. USACE has secured the necessary funding to complete the dredging project, assuming the City of Newport Beach (City) also funds 50% (up to $10 million) of the anticipated costs as it has committed. The City's adopted Capital Improvement Program (CIP) budget includes $10,000,000 in funding for this project. To memorialize the City's contribution to the federal government, USACE requires a Memorandum of Agreement (MOA). Lastly, because a portion of the dredging is over County of Orange (County) tidelands, the County desires to contribute funds to the City, which will pass those funds to USACE. In the near future and likely after bids are received, a County/City MOA will be presented to the City Council for consideration.

RECOMMENDATION:

a) Find that the approval of the MOA with USACE is covered by the Final EIR No. ER2021-001 (SCH No. 2109110340) in accordance with the California Environmental Quality Act (CEQA), and the Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) prepared by USACE in accordance with the National Environmental Protection Act (NEPA), and that approval of the MOA with USACE will not result in new or additional significant effects on the environment; and

b) Authorize the Mayor to execute an MOA with USACE relating to City financial participation in the Lower Newport Bay dredging project.

DISCUSSION:

Overview

Newport Harbor is one of the largest recreational harbors in the United States. Natural processes of storm water and erosion flowing into the harbor, primarily from San Diego Creek, result in the movement and accumulation of sediment which must be dredged periodically to maintain the federally authorized channel depths for safe navigation.

The Federal Channels extend from the Entrance Channel to the Turning Basin (adjacent to the Newport Boulevard Bridge), and from the east anchorage between Bay Island and Lido Isle to the Marina Park area. These channels are the responsibility of and are maintained by the federal government via USACE.

The City has, in the past, contributed funds to assist with the federal dredging effort because the dollar amounts historically allocated by the federal government are insufficient to properly maintain the channels to their necessary authorized depths.

A portion of the Lower Newport Bay was dredged between May 2012 and January 2013, removing 600,000 cubic yards of material. Unsuitable material dredged during that project was placed at the Port of Long Beach's Middle Harbor Fill Site which was available at that time. The other dredged material that met the required standards was placed at the federally managed open ocean disposal site (LA-3) which is six miles from the Entrance Channel. Prior to the 2012-13 dredging project, approximately 270,000 cubic yards of clean material was removed in 1998 and 1999 from the Main Channel and Upper Bay Channels, and disposed at LA-3.

USACE typically conducts annual bathymetric (depth) surveys to determine the amount of sediment that has accumulated in the Federal Channels and to assess the need for maintenance dredging. The 2018 USACE survey indicated that approximately 1.2 million cubic yards of sediment within the established channels requires maintenance dredging to reestablish authorized navigation depths. An updated bathymetric survey has now been completed, and it will be reconciled during final plan review before the project is bid in the fall.

Recent sediment characteristic studies were also conducted to evaluate disposal options as required by the regulatory agencies. The most recent sediment sampling effort, conducted in 2018 and 2019, determined that most of the material was suitable for disposal at either LA-3 or within the nearshore disposal zone along the City's ocean beaches.

However, some bottom material within the Federal Channels is unsuitable for open ocean disposal even though the material passed toxicity tests. Therefore, this material requires an alternative disposal location, and dredging these areas is not feasible without also identifying a practicable management option for this unsuitable material. As the local sponsor for the dredging project, the City is responsible for identifying a disposal location on behalf of USACE.

To manage this unsuitable material, staff reviewed all viable sediment disposal solutions including placing the material at the local ports of Los Angeles and Long Beach as fill, and/or using the material for upland or aquatic disposal within a confined disposal facility (creating land). At this time, the most feasible and cost-effective option to dispose of this bottom sediment material is to construct a Confined Aquatic Disposal (CAD) site within the harbor.

A CAD is constructed underwater by digging a hole then disposing the initial material removed from the hole within the nearshore disposal zone along the City's ocean beaches for replenishment, then placing the non-open ocean quality bottom sediment back inside this hole. A cap of suitable material is then placed on top, creating a physical barrier between any contaminants and the overlying water column and benthic organisms. A defined portion of the CAD will be available for those Newport Harbor residents who might also have material within their slips and bay frontage that is unsuitable for open ocean disposal.

At the May 25, 2021 meeting, City Council adopted Resolution No. 2021-46 which 1) certified Environmental Impact Report No. ER2021-001; 2) adopted the Mitigation, Monitoring and Reporting Program; 3) made Facts and Findings; and 4) approved the construction of the Confined Aquatic Disposal facility and dredging outside the Federal Channels in Lower Newport Harbor.

<u>USACE MOA</u>

From a funding perspective, USACE spent approximately $4 million in 2021 for Phase I, which consisted of dredging the Entrance Channel and repairing the east jetty. After receiving additional funds through the federal Infrastructure Investment and Jobs Act, USACE has approximately $12 million allocated toward completing the dredging project in Newport Harbor. With the ongoing estimate of $20 million, this represents more than half of the required funds. The City has also committed to a 50% match of the USACE project funding, up to $10 million in City funds.

In order for the City to contribute funds, a formal MOA must be executed with USACE. (Attachment A). The attached MOA presented is essentially the same as the prior MOA executed between the USACE and the City. Public Works and the City Attorney's Office have reviewed the MOA for funding the Lower Bay Dredging project, and recommend the Council approve and execute this new funding agreement.

Prior to USACE bidding the project, the promised City funds must be transferred to the federal government. If any City funds are remaining at the end of the project, USACE will return those unspent funds.

<u>County Contribution</u>

Because the project will be dredging a portion of County tidelands, the City has asked the County to consider contributing funds (about $2 million) to cover the associated project costs. Because the City is the lead local sponsor with USACE, and because the required timeframe for MOA pre-approval through the federal process is lengthy (at least nine months), staff suggests that the City be the repository of a County contribution even if it means the City will front the money and be reimbursed by the County in the future via a City/County MOA. The MOA would be developed in the near future and prior to contract award. (In 2012, the City and County approached the project in the same manner – the City passed the County funds along to USACE.)

FISCAL IMPACT:

The project is estimated to cost approximately $20 million. Of this amount, approximately $12 million will be paid by the federal government leaving a funding shortfall of approximately $8 million. However, in today's current economic climate, including volatile fuel prices, the project may exceed the original estimate after bidding in the fall. The Council will consider contributing up to $10 million of Tidelands Funds toward this project. Also, the County has expressed an interest in, but has not yet finally committed to, contributing approximately $2 million in additional funds to cover dredging over County tidelands. In total, the project would potentially be funded up to $24 million, which should offset any adjustments caused by the current economic climate.

The adopted FY 2022-23 Capital Improvement Program (CIP) budget includes $10,000,000 for this agreement. It will be expensed to the Tidelands Capital Fund in the Public Works Department, Account Nos. 10101-980000-18H07 and 10101-980000-22H07. The Tidelands Capital Fund was created to allow for the sequestration of incremental increases from tidelands rent adjustments solely to finance critical in-harbor capital improvements like seawall repairs, piers and dredging.

ENVIRONMENTAL REVIEW:

Find that the approval of the MOA with USACE is covered by the Final EIR No. ER2021-001 (SCH No. 2109110340) in accordance with the California Environmental Quality Act (CEQA), and the Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) prepared by USACE in accordance with the National Environmental Protection Act (NEPA), and that approval of the MOA with USACE will not result in new or additional significant effects on the environment.

NOTICING:

The agenda item has been noticed according to the Brown Act (72 hours in advance of the meeting at which the City Council considers the item).

ATTACHMENT:

Attachment A – USACE Memorandum of Agreement for Dredging Newport Harbor

MEMORANDUM OF AGREEMENT
BETWEEN
THE DEPARTMENT OF THE ARMY
AND
THE CITY OF NEWPORT BEACH
FOR MAINTENANCE DREDGING OF
NEWPORT HARBOR, CALIFORNIA

This MEMORANDUM OF AGREEMENT (hereinafter the "MOA") is entered into this ________ day of ________________, ________, by and between the Department of the Army (hereinafter the "Government"), represented by the U.S. Army Engineer, Los Angeles District (hereinafter the "District Engineer"), and the City of Newport Beach (hereinafter the "Contributor"), represented by its Mayor.

WITNESSETH, THAT:

WHEREAS, the Newport Harbor, California maintenance project (hereinafter the "Project") was authorized by the River and Harbor Act of 1937, Pub. L. 75-392, 50 Stat. 844, 849, as amended by the Rivers and Harbors Act of 1945, Pub. L. No. 79-14, § 2, 59 Stat. 10, 21;

WHEREAS, the amount of Federal funds available for maintenance dredging of the Project is sufficient to proceed with dredging contracts but insufficient to perform all scheduled work;

WHEREAS, the Contributor considers it to be in its own interest to contribute funds voluntarily to be used by the Government to perform additional maintenance dredging of the Project (hereinafter the "Maintenance Work"); and

WHEREAS, the Government is authorized pursuant to 33 U.S.C. 701h to receive and expend funds to be used for the Maintenance Work.

NOW, THEREFORE, the Government and Contributor agree as follows:

1. The Contributor shall provide to the Government up to $10,000,000 to pay costs associated with the Maintenance Work, including the costs of environmental compliance, supervision and administration, and engineering and design.

2. Within sixty (60) calendar days of execution of this MOA, the Contributor shall provide the funds to the Government by delivering a check payable to "FAO, USAED Los Angeles" to the District Engineer or providing an Electronic Funds Transfer of such funds in accordance with procedures established by the Government.

3. The Government shall not commence any Maintenance Work until all applicable environmental laws and regulations have been complied with, including, but not limited to, the National Environmental Policy Act of 1969 (42 U.S.C. 4321–4347) and Section 401 of the Clean Water Act (33 U.S.C. 1341).

4. The Government shall provide the Contributor with quarterly reports of obligations for the Maintenance Work. The first such report shall be provided within thirty (30) calendar days after the final day of the first full quarter of the Government fiscal year following receipt of funds pursuant to this MOA. Subsequent reports shall be provided within thirty (30) calendar days after the final day of each succeeding quarter until the Government concludes the Maintenance Work.

5. Upon conclusion of the Maintenance Work and resolution of all relevant claims and appeals, the Government shall conduct a final accounting of the costs of such work and furnish the Contributor with written notice of the results of such final accounting. If the costs of the Maintenance Work are less than the sum of the Federal funds and the amount of funds provided by the Contributor, the Government shall refund the excess to the Contributor within thirty (30) calendar days of such written notice.

6. No credit or repayment is authorized, nor shall be provided, for any funds provided by the Contributor and obligated by the Government for the Maintenance Work.

7. Nothing herein shall constitute, represent, or imply any commitment to budget or appropriate funds for the Project in the future; and nothing herein shall represent, or give rise to, obligations of the United States.

8. The Contributor shall hold and save the Government free from all damages arising from the Maintenance Work, except for damages due to the fault or negligence of the Government or its contractors.

9. In the exercise of their respective rights and obligations under this MOA, the Government and the Contributor each act in an independent capacity, and neither is to be considered the officer, agent, or employee of the other.

10. Notices.

a. Any notice, request, demand, or other communication required or permitted to be given under this MOA shall be deemed to have been duly given if in writing and either delivered personally or mailed by first-class, registered, or certified mail, as follows:

If to the Contributor:

City Manager
City of Newport Beach
100 Civic Center Drive
Newport Beach, CA 92660

If to the Government:

Chief, Navigation Branch
U.S. Army Corps of Engineers
915 Wilshire Boulevard, Suite 1100
Los Angeles, CA 90017

b. A party may change the recipient or address to which such communications are to be directed by giving written notice to the other party in the manner provided in this paragraph. Any notice, request, demand, or other communication made pursuant to this paragraph shall be deemed to have been received by the addressee at the earlier of such time as it is actually received or seven (7) calendar days after it is mailed.

11. This MOA may be modified or amended only by written, mutual agreement of the parties.

(Signatures on next page)

IN WITNESS WHEREOF, the parties have executed this MOA as of the day, month, and year first above written.

THE DEPARTMENT OF THE ARMY

BY:__________________________
Julie A. Balten
Colonel, U.S. Army
District Engineer

DATE:________________________

THE CITY OF NEWPORT BEACH

BY:__________________________
Kevin Muldoon
Mayor

DATE:________________________

APPROVED AS TO FORM
OFFICE OF THE CITY ATTORNEY

for

Aaron Harp
City Attorney

ATTEST:

____
Leilani Brown
City Clerk

CERTIFICATE OF AUTHORITY

I, Aaron C. Harp, do hereby certify that I am the principal legal officer of the City of Newport Beach, that the City of Newport Beach is a legally constituted public body with full authority and legal capability to perform the terms of the Agreement between the Department of the Army and the City of Newport Beach, and that the persons who have executed this Agreement on behalf of the City of Newport Beach have acted within their statutory authority.

IN WITNESS WHEREOF, I have made and executed this certification this _____________ day of ____________ 20__.

____

Aaron C. Harp
City Attorney

CERTIFICATION REGARDING LOBBYING

The undersigned certifies, to the best of his or her knowledge and belief that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all sub-awards at all tiers (including subcontracts, sub-grants, and contracts under grants, loans, and cooperative agreements) and that all sub-recipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by 31 U.S.C. 1352. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

____

Kevin Muldoon
Mayor

DATE: ____________________________

Revell, Mandy@Coastal

From: Debra Bibb <dbibb@pacificsir.com>
Sent: Friday, October 7, 2022 4:54 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.
I am a 60 year resident and 46 year homeowner in Newport Beach.
I grew up sailing on the bay every day and water skiing in the back bay. Newport Harbor is in dire need of a major dredge. This is the best option for our harbor and it's future.
Please approve this needed project.

Thank you,

Debi Bibb
2552 Circle Drive
Newport Beach Ca 92663

949.533.5101

Debi Bibb

M 949.533.5101 |

Revell, Mandy@Coastal

From:	Stefanie Sessina <stefanie@jfnovaklaw.com>
Sent:	Friday, October 7, 2022 4:43 PM
To:	SouthCoast@Coastal
Cc:	Kim Lewand-Martin; Jennifer Novak; Revell, Mandy@Coastal
Subject:	Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)
Attachments:	2022.10.07_FNH comment ltr CCC Final SIGNED PDF.pdf

EXHIBITS 1 - 7.pdf

Respectfully,
Stefanie

Law Office of Jennifer F. Novak
500 Silver Spur Road, Suite 206
Rancho Palos Verdes, California 90275
(310) 693-0775 office
www.jfnovaklaw.com
stefanie@jfnovaklaw.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:43 PM
To: Revell, Mandy@Coastal
Subject: FW: No to the CAD

-----Original Message-----
From: Kari Kazanjian <karikaz1@yahoo.com>
Sent: Friday, October 7, 2022 3:03 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: No to the CAD

Kari Kazanjian opposed to the CAD
thank you

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:43 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD

From: Wayne Graveline <wayneandlexi@yahoo.com>
Sent: Friday, October 7, 2022 3:50 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD

I am opposed against the CAD.

G Wayne Graveline

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:41 PM
To: Revell, Mandy@Coastal
Subject: FW: Opposed

From: Bar2 Gmail <barchan2@gmail.com>
Sent: Friday, October 7, 2022 4:29 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Opposed

Debbie Chao
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

Revell, Mandy@Coastal

From: Bar2 Gmail <barchan2@gmail.com>
Sent: Friday, October 7, 2022 4:29 PM
To: Revell, Mandy@Coastal
Subject: Opposed

Debbie Chao
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

Revell, Mandy@Coastal

From: Paul Conzelman <paul@scdevelopment.net>
Sent: Friday, October 7, 2022 4:20 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640

Opposed

I want to register my opposition to this application. The use of a CAD in the recreational Newport Harbor is shortsighted and negatively effects the long term health of the bay. Please select an alternative solution.

Thank you,
Paul Conzelman

Revell, Mandy@Coastal

From: Dianne Wells <diannebwells@gmail.com>
Sent: Friday, October 7, 2022 4:18 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640; Agenda F17a

Dianne B. Wells
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

Mandy.Revell@coastal.ca.gov
California Coastal Commission
South Coast Area Office
301 East Ocean Blvd Suite 300
Long Beach CA 90802-4302

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:17 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD

From: Tad (Douglas) Lowrey <tadlow@mac.com>
Sent: Friday, October 7, 2022 1:38 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD

I'm a resident of Lido Island. I am familiar with the CAD and the issue that the City is trying to resolve. I'm opposed to the current proposed plan. I believe there should be a better solution, and I recently heard about one for the back bay that had a lot of advantages, including that it would be less costly. I think this should be denied or placed on hold to look for alternative options for the disposal/storage.

Regards,

Tad (Douglas) Lowrey

909 913-1617

tadlow@mac.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:17 PM
To: Revell, Mandy@Coastal
Subject: FW: Application #5-21-0640 OPPOSED
Attachments: Application #5-21-0640_opposed.docx

From: Lisa Stanson <lstanson@mac.com>
Sent: Friday, October 7, 2022 1:39 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>; Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: Application #5-21-0640 OPPOSED

Lisa Stanson

Opposed

Application #5-21-0640

Agenda F17a

October 14, 2022

Dear Coastal Commission,

Dumping contaminated sludge into the center of Newport Harbor would create a potential environmental hazard for residents and visitors. This "sediment unsuitable for open ocean disposal" has unacceptable levels of mercury and other toxins, and the "final 3-foot thick cap layer" of uncontaminated sediment is the only "construction" to contain this contaminant.

Why would one move something to a new area of the harbor that is unacceptable for another area of the harbor? And at great expense to the City not only for the project, but for ongoing maintenance. This will also make it impossible to ever dredge that section of the harbor which has historically needed dredging.

I am opposed to this plan.

Sincerely,

Lisa Stanson

Lido Isle, Newport Beach Resident

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:17 PM
To: Revell, Mandy@Coastal
Subject: FW: Coastal Commission regarding the CAD

From: the Mackels <teammackel@gmail.com>
Sent: Friday, October 7, 2022 1:57 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>; Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: Coastal Commission regarding the CAD

Drew Mackel
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

Coastal Commission, SouthCoast@coastal.ca.gov and **Mandy.Revell@coastal.ca.gov**

regarding the CAD, I AM OPPOSED.

Revell, Mandy@Coastal

From: Win Fuller <wfuller1@pacbell.net>
Sent: Friday, October 7, 2022 4:16 PM
To: Revell, Mandy@Coastal
Subject: Opposition to Application #5-21-0640/ Agenda F17a/ October 14, 2022

Mandy, please put me on record as opposing the above application and agenda items to be heard October14, 2022.
Win Fuller

Opposed

Application #5-21-0640

Agenda F17a

October 14, 2022

I believe dumping contaminated sludge into the center of Newport Harbor would create a potential environmental hazard for visitors and residents of Newport Harbor. I believe that the final 3' cap layer of uncontaminated sediment is insufficient construction to contain the toxic-contaminated sediment. The sediment will likely be disturbed by boats dropping anchor to the bottom and dragging until secured.
Sediment is also disturbed by propeller thrust during anchoring and positioning.

Too, dredged -contaminated sludge, unsuitable for open ocean disposal could drift to popular public and private beaches near the anchorage and around the harbor including The Balboa Peninsula , Harbor Island , Linda Island , Bay Shores , Bay Island, Balboa Island ,Lido Island ,Collins Island ,Beacon Bay , and the Corona del Mar area., which would be most unhealthful. The public's health and recreation including kayaking , paddle boarding , sailing, swimming would be affected.

My further understanding is that the sediment sampling has not been completed to determine unsuitability and suitability, for ocean disposal- - -a good reason to pause.

Finally and simply ; we are taking the bad stuff out of the bay and putting it back in the bay. Instead , we should consider drying out the material -treating it and putting it to good use as landfill. The CAD project will likely take at least 3 to 4 years to complete , prolonging the disruption of the quality of life so enjoyed by visitors and residents alike.

My recommendation for all the aforementioned reasons are to effect the contaminated material disposal on land for appropriate land use and not approve the CAD plan .

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:16 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: C. Thomas Ruppert <cthomas@ciapro.net>
Sent: Friday, October 7, 2022 2:44 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Dennis Durgan Debi Bibb <ddurgan@att.net>; Phillip Lacy Ruppert Kimberly Brooke Ruppert <pruppert@browningautogroup.com>; Geoffrey Ruppert <ruppertgeoffrey@gmail.com>
Subject: CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Subject: CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

To Whom It May Concern...

I am in complete agreement with The Commission staff who is recommending that The Commission approve Coastal Development Permit Application # 5-21-0640 as conditioned.

C. THOMAS

CARLTON THOMAS RUPPERT JR.
PRODUCER / AGENT
Chief Operating Officer &
Director of Internal Operations
CA LIC # 0M26720

Chrysalis Insurance Agency (Incorporated)
3001 Red Hill Ave, Ste. 2-226
Costa Mesa, CA 92626
714-464-8080 Office, 714-464-8070 Fax
714-941-2103 Direct, 949-274-5236 Mobile

www.ciapro.net

PERSONAL & COMMERCIAL INSURANCE

Home (Renters), Auto, Personal Umbrella, Jewelry, Collector Vehicles
General Liability, Professional Liability
Excess / Umbrella Liability
Directors & Officers
Property (Fire, Wind, Hail, Earthquake, Flood)
Inland Marine / Equipment Floater
Commercial Auto
Cyber Liability (Data Breach), Ransomware
Workers Compensation / EPLI

YACHT & SHIP INSURANCE

Hull Coverage – Physical Damage
Liability & Uninsured Boater
Commercial Towing
Medical Payments
Personal Property (Fishing Equipment)
Fuel Spill Liability
Panama Canal Transit / Named Storm Endorsement

Revell, Mandy@Coastal

From: David Rhodes <drhodes@acs-architects.com>
Sent: Friday, October 7, 2022 4:12 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640 Agenda F17a October 14, 2022
Attachments: Letter to California Coastal Comissioners re Newport Beach CAD Proposal October 7 2022.pdf; Letter to California Coastal Comissioners re Newport Beach CAD Proposal August 31 2022.pdf

Mandy,
Please find my attached letter in opposition.
I have also re-sent my previous letter.

Respectfully Submitted,

David L. Rhodes, AIA
President

ACS NEWPORT BEACH

101 Shipyard Way Suite B Newport Beach CA 92663

T 714 436 9000 x1522 M 714 476 3550
www.4acsi.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 4:12 PM
To: Revell, Mandy@Coastal
Subject: FW: OPPOSED 35-21-0640

From: Sharon Grimes <sharongrimes1@gmail.com>
Sent: Friday, October 7, 2022 3:55 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>; Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>; Sharon Grimes <Sharongrimes1@gmail.com>
Subject: OPPOSED 35-21-0640

OPPOSED

Sharon Grimes

Application #5-21-0640

Agenda F17A

October 14, 2022

Dear Coastal Commission,

Please DONOT bury contamination in Newport Harbor Bay. I grew up in Washington State a few miles from the **Hanford Nuclear Project**. My family has been involved with **Nuclear Waste for decades.** You can still fish swim etc. in the three rivers there. The Columbia, Snake and Yakima Rivers are clean clear available for use. Because they listened to the **chemist and** engineers **not the Politicians, or City Employees without Chemical or Engineering degrees/backgrounds.** We have all seen the ads for **Camp Lejeune lawsuits** because of waste that contaminated the water there. Innocent Families serving our country keeping us safe have suffered because of improper waste disposal.

PLEASE VOTE NO!

Sincerely,
Sharon Grimes
Newport Beach, Resident
949-466-5756

ACS ARCHITECTURAL
CONSTRUCTION
SERVICES
INC

October 7, 2022

David L. Rhodes
Opposed
Application #5-21-0640
Agenda F17a

Mandy.revell@coastal.ca.gov
California Coastal Commission
South Coast Area Office
301 East Ocean Blvd. Suite 300
Long Beach, CA 90802-4302

Re: Request by the City of Newport Beach
Installation of a Confined Aquatic Disposal (CAD)

Dear Commissioners,

Since my last letter to you dated August 31, 2022, I have spent additional time seeking answers to my questions concerning the proposed CAD. My search has included attending city meetings, community meetings, reading blogs including the newportharborfoundation.org one which supports the CAD. After reading the blog items supported by members of the Newport Beach City Council and your own Coastal Commission Staff's Summary of Recommendations, I am bewildered as to how we got here.

My conclusion is that we have all been so trusting in some of our elected and appointed officials that now those officials are embarrassed to admit they have been misled or duped into supporting this dangerous proposal.

That is one explanation as to why the City Council Members and Staff have looked the other way despite the concerns and independent findings of residents regarding the proposed CAD. For years the City has hitched their wagon and story to a proposal created and supported by Anchor QEA, LLC, the consultant standing to benefit the most from this solution. So much time and effort has gone into this single-minded solution that the City is asking you the Coastal Commission, charged with protecting our coastal environment, to let-them-off-the-hook. I pray you don't.

To give you a better picture of where I am coming from, I would like to address some of the statements found on the newportharborfoundation.org site as well as some of your staffs listed Reasons for Approval:

Reason for Approval

The Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways

ATLANTA
CINCINNATI
MILWAUKEE
NEWPORT BEACH

101 Shipyard Way
Suite B
Newport Beach CA
92626

acs-architects.com

because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways (Staff Report page 24).

Rebuttal: This statement appears to address the upland disposal in that is refers to truck or train trips. It does not consider or address to local disposal on the Lower Castaways site or alternate golf course site proposed by Phil Thompson.

Reason for Approval

The project construction would actually result in an increase of the available area for boats to pass through compared to existing conditions with an occupied anchorage in place (Staff Report page 6).

Rebuttal: This statement is disingenuous in that placing the CAD in the harbor is not a prerequisite for dredging the main harbor channels. Please understand that I am in favor of dredging.

Reason for Approval

The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3).

Rebuttal: Permanent isolation of the contaminated sediments is what everyone wishes to happen. The report states that "the contaminated sediments will be confined and not be stirred up and re-suspended in the water where it makes contact with boats, swimmers, and wildlife". No one can guarantee this. Placing the CAD directly under an anchorage used by novice boaters dragging anchors across a thin cap is undoubtedly a recipe for unavoidable problems no matter how well-intentioned and is just wishing.

Additionally placing the CAD one of the highest activities areas of the harbor is a question to start with. This area in in direct alignment with water flows into Newport Harbor, thus the concentration of DDT from upland areas. Why on earth would anyone place a CAD at this location preventing future dredging from happening forever? With future silting this places a permanent speed-bump in our navigable waters.

Reason for Approval

The proposed Newport Beach disposal site for the clean sand is the least damaging feasible alternative and the proposed CAD facility is the least damaging feasible alternative for disposal of contaminated sediments (Staff Report page 3).

Rebuttal: I have heard a lot about the questionable testing of contaminated sediments. I will leave that up to the experts to determine if this testing was done properly. However I do believe based on my service as a professional that not enough samples were taken to adequately determine the amount and toxicity of the material to be disposed. I do not know how you make or even defend a statement such as "a CAD facility is the least damaging feasible alternative for disposal" without further study. I believe the EIR needs to be re-examined for recertification in light of new facts emerging.

There has been a lot of chatter about the proposed Lower Castaways proposal. I for one would like to see the pro-forma cost used to determine the cost of this project at $89 million. As an architect, I don't believe that cost for a minute and find it to be very much inflated. In addressing the alternative proposals required by the EIR I would like to see this compared to the cost of the CAD including lifetime monitoring and any contingency for handling remedial requirements.

ATLANTA
CINCINNATI
MILWAUKEE
NEWPORT BEACH

101 Shipyard Way
Suite B
Newport Beach CA
92626

acs-architects.com

As stated in my previous letter, this is an emotional issue for many. Dredging must be done but the CAD is not the only solution and likely not be the best one. I believe you will be serving the public by looking at all of the alternatives and not make a hasty decision under the pressure of time. We have time to do this right.

If you, the honorable California Coastal Commission, approve this flawed proposal, you will be endorsing a solution that you cannot guarantee will be safe for all. If or when it fails you will also be giving cover to the City, staff, and anyone else supporting the CAD to point to you as their enabler. The City staff and others have backed the Newport Beach City Council into a corner. They can't back down at this eleventh hour and admit wrongdoing.

Don't fall for it. You have a job to do and I as one concerned resident do not want our beloved City tarnished in a case study of "What Not to Do in a Residential Harbor".

Respectfully Submitted,

David Rhodes, AIA
President

ACS ARCHITECTURAL
CONSTRUCTION
SERVICES
INC

August 31, 2022

David L. Rhodes
Opposed
Application #5-21-0640
Agenda W13b

California Coastal Commission
Southcoast@Coastal.CA.gov

Re: Request by the City of Newport Beach
Installation of a Confined Aquatic Disposal (CAD)

Dear Commissioners,

I am an architect in the city of Newport Beach and a Lido Isle resident having lived on the Isle beginning in 1987. I am also a Staff Commodore of LIYC 1997. I am not a marine architect, although I have been involved in a number of projects over the years with CEQA. Most of my involvement with CEQA has centered on the issues dealing with traffic in vehicular and pedestrian intersections. That is why I question the appropriateness of placing a Confined Aquatic Disposal or "CAD" at the intersection of what is a marine version of "Main & Main". I stated this in the City's scoping meeting December 4, 2019.

I am quite familiar with the activities in that part of our harbor. Along with being a boater, as Commodore, I was previously responsible for running our youth and adult sailing programs involving nearly 200 sailors. Limiting the use of that area for any sustained period of time much less ten years would devastate the quality of small boat regattas and thus all but curtail the youngest of our youth sailing programs. Running them adjacent to the equipment at the CAD site if even possible would be much too dangerous. Running regattas entirely in front of LIYC or Newport YC would be nearly impossible as the courses would be too short to be considered in almost all conditions. Running our regatta's from other areas of the harbor such as the western turning basin would cause logistical problems as well as being too distant for the younger of our sailors.

While placing the CAD in the middle of our harbor greatly perplexes me, I have to date unanswered concerns. When I attended the scoping meeting various quantities of dredged material were mentioned. Frankly, it was obvious that the city did not have (does not have) a clear understanding of the amount of material that will be placed into the CAD nor the amount of "unsuitable material" that will be dredged. Many of the assumptions that have been made regarding the quantity of material are purely that, assumptions. In my world as an architect when I am designing foundations, I need to have a comprehensive soils study done including several borings to identify the limits and depth of the material. This has not been adequately measured and as a result assumptions have been made that appear to be vastly overstated.

My concern regarding the calculation of the amount of "unsuitable material" to be dredged. If the city were to further analyze the material through core samples and testing it may turn out that the unsuitable material is approximately 20,000 CY or even less. In that case there would likely be no need for a CAD as the material could be disposed of off-site or with further testing possibly at LA3.

ATLANTA
MILWAUKEE
NEWPORT BEACH

101 Shipyard Way
Suite B
Newport Beach CA
92663

To be clear I have no objection to dredging and understand its need. However I believe a CAD should be a last resort due to its permanency. It's interesting that our own Harbor Commissioners originally recommended siting the CAD facility adjacent to the contaminated material not in the middle of Main and Main. Although I have concerns of employing the CAD solution at all, if the decision is to utilize a CAD it seems appropriate to deal with the problem adjacent to where it occurs. None of this material occurs in the relatively clean area of the Eastern turning basin. So why bring contaminated material there?

The CEQA guidelines require alternative solutions be considered. Although I have nothing against Anchor QEA, LLC, having the same company furnish the analysis that will provide the work is a conflict of interest and entirely inappropriate. I have heard that Anchor is a CAD expert. While that is good, it may however lead, if not appear to lead, them to be predisposed to a CAD solution. Why not have an independent third party provide the analysis? And why have other alternative solutions including the Lower Castaways one provided by Team Palmer not been given thorough consideration by the City?

Apart from the City's position, I ask you as our Coastal Commissioners to give the Lower Castaways alternative solution serious consideration as I believe you will be surprised at the legitimacy of it. And I believe you will be serving the public by looking at all of the alternatives and not make a hasty decision under the pressure of time. <u>We have time to do this right and not become an historical case study of what not to do.</u>

I know this is an emotional issue for many. I have tried to take the emotion out of this and look only at the facts which I feel are not complete. I look forward to hopefully seeing a comprehensive study of the alternatives and the creation of a plan that does not disrupt the recreational quality of our lives nor damage Newport Harbor. A plan the residents and the city of Newport Beach and you as our Coastal Commissioners can stand behind. And a plan in which we can be proud of working out together.

Respectfully Submitted,

David Rhodes, AIA
President

Revell, Mandy@Coastal

From:	SouthCoast@Coastal
Sent:	Friday, October 7, 2022 4:11 PM
To:	Revell, Mandy@Coastal
Subject:	FW: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)
Attachments:	SPON F17a Comment Letter 10-7-22.pdf

From: Charles Klobe <cklobe@me.com>
Sent: Friday, October 7, 2022 4:01 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

Good day,

Please find attached the SPON comment letter on this item.

Thanks,

Charles Klobe
Cell: 949-500-3969

SPON
Still Protecting Our Newport
Inspiring The Next Generation

PO Box 102 | Balboa Island, CA 92662 | 949.864.6616

October 7, 2022

California Coastal Commission
South Coast Area Office
301 E. Ocean Blvd., Suite 300
Long Beach, CA 90802-4302

Re: **F17a**: Application No. 5-21-0640 (City of Newport Beach, Newport Beach) for Commission Meeting of 10/14/22
Support Approval

Honorable Commissioners,

SPON started after a 1974 torrential rainstorm filled Newport Bay with every variety of unsavory clutter. We care about the health of the bay.

We believe the project before you is the best solution for cleaning the bay. We support the project and conditions recommended in the staff report. Many folks who have written in opposition to this project are not fully informed. The City has tried to provide outreach but most folks have chosen to ignore this until now.

Additionally, approximately 282,400 cubic yards of clean sediment excavated from the harbor floor to create the CAD cell would be transported by bottom dump scow and placed along the nearshore ocean beach, where the waves and currents would move the sand onto Newport Beach. This sand is desperately needed.

Thank you for your consideration of our comments.

Sincerely,

Charles Klobe
President

Revell, Mandy@Coastal

From: sharongrimes1@gmail.com
Sent: Friday, October 7, 2022 4:10 PM
To: SouthCoast@Coastal; Revell, Mandy@Coastal; sharongrimes1@gmail.com
Subject: OPPOSED
Attachments: OPPOSED.pdf

OPPOSED

Sharon Grimes
Application #5-21-0640
Agenda F17A
October 14, 2022

Dear Coastal Commission,

Please DONOT bury contamination in Newport Harbor Bay. I grew up in Washington State a few miles from the **Hanford Nuclear Project**. My family has been involved with **Nuclear Waste for decades.** You can still fish swim etc. in the three rivers there. The Columbia, Snake and Yakima Rivers are clean clear available for use. Because they listened to the **chemist and** engineers **not the Politicians, or City Employees without Chemical or Engineering degrees/backgrounds.** We have all seen the ads for **Camp Lejeune lawsuits** because of waste that contaminated the water there. Innocent Families serving our country keeping us safe have suffered because of improper waste disposal.

PLEASE VOTE NO!

Sincerely,
Sharon Grimes
Newport Beach, Resident
949-466-5756

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 4:08 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Jan West

Date: October 7, 2022
Time: 11:07 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_6) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Safari/605.1.15
Remote IP: 172.116.150.174
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 3:57 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Amy conzelman

Date: October 7, 2022
Time: 10:56 pm
Page URL:
https://friendsofnewportharbor.org/?fbclid=IwAR1JdGptf2dkQLCqSc9q4_cVbbKBPVRbWdxWTcDYi6c7YYIPkluubTU_LVo
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/19G82
[FBAN/FBIOS;FBDV/iPhone12,1;FBMD/iPhone;FBSN/iOS;FBSV/15.6.1;FBSS/2;FBID/phone;FBLC/en_US;FBOP/5]
Remote IP: 174.243.208.116
Powered by: Elementor

Revell, Mandy@Coastal

From: Sharon Grimes <sharongrimes1@gmail.com>
Sent: Friday, October 7, 2022 3:55 PM
To: SouthCoast@Coastal; Revell, Mandy@Coastal; Sharon Grimes
Subject: OPPOSED 35-21-0640

OPPOSED

Sharon Grimes

Application #5-21-0640

Agenda F17A

October 14, 2022

Dear Coastal Commission,

Please DONOT bury contamination in Newport Harbor Bay. I grew up in Washington State a few miles from the **Hanford Nuclear Project**. My family has been involved with **Nuclear Waste for decades.** You can still fish swim etc. in the three rivers there. The Columbia, Snake and Yakima Rivers are clean clear available for use. Because they listened to the **chemist and** engineers **not the Politicians, or City Employees without Chemical or Engineering degrees/backgrounds.** We have all seen the ads for **Camp Lejeune lawsuits** because of waste that contaminated the water there. Innocent Families serving our country keeping us safe have suffered because of improper waste disposal.

PLEASE VOTE NO!

Sincerely,
Sharon Grimes
Newport Beach, Resident
949-466-5756

Revell, Mandy@Coastal

From: Wayne Graveline <wayneandlexi@yahoo.com>
Sent: Friday, October 7, 2022 3:51 PM
To: Revell, Mandy@Coastal
Subject: CAD

I am opposed against the CAD.

G Wayne Graveline

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 3:34 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Carolyn Ross

Date: October 7, 2022
Time: 10:33 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 108.184.86.213
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 3:33 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Jill Ayres

Date: October 7, 2022
Time: 10:32 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 108.184.68.231
Powered by: Elementor

Revell, Mandy@Coastal

From: CHARLES GANT <charlesgant@att.net>
Sent: Friday, October 7, 2022 3:18 PM
To: Revell, Mandy@Coastal; Chris Cummings
Subject: Opposition
Attachments: Application5-21-0640_Agenda F17a_CGant.pdf

Sent from AT&T Yahoo Mail for iPad

Charles Gant
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

October 7, 2022

Mandy Revell
California Coastal Commission
South Coast Area Office
301 East Ocean Blvd Suite 300
Long Beach, CA 90802-4302
(562) 590-5071

Dear Ms. Revell,

I am really concerned about the City's proposal to bury tons of contaminated soil into the bay. Because we are trying to save the oceans, this project has to be postponed or canceled while other locations can be found to store this crap. Stop this project while other options can be explored and more data can be collected! We need to make sure that the City is protecting us from the horrible poison that you could be putting in our bay!

charlesgant@att.net

310-891 1849

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 3:13 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Lesly Davenport

Date: October 7, 2022
Time: 10:13 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 108.184.72.12
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 3:05 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

patti Bellitti

Date: October 7, 2022
Time: 10:05 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 Safari/604.1
Remote IP: 172.58.20.148
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 3:04 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Carole steele

Date: October 7, 2022
Time: 10:04 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 Safari/604.1
Remote IP: 172.58.20.185
Powered by: Elementor

Revell, Mandy@Coastal

From: Kari Kazanjian <karikaz1@yahoo.com>
Sent: Friday, October 7, 2022 3:04 PM
To: Revell, Mandy@Coastal
Subject: No to the CAD

Kari Kazanjian is opposed to the CAD

thank you

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 3:00 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Robbin Fleming

Date: October 7, 2022
Time: 10:00 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 Safari/604.1
Remote IP: 70.224.65.123
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 2:58 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Kari Kazanjian

Date: October 7, 2022
Time: 9:57 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Safari/605.1.15
Remote IP: 108.184.89.27
Powered by: Elementor

Revell, Mandy@Coastal

From: Robert Coldren <rcoldren@coldrenlawoffices.com>
Sent: Friday, October 7, 2022 2:44 PM
To: Revell, Mandy@Coastal
Cc: Brooke Coldren
Subject: CAD -newport beach bay dredging project
Attachments: 2022.10.06_OCCK Surfrider CAD CDP Comment Letter.pdf; 2022.10.06_OCCK Surfrider CAD CDP Appendix.pdf; CCC Public Notice 5-21-0640.pdf

SENT VIA ELECTRONIC MAIL
Mandy Revell, Coastal Program Analyst
California Coastal Commission, South Coast District Office
301 Ocean Blvd., Suite 300, Long Beach, CA 90802
Mandy.Revell@coastal.ca.gov
To: CDP App. No. 5-21-0640 (City of Newport Beach CAD Facility)
Dear Ms. Revell and Commission Staff:

Dear decision makers:
As local Newport Beach residents, we (my wife Brooke and I align ourselves with Orange County Coastkeeper's comments on the City of Newport Beach's CDP App. No. 5-21-0640 regarding construction of a Confined Aquatic Disposal Facility (CAD). Accordingly, we request CDP denial and/or modification in accordance with Coastkeeper's comments.
We independently hereby to incorporate all of those comments and objections by reference.We also wish to supplement those submissions and remarks: My wife and I have a particular concern about our quality of life as homeowners who live "on the Bay". The public beaches all along on Lido Island , Lido Peninsula, the peninsula ,and all other public and private areas will be full of extremely cloudy water for years (due to the dredging etc.)it's our understanding that visibility will be reduced within the bay from 70% to 20%
We also object to the project as proposed because of the amount of increased vote traffic up and down our channel. All of this can be eliminated if we simply look at other project alternatives and do not go further "downstream" on this "CAD" solution . We also can't believe you are putting "dirty" sediment in an 8 acre hole 40 or 60 feet or whatever deep in the middle of our turning basin. Had the proponents of this project not worked with such "quiet speed" I can assure you there would be a much larger/huge turnout at the meeting on the 14th with many more really concerned and frightened residents. I personally have met and spoken with probably more than 100.
Finally, my wife and I want the harbor dredged and we understand that is important. We object not to the dredging, but to THIS project as presently proposed, and specifically to the current plan of moving much more sediment than is required and rendering the turning basin off-limits for any dredging ever again in the future by our children or children's children. We urge you to either provide more time for study or reject the project/denny the application.

Thank you

Rob

Ps . See attachments hereto Incorporated by reference.

Robert S. Coldren, Esq.
Coldren Law Offices, APLC*
1301 Dove Street, Suite 800
Newport Beach, CA 92660

Main: (714) 955-6106 (ext.507)

Mobile: (949) 220-6241
Rcoldren@Coldrenlawoffices.com

*Of Counsel CALLAHAN & BLAINE
*Of Counsel Rudderow Law Group

Agenda Item 17.a
CDP App. No. 5-21-0640
Orange County Coastkeeper &
Surfrider Foundation
Requesting Denial of CDP

Appendix

EnviroSolutions Incorporated

Environmental Characterization to Closure

Review of Proposed Construction of a Confined Aquatic Disposal Facility

City of Newport Beach, California

California Coastal Commission

CDP Application No: 5-21-0640

PREPARED BY:

Dr. William J. Rogers

Omega EnviroSolution, Inc.

October 6, 2022

Introduction

I have been requested by counsel for Orange County Coastkeeper evaluate the environmental risks associated with the City of Newport's proposed Dredging Project and In-Harbor Sediment Plan and Confined Aquatic Disposal. I have reviewed the following documents as well as supporting scientific and regulatory guidance:

December 4, 2020 Lower Newport Bay Confined Aquatic Disposal (CAD) Construction Project (PA2019-020) State Clearinghouse Number: 2019110340

November 24, 2020 Lower Newport Bay, "Sediment Management Plan"

EPA/600/R-15/176 "Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological risk Assessments"

California Coastal Commission Staff Report CDP Application No.: 5-21-0640 W13b August 26, 2022

California Coastal Commission Staff Report CDP Application No.: 5-21-0640 W13b September 7, 2022 Exhibits

California Coastal Commission Staff Report CDP Application No.: 5-21-0640 F17a September 30, 2022

California Coastal Commission Staff Report CDP Application No.: 5-21-0640 F17a October 14, 2022 Exhibits

QUALIFICATIONS OF DR. WILLIAM J. ROGERS

I am a Regents Full Professor, senior researcher and the program director of the Environmental Science Program at West Texas A&M University. I am the University Radiation Safety Officer and certified Naturally Occurring Radioactive Materials (NORM) surveyor. I have also served as the Associate Dean of Academic and Research Environmental Health, Safety and Compliance responsible for all aspects of student and research faculty and staff health and safety. As shown in my attached curriculum vitae, (Attachment 1), I have a doctorate in Fish and Wildlife Science specializing in environmental and ecological risk assessment, environmental toxicology and modeling of contaminant effects. I also have a Bachelor of Science degree in Biology and Master of Science degree in Biology. I am a member of the Institute of Hazardous Materials Management and a Certified Hazardous Materials Manager at the highest level (Masters Level # 1694). I am a member of the Society of Environmental Toxicology and Chemistry (SETAC), the Society of Risk Analysis, a scientific and technical reviewer and Associate Editor for the journal *Ecotoxicology* specializing in environmental and ecological toxicology and risk assessment. I am also a working member of the Texas Commission on Environmental Quality (TCEQ)

Ecological Risk Working Group. I am the principal investigator for the TCEQ in the development of ecological "protective cleanup levels" for chemical contaminants in specific habitats found in Texas. I

have provided support to the United Nations Environmental Program, World Bank and United Nations Food and Agricultural Organization on environmental cleanup, human health risk assessment and environmental monitoring in Azerbaijan, Argentina, Russia and Romania. Serving as the World Bank's technical lead and project manager, I supervised the development and implementation of two of the World's largest environmental remediation projects in Azerbaijan-Caspian Sea (115 hectares or 284 acres of oil production contamination and the recovery of over 1,000 metric tons or 1,102 tons of mercury from chlorine manufacturing contaminated soils). Both projects were selected as model and benchmark projects by the Caspian Sea Partners. I have served as an advisor to the Chlorine Manufacturers Association Board addressing human health and environmental effects of "persistent toxic bio-accumulating chlorinated chemicals (PTBs)" and have written a position paper on the human health risk and cleanup of "persistent organic pesticides (POPs)" for the World Bank. I served as the southwest regional coordinator on the Secretary of Interior's Task Force on Selenium and Other Toxic Substances (with independent National Academy of Science panel oversight) and organized both screening level and detailed human health risk and environmental risk assessments for all Department of Interior water supply and irrigation projects in the Southwestern United States. I have managed large-scale human health and ecological risk assessments at such sites as the Department of Energy Pantex Nuclear Weapons Plant and Oak Ridge National Laboratory. At the Pantex Nuclear Weapons Plant, I directed the site characterization, technical feasibility, risk assessment and remedial action of more than 144 hazardous waste, hazardous substance and radioactive sites on the facility. I was the principal author of the Ecological Risk Assessment Program Plan for Evaluation of Waste Sites on the Department of Energy Savannah River Plant. I have over forty years of experience in virtually all aspects of environmental risk assessment, restoration, and protection. I have numerous publications and presentations that deal directly with human, environmental and ecological risk assessment. A listing of my publications and technical papers are included in my attached curriculum vitae. I have taught and continue to teach *Ecological Risk Assessment, Environmental Impact Assessment and Reporting, Environmental Law, Environmental Regulations, Human Ecology, Environmental Sampling, and Toxicology* at the university masters level and *Agricultural Human Health Risk Assessment* at the doctoral level.

I am familiar with the procedures, methods and models used in environmental, human and ecological risk assessment as well as hazardous constituent releases to soil and water, release site characterization and remediation. I am familiar with the procedures and methods related to laboratory analytical work and EPA accepted quality assurance and validation requirements.

SPECIFIC QUALIFICATIONS

I have specific experience in both human health and environment and ecological risk assessment from exposure to hydrocarbons, heavy metals, chlorinated organic compounds including PCBs, Dioxins/Furans and pesticides, hydrocarbons, radiation, chlorides/salts and exploration and production (E&P)

substances. Specific work includes testing and evaluation, development of "protective cleanup levels" and site remediation of those chemicals. I have extensive experience in both estuarine and off-shore assessment of contaminant impacts to both ecological and human health. I have conducted training on oil boom deployment for the oil industry. I participated in a review of impacts and briefed the Louisiana Parishes on the potential short and long-term impacts of the Deep Water Horizon release. I have conducted reviews of Oil Protection Act of 1990 "Facility Response Plans" and I have directed both table top and live "mock" spill response demonstrations. I have published a book on environmental compliance for the oil industry. I developed and currently maintain, under contract to Texas Commission on Environmental Quality, the "Ecological Protective Cleanup Level (PCL) Model and Database" to integrate and quantify observed and predicted human and ecological effects at construction and contaminated and disturbed sites/habitats for all habitats in Texas. The model has been reviewed and supported by the Texas Ecological Working Group comprised of federal and state agencies as well as private and industrial stakeholders. The model is required by regulation for use in evaluating ecological risk as contaminated sites throughout Texas including estuarine habitats. I have also directed the preparation of and EIA for the World Bank and International Finance Corporation (IFC) to meet their Environmental and Social Performance Standards for the Azerbaijan project. I served as a Regional Environmental Specialist in the US Department of Interior and have led and participated in the NEPA and EIA process on well over 20 projects. I recently prepared a critical evaluation of the Environmental Impact Assessment for Exploratory Drilling in the Cooper Block, Offshore The Bahamas, Bahamas Petroleum Company PLC. and the Perseverance Well Exploration Drilling Program Environmental Management Plan Bahamas Petroleum Company PLC. Environmental Authorization Application.

Overview of the City of Newport Proposed Dredging Project and In-Harbor Sediment Plan and Confined Aquatic Disposal

The City of Newport Beach proposes dredging approximately 1.2 million cubic yards of accumulated sediment returning the waterways to their original -10 to -20 feet depths. In-harbor material disposal is an EPA-supported method of properly managing sediment that contains low levels of pollutants. This method is supported by the U.S. Environmental Protection Agency and has been successfully implemented in ports and harbors such as Long Beach, Port Hueneme, Boston, New Bedford, Chesapeake Bay, Humboldt Bay and Baltimore. CADs are widely accepted by the regulatory agencies as an environmentally safe approach for sediment management. In a news release dated September 23, 2022 it is stated that, "The sediment identified for in-harbor placement is not considered hazardous or toxic under the stringent definitions of the EPA. The sediment has been tested and is not toxic or hazardous as defined by state or federal regulations." These terms have very specific regulatory definitions that do not apply to the material being dredged. Rather, the material is considered "unsuitable" for open ocean disposal at EPA's dredge material disposal sites offshore. The primary contaminant of concern in the harbor is trace amounts of mercury (found in fluids such as motor fuels) that is contained in the harbor bottom sediments. The generally accepted threshold allowed in Southern California for open ocean disposal is 1.0 parts per million (ppm) of mercury within the sediment. The in-harbor mercury levels to be placed within the CAD range from about 1.5 ppm to 5 ppm.

Summary of Opinions:

(1) The use of silt curtains is an absolute must and will require extensive maintenance and cost not considered in the alternative evaluation. The costs of installing, maintaining and operating over a half mile of silt curtain and surface booming was not considered. The impact to barge cycling time and expected delays was not considered. The loss of entrained contaminated sediments during scow ingress and egress into the silt curtain enclosure was not considered. The assumption that these costs are "insignificant" is not supported by my experience.

(2) The use of a BAZ of only 6" is not supported by the expected species that will be found existing at the site or surrounding area. Bioturbation and movement of the contaminants into the environment has been understated. A survey of the expected reoccupying organisms onto the CAD and expected burrowing depths must be conducted. The interim two year cap of 12" is unlikely to be sufficient to prevent bioturbation.

(3) Accumulation of contaminants in the sediments surrounding the CAD is expected to be significant based on the silt/clay composition of the dredged materials. The EIA and supporting STFATE states that water turbidity and quality will improve in 4 hrs but this indicates that settling to the surrounding sediment or dilution in the water column must occur. It is important to note that the STFATE model is a short-term fate of dredged material disposed in open water for predicted water quality effects and not for predicted sediment deposition effects. Other models such as SETTLE for design of Confined Disposal Facilities (CDFs) for Suspended Solids Retention and Initial Storage Requirements, DYECON for determination of hydraulic retention time and efficiency of CDF's, and other more appropriate fate and transport models should have been used.

(4) Sediment sampling is not included in the CAD sampling and monitoring plan and must be included to monitor the efficacy of the CAD containment over time. Water samples will grossly underestimate the CAD efficiency due to currents and the dilution effect. Sediment sampling is a far better measure. Virtually all of the water sampling benchmarks used in the EIR were "acute" rather than "chronic" benchmarks. The use of the ERM as a benchmark is really a starting point. Ecological risk assessment is

needed to determine the protective levels to be followed during dredging, CAD operation and post closure monitoring.

(5) The CAD plan states that mercury is a primary concern. The report lacks a discussion of the potential methylation of mercury, the form of mercury found in the dredge materials and a discussion on preferred capping materials for mercury such a zeolitic capping materials. The unanswered question is whether or not sand is a suitable confining material for the materials being stored.

(6) The EIA states that silt curtains could be used but does not indicate if this was considered in the alternative analysis.

(7) The EIR was superficial in its alternative analysis. For example, the upland disposal alternatives were summarily dismissed based on sweeping statements such as the cost of dewatering when in fact disposal facilities can also blend other dry materials into the waste to past the “paint filter test”. It is also interesting that the public was challenged to locate a material handling location. This process should have been completed in the EIR alternative analysis. It is remarkable that upland disposal options were dismissed without any estimated costs.

(8) A fair evaluation of the alternative costs as well both human and environmental protection is needed on this project. The City is taking legacy agricultural/industrial wastes and placing them within a relatively clean area within 500 feet of a residential and popular recreational beach. The public deserves a fair evaluation.

(9) The referenced modeling clearly states that contaminated materials will be lost to the area outside of the CAD. A thickness of from 1.3 to 2.3 feet of contaminated sediment outside the CAD is predicted and is not insignificant. The EIR lacks any risk assessment on the potential human health and ecological impacts of these predicted exposed contaminants. Based on the small particle size of the contaminated dredge materials, the expected retention time and currents the expected area of influence is expected to be much larger than the area immediate to the CAD. In my soils lab, soil particle size distribution solutions containing clays (<0.002 mm in diameter) and silts (0.002 to 0.05 mm in diameter) stay in solution for days, often weeks, prior to settling if they settle at all. To suggest that clay particles will clear in 4 hours is just not supported by any dispersion modeling that I know of. The question is then where did those silt attached contaminants go? This question needs to be answered!

(10) A fair evaluation of the upland and aquatic alternatives is needed to support the decision making process as well as the public involvement process. The approach that all of the unanswered questions will be addressed later is not supported by California environmental review requirements nor the National Environmental Policy Act guidelines. All anticipated costs and potential impacts must be addressed in the EIAs/EIS documents.

Comments of Proposed Confined Aquatic Disposal (CAD)

Comment: The mercury levels are 5X the allowable deep open water disposal limits. PCB levels are 2.8 X the ERM. It is important to note that the ERM is a median value 50^{th} percentile taken from literature effects review of the scientific literature in which all response levels were recorded and the median provides an indication of toxic response. One must bear in mind that 50% of the response levels fall above the ERM and 50% below. The ERL is the 10th percentile of literature effects levels of contaminants.

Comment: In the Appendix D Sediment Management Plan Page 25, Section 3.2.2 Confined Aquatic Disposal Illustration 1 CAD Construction Overview and supporting language illustrates and describes surface release of the unsuitable material via a disposal scow. This practice without the use of sediment retention currents would allow the materials to suspend and drift from the CAD prior to settling into the CAD. As stated in "California Coastal Commission, CDP 5-21-0640 Exhibit 4 p. 14 of 49" section 2.5 Suitability of Sediments in Federal Channels for Open Ocean or Nearshore Disposal" grain size analysis indicated that the dredged materials were found to consist primarily of fines (68.6% to 98.2% silt and clay). In California Coastal Commission Staff Report: Regular Calendar W13b on CDP Application No. 5-21-0640 identified the following Section III. Special Conditions:

> E. Silt curtains shall be utilized during dredging and material placement activities to reduce turbidity by isolating the active dredging site from the rest of Lower Newport Bay. Additionally, a floating boom shall be maintained around the Project area.
> F. The silt curtains must be comprised of Type III geotextile material.
> G. The silt curtains must be maintained as a full turbidity enclosure. The silt curtains must be supported by floating debris booms in open water areas.
> H. Silt curtains must be continuously monitored for damage, dislocation, or gaps and must be immediately repaired where it is no longer continuous or where it has loosened.
> I. Silt curtains shall be located within the footprint of the CAD perimeter.

These special conditions were not considered nor depicted in the dredge placement into the CAD EIR. In review of the California Coastal Commission 9/30/22 F17a Staff Report the use of silt curtains is required during all phases of the material placement into the CAD. However, on page 29 in section 7.1 of the F17a report it states, "During dredging and material placement activities "Silt curtains may be required to reduce turbidity by isolating the active dredging site from the rest of Lower Newport Bay." These costs were not considered in the EIR alternative analysis.

In addition, Special Condition J. states:

> J. Material placement would take place outside of tidal extremes. Material placement activities should be limited to neap and non-peak tides, defined as plus or minus 2 hours from slack tide, to limit the horizontal distribution of dredged or fill material placed in the CAD facility due to reduced current speeds. In addition, placement activities should be conducted during a
>
> nonpeak flood tide. These measures would limit the loss of dredged or fill material outside the CAD facility during placement operations.

These Special Conditions were not considered in the EIR alternative cost analysis. The cost and maintenance for silt curtains is a significant portion of the CAD operational costs. Considering the grain size of the dredged materials (68.6% and 98.2% silt and clay) the use of bottom dumping scows without silt currents is unacceptable and should have been considered in the cost analysis when comparing disposal alternatives. Even opening and closing the curtains to allow scow access to the CAD would result in significant losses of contaminated dredge materials from the CAD during filling.

As stated in the EIR, W13b and F17a California Coastal Commission reports and Sediment Management Plan the planned water sampling is proposed without mention of sediment sampling. Considering the potential for the fine materials to escape the CAD a sediment sampling and monitoring plan should be included in the CAD sampling and monitoring plan. The potential for sediments to migrate from the CAD operations is discussed throughout the F17a report and STFATE modeling indicates that:

> "• During spring tides, best management practices should be implemented to limit placement events during non-peak tidal current velocities (i.e., plus or minus 2 hours from slack tide) to limit the horizontal distribution of fill material.
> • Disposal events occurring during non-peak ebbing tides result in 10% to 21% of material lost outside the proposed CAD facility.
> • Most of the material lost outside the proposed CAD facility would deposit within 75 feet."

The report further states:

> • "The greatest amount of material lost outside the proposed CAD facility occurred during ebbing tides when placement of material suitable for use as an interim cover containment layer or final cap layer was occurring. Because this material would be sequenced after placement of unsuitable material, any material deposited beyond the boundaries of the proposed CAD facility would act as thin layer cover over any unsuitable material that may have been "lost" from the proposed CAD facility.
> • Disposal events occurring during non-peak flooding tides result in 6% to 9% of material to be lost outside the proposed CAD facility.
> • The maximum observed thicknesses of deposited material ranged from 1.3 to 2.3 feet within the model grid cell directly associated with the placement location. Deposit thicknesses rapidly decreased within 75 feet."

The modeling clearly states that contaminated materials will be lost to the area outside of the CAD. A thickness of from 1.3 to 2.3 feet of contaminated sediment outside the CAD (potentially >5X the mercury ERM) is not insignificant. Throughout the discussion, (Staff Report F17a section 7.1 page 29), CAD successes at other locations such as Port Hueneme are referenced but one must understand that

the materials are much different and are not comparable. For example, the Port Hueneme dredged materials were dominated by sand particles and not the 68.6% and 98.2% silt and clay found in the Newport sediments. The results from the STFATE model predicted, "However, predicted water quality concentrations 4 hours after material placement were equal to the existing background water quality concentrations." As stated in Staff Report F17a page 37, "One of the potential adverse effects from dredging, ocean disposal, and beach replenishment activities in this location is the re-suspension and relocation of contaminants. Contaminants of concern in the Lower Newport Harbor include DDTs, PCBs and mercury. These contaminants usually are bound to finer grain material such as clay and silt." As stated, it is likely that the contaminants would adhere to silt and clay particles and it is unlikely, due to the small particle size, that those particles would settle out within just 4 hours. More likely, the turbidity would clear due to current movement of the sediment particles to the area surrounding the CAD. It is also important to note that the CAD is within approximately 500 feet of residential and recreational beach areas. It is also noteworthy that in Section 7.1.1 Water Quality Monitoring it states that, "dissolved metals, polychlorinated biphenyls (PCBs) and DDT" will be in samples but mercury is not typically included in the standard dissolved metals analysis. Mercury and methylmercury, the contaminants of most concern, are not specifically included in the water quality monitoring plan. The Port Hueneme experience is again referenced in the report stating that mercury methylation is not expected but again the sediments found at the Port Hueneme site were and are much different in both grain size and depth to the CAD surface.

Bioturbation

As stated in 5-21-0640 page 35, "Bioturbation is the mixing and overturning of sediments caused by organisms residing in soft bottom marine substrates. Anchor QEA determined the design bioturbation depth by estimating the most extreme burrowing depth of organisms with the potential to reside at the site. Ultimately, the maximum burrowing depth of six inches was selected given the depth of the CAD which limits the types of species present and monitoring at a similar CAD facility in Long Beach."

Comment: EPA/600/R-15/176 "Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological risk Assessments" provides a discussion on bioturbation depths and depths that should be considered in site remediation and ecological risk assessments. A "Biological Active Zone" or BAZ of 6" is considered as minimal. The document provides a review of burrowing depths of various benthic burrowing organisms many of which can be found in the CAD area and at the proposed CAD depths.

Comment: A review of the depths and potential species that could occur at the site, the assumption of a maximum burrowing depth of 6" is highly optimistic. This is of primary concern during the interim cap presence when less than a 1-foot cap will be maintained. It is stated that 9,000 Cu. Yds. of clean sand would be used to maintain a 1 foot interim cap. Based on my preliminary calculations and a 590 X 590 CAD it would take 12,892 cubic yards of sand to establish a 1 foot cover. The estimate of 9,000 Cu. Yds. might be suitable during the initial filling but would be inadequate as the cell fills. The cap costs were then underestimated in the CAD EIR.

In addition, the proposal calls for 33,600 Cu. Yds. of cover but it will require at least 38,678 Cu. Yds. to establish the 3 foot protective cap. This also does not address the source of the material, material lost during placement and extension of the cap beyond the 590 X 590 surface footprint. Again, these costs were not considered in the CAD EIR.

The selection of the 6” biological active zone is not supported by any onsite survey or predictions of the organisms that would reoccupy the CAD and their expected burrowing depths. While reference is made to the Port Hueneme studies, it is important to note that no measurements were taken on the burrowing depths at that facility. Samples were taken but no effort was taken to measure or to record the burrowing depths at that location.

I hold my opinion and supporting points to a reasonable degree of scientific certainty.

William J. Rogers

ANCHOR QEA

May 20, 2021
Lower Newport Bay Confined Aquatic Disposal (CAD) Construction Project (PA2019-020)
State Clearinghouse Number: 2019110340

Final Environmental Impact Report

Prepared for the City of Newport Beach

January 20, 2020

SENT VIA EMAIL

Mr. Chris Miller
City of Newport Beach
100 Civic Center Drive
Newport Beach, CA 92660

Re: Coastal Commission Staff Comments on Draft EIR for the Lower Newport Bay Confined Aquatic Disposal Construction Project, SCH No. 2019110340

Dear Mr. Miller:

CCC-1

Coastal Commission staff appreciates the opportunity to review and provide comment on the Draft Environmental Impact Report for the Lower Newport Bay Confined Aquatic Disposal Construction Project. The following comments address, in a preliminary manner, the issue of the proposed project's consistency with the Chapter 3 policies of the California Coastal Act of 1976. This letter is an overview of the main issues Commission staff has identified at this time based on the information we have been presented and is not an exhaustive analysis. The comments contained herein are preliminary in nature, and those of Coastal Commission staff only and should not be construed as representing the opinion of the Coastal Commission itself. The following are Commission staff's comments in the order presented in the Draft EIR.

CCC-2

2.5 Proposed Project Construction

In this section and in various sections throughout the document, the impression is given that the proposed use of near-shore ocean beaches is currently an approved location for the City to deposit dredged sediment. To clarify, the near-shore ocean beaches disposal option will require approval by State and Federal agencies. Although the City has submitted Coastal Development Permit Application No. 5-19-1296 seeking reauthorization for dredging activities within Newport Bay, which includes a request to utilize offshore ocean beaches as an optional disposal location, that coastal development permit application is still incomplete. Other agencies may or may not provide their concurrence with the proposed activities through the pending Regional General Permit 54.

CCC-3

2.5.1 Construction Best Management Practices

With regard to the bottom-dump barge that will transport the dredged material unsuitable for open ocean disposal to the proposed CAD facility, the EIR should identify Best Management Practices to ensure chemical constituents of concern do not become released into the water column after they have been released from the bottom of the barge during deposition.

CCC-4

2.5.2.2 Unsuitable Material Placement and Interim Cover Containment Layer Placement

During the time the CAD facility is “open”, in other words, when unsuitable material is being placed in the CAD facility, how often will the 1-foot thick interim cover containment layer be placed over the CAD to provide temporary isolation of the underlying sediments in between disposal episodes? The EIR should analyze alternative construction methods for their potential to safely isolate contaminated material and their potential for failure or leakage.

CCC-5

3.3 Biological Resources

This section states that potential impacts on biological resources were qualitatively evaluated based on the habitat preferences for various species known or presumed to be present in the proposed Project area, as well as the quantity and quality of existing habitat. Were there any recent in-situ subtidal surveys conducted for this project? After reviewing the 2009 Marina Park Final EIR prepared in support of the City of Newport Beach Marina Park Project that is referenced in this section to be representative of the proposed project impacts, it appears that no "on-the-ground" quantitative diver or ROV surveys or grab samples were conducted to adequately describe the species living there. Rather, the descriptions of potential bottom habitat and Essential Fish Habitat (EFH) were based on what was likely to be there, not on what was surveyed there. In order to understand the current status of the bottom habitat where the City of Newport Beach now wants to construct the CAD, please provide quantitative subtidal and biological surveys in and near the proposed project location footprint that would describe the nature of the bottom habitat and fish and invertebrate species populations specific to the project area. In addition, the EIR should include a thorough assessment of potential direct effects on benthic infauna, and also indirect effects that may result from bioaccumulation and biomagnification of contaminants of concern in higher trophic levels of marine life and marine-dependent wildlife.

CCC-6

3.9.3.4.2.1 California Coastal Act

As stated, Section 30221 of the Coastal Act requires that oceanfront land suitable for recreational use shall be protected for recreational use and development unless present and foreseeable future demand for public or commercial recreational activities that could be accommodated on the property is already adequately provided for in the area. According to the comments section, during construction, public and private access to the water in potions of the Project Area may be temporarily restricted during dredging, but what about during construction of the CAD? The proposed location is in the center of the harbor’s turning basin. Will the public be able to safely recreate in this area during construction of the CAD and during disposal to occur over the span of 10 years?

The EIR should identify any potential impacts to public access and recreation and provide a plan for avoiding such impacts by orienting and timing project activities so that watercraft may still access the harbor.

CCC-7

Section 30233 of the Coastal Act allows dredging and filling of coastal waters or wetlands only where feasible mitigation measures have been provided to minimize adverse environmental effects, and for only eight uses listed in the Coastal Act. Section 30233 of the Coastal Act also requires that the proposed dredging and fill of coastal waters be ***the least environmentally-damaging feasible alternative*** including the use of feasible mitigation measures to reduce adverse environmental effects (emphasis added). Please ensure that the final EIR includes a thorough analysis of all alternatives. If the CAD is the only place where certain contaminated sediments may be safely deposited, please include evidence of other disposal sites that were considered and deemed infeasible, including upland (landfill) disposal sites. Please also reference the processes and procedures that will determine which dredged materials are deposited in the CAD, which materials are deposited in open ocean sites, and which clean materials are deposited in areas suitable for beach use.

Please note the comments provided herein are preliminary in nature. More specific comments may be appropriate as the project develops and an alternative is selected. Thank you again for the opportunity to comment on the Draft EIR. We look forward to future collaboration on preservation of coastal resources within the South Coast region. If you have any questions or concerns, please do not hesitate to contact us at the Coastal Commission's Long Beach office.

Sincerely,

Mandy Revell
Coastal Program Analyst

Comment ID	Text
CCC-1	The comment generally summarizes the commenter's mission and introduces its comments on the DEIR. Because the comment omits any significant environmental issues, no additional response is warranted (CEQA Guidelines Section 15088). Generally, however, the preparers of this EIR thank the CCC for its review and comments.
CCC-2	The comment claims that the DEIR prematurely assumes that proposed use of nearshore ocean beaches is currently an approved location for the City to deposit dredged sediment. Please see the Response to Comment RWQCB (2)-3. An EIR does not allow any aspect of the proposed Project to move forward, but acts as the environmental analysis upon which decision-makers, including the lead and responsible agencies, can use to approve or disapprove a project and/or related permits. The DEIR properly discloses that several agencies need to permit several aspects of the proposed Project, including use of nearshore beaches. As discussed in Section 1.3 of the DEIR, as lead agency, the City has the primary responsibility to perform the environmental analysis. Under CEQA Guidelines Section 15086, lead agencies must "consult with, and request comments on, a draft Environmental Impact Report (EIR) from public agencies that are responsible agencies; trustee agencies with resources affected by the project; and any state, federal, or local agency that has jurisdiction by law with respect to the project or that exercises authority over resources that may be affected by the project." Table of the DEIR 1-1 notes that the CCC would be responsible for any placement of material in state tidelands (including nearshore beaches) and includes a discussion of the RGP 54 approval process. Accordingly, the DEIR presents a full analysis of the proposed Project, including all aspects requiring agency approval, for responsible and trustee agencies to review and provide comments, as well as for use in considering approval of applicable permits. Table 1-1 has been updated to clarify those aspects of the proposed Project that require approval by responsible agencies.
CCC-3	The comment recommends that the DEIR identify BMPs to ensure chemical constituents of concern do not become released into the water column after they have been released from the bottom of the barge during deposition. Please see Section 2.5.4, which provides a summary of BMPs that will be required as a condition of the proposed Project and incorporated into the proposed Project plans and contract specifications as appropriate. In addition, Section 3.8.3.4.1 presents a comprehensive analysis of the potential environmental effects of nearshore placement and includes specific BMPs and mitigation measures focused on reducing any potential for impacts. The following mitigation measures were identified: • **MM-HYDRO-1:** Conduct water quality monitoring during all construction activities. The project will obtain the required permits under the RWQCB and/or the USACE. Water quality monitoring will be implemented to comply with numeric receiving water limitations (Table 3-10) and other permit requirements during construction activities to minimize potential water quality impacts to Lower Newport Bay. • **MM-HYDRO-2**: Implement Water Quality BMPs. Construction contractors shall use BMP water quality controls to ensure compliance with the water quality standards identified herein. Measures could include use of a silt curtain during dredging and/or material placement, a floating boom to be maintained around the proposed Project area, and daily inspection of construction equipment for leaks or malfunction. Storage or stockpiling of materials related to construction may be prohibited where such materials could enter the waters of Lower Newport Bay.

Comment ID	Text
	Inclusion of BMPs and MM-HYDRO 1 and MM-HYDRO 2 were found to reduce the potential for impacts to water quality to less than significant, fully addressing the CCC's comment.
CCC-4	Please see comment CCC-3. Placement within the CAD facility would occur over a 6-month period with no proposed interim clean cover placement within that defined window. A similar approach was used during CAD facility placement at Port Hueneme, the City of Long Beach, and the Port of Long Beach during similar project construction events without the release of contaminants into the water column. During the modeling work to support the proposed Project, estimates for potential water column release were calculated and determined to be negligible. Water quality monitoring is standard during disposal events to look for potential sediment turbidity and chemical releases as a final precaution.
CCC-5	The comment accurately notes that no physical, recent, quantifiable survey has been conducted to assess existing conditions and to evaluate impacts that could occur with implementation of the proposed Project. Rather, potential impacts to aquatic flora and fauna from the proposed nearshore ocean disposal were described in Section 3.3 of the DEIR. The analysis presented instead relies on existing information, including most notably the biological survey completed to support the City's Marina Park project (City 2009). The biological survey was later augmented based on public input received during the DEIR process through the preparation of a biological assessment that evaluated sensitive habitats and species in the vicinity of beach replacement sites used for disposal of dredged sediment in support of the project. While the Marina Park biological survey was completed in 2009, conditions in the nearshore environment have likely not changed and the survey results remain accurate. In 2015, side-scan and underwater surveys were conducted in western Newport Beach to update information from the *1988 Supplemental Environmental Impact Statement/Environmental Impact Report 583 for the Phase II General Design Memorandum on the Santa Ana River Mainstem Project* (Chambers Group, Inc., and Moffatt & Nichol 2016) on nearshore resources at disposal areas. The survey confirmed habitat types (mostly sandy bottom) and habitat conditions remained the same. Additionally, the nearshore community tends to include a similar set of species throughout mainland southern California because only a limited number of species are adapted to the harsh open coast sand bottom environment (USACE 2012). The City believes that the analysis described in Section 3.3 and supporting documentation fully referenced in the DEIR are adequate to assess impacts that could result from the proposed Project. The comment requests an assessment on potential effects to benthic infauna as well as the indirect effects that may result from bioaccumulation and biomagnification of contaminants of concern. Benthic infauna at the CAD location would be displaced during excavation. Benthic organisms and other biota (fish, birds, etc.) adjacent to the site are not predicted to be impacted based on the studies that have been conducted (as noted in the *Lower Newport Bay Federal Channels Dredging, Sampling and Analysis Program Report* [Anchor QEA 2019a; Appendix B to the BODR]). Bioassays showed the materials to be placed into the CAD are not harmful to animals when placed in direct and indirect contact with the sediments. Also, chemical accumulation in animal tissues was also not at a level that would suggest that there are risks to the higher trophic level animals that might consume them. The results of water quality partitioning calculations also suggest that chemicals of concern will not be released into the overlying water either during placement or over time after placement.

Comment ID	Text
CCC-6	The comment requests information related to the potential impacts to recreation in the Harbor during construction of the CAD. Please see Master Response 4. The potential impacts to recreation during construction and over the life of the proposed Project were fully analyzed in Section 3.11. Section 3.11 fully discloses the potential impacts to recreation both during initial CAD construction as well as during the periods when the CAD facility will be open for residents' use. As discussed in Section 3.11, there would be short-term restrictions on some recreational activities in the immediate area of the CAD during construction. Most recreational activities could be sufficiently relocated to other appropriate areas within Lower Newport Harbor. Approximately 2 years following construction of the CAD facility and placement of an interim cap, the City and its residents would have a second opportunity for a 6-month period to place additional material (Phase 6). During this 6-month period, boating in the immediate area of the CAD facility would also be restricted. While most recreational activities could be relocated, interference with recreational sailing and regattas in Newport Harbor is anticipated during CAD facility construction, which could result in a potentially significant impact. Mitigation measure MM-REC-1, Coordinate with Sailing Centers, would be implemented to reduce this potential impact to less than significant. The comment suggests that disposal could be continuous over 10 years. As discussed in the DEIR (Section 2.5), the City's original proposal was to allow the City and its residents an opportunity for up to 10 years to place material within the CAD facility. In response to public comments received on the NOP, the City modified that approach to an abbreviated timeline of 6 months approximately 2 years after the CAD facility was constructed. The intention of this 2-year period is to allow the City and its residents time to develop a dredge design, obtain applicable permits and approvals, and select a contractor so dredging can be coordinated within that 6-month window. As discussed in Section 2.3.2.1 of the DEIR, if the Final EIR is certified and permitted, the City would seek to modify the Regional General Permit 54 (RGP 54) for dredging with the RGP 54 Plan Area and to include disposal within the CAD facility. Alternatively, applicants may apply directly to the regulatory agencies, and dispose of their material within the CAD facility (assuming the CAD facility is certified and permitted).
CCC-7	The comment recommends that the Final EIR include feasible mitigation measures to reduce potential environmental impacts and include a thorough analysis of all alternatives. Please see Section 6 of the DEIR, which includes a robust alternatives analysis considering a no project scenario as well as alternative disposal sites, including a discussion of other disposal sites that were considered and deemed infeasible. Section 6.2.2 analyzes the disposal of Material at Port Fill Site, while Section 6.3.2 analyzes upland disposal. In response to referencing the processes and procedures that will determine which materials are deposited in the CAD, deposited in open ocean sites, and deposited in areas suitable for beach use, please see Section 2.1 of the DEIR, which outlines the process for determining sediment suitability and placement options. Figure 1-2 presents the results of DMMT coordination and identifies sediment that is suitable for open ocean disposal or requires an alternate disposal option. Section 6.4 includes a clear comparison of all alternatives. In addition, the comment requests that the Final EIR reference the processes and procedures that will determine which dredged materials are deposited in the CAD, which materials are deposited in open ocean sites, and which clean materials are deposited in areas suitable for beach use.

Response to Comments

Draft Clean Water Action Section 401 Water Quality Certification and Order for Dredged or Fill Discharges to Waters of the United States (Draft Order)
for
City of Newport Beach, Permittee
Lower Newport Bay Confined Aquatic Disposal Construction Project (CAD Project)
WDID No. 302021-09

Comment Deadline: September 16, 2022

Comment Letter #	Date	Commenter	Affiliation
OCCK-1	September 6, 2022	Lauren Chase	Orange County Coastkeeper
OCCK-2	September 16, 2022	Lauren Chase	Orange County Coastkeeper
FNH	September 16, 2022	Jennifer F. Novak	Friends of Newport Harbor, LLC

The Santa Ana Regional Water Quality Control Board (Santa Ana Water Board) also received 95 letters of support for the CAD Project during the comment period on the Draft Certification from various members of the public. As those letters of support did not propose any changes to the Draft Certification, there are no responses to those comments in this document.

Changes made in response to comments are outlined below and incorporated into the final Certification issued by the Santa Ana Water Board's Executive Officer. Please contact Claudia Tenorio at (951) 782-4963 or Claudia.Tenorio@waterboards.ca.gov with any questions.

Comment #	Comment	Response
OCCK-1.1	"[O]n page 6 of the draft, is the reference to R8-2022-0037 intended to reference R8-2011-0037?"	The commenter is correct that this was an error. A correction has been on page 6 of the final Order to reflect the correct Order No. R8- 2011-0037.

Comment #	Comment	Response
OCCK-2.1	"Coastkeeper recognizes the contaminated sediment is already present in the Bay. Indeed, Coastkeeper notes the Bay is impaired for, among other parameters, DDT and PCBs. Thus, Coastkeeper is concerned about the potential for reintroduction of materials into the already-impaired marine environment via one or a combination of: burrowing, propeller disturbance, anchor incidents, or uneven layering, particularly during the two-year, interim 1' cap period. As noted in the Coastal Commission's Staff Report, '[t]he [City] estimates that private vessel anchors will likely penetrate up to one foot into the seabed' – i.e., through the interim cap layer, even assuming no other disturbances. Coastkeeper notes CDFW previously asked the City to use 'a thicker interim containment layer (>one-foot thick) to minimize mobilization of contaminated sediments that could occur from vessels anchoring or mooring....' Coastkeeper renews that ask here."	The Santa Ana Water Board acknowledges and shares the concern over the proposed thickness of the interim cap, and the potential resuspension of contaminated sediment materials due to burrowing. The Order has been updated to include visual bioturbation monitoring, if placement of dredged material from outside the Federal Channel has not been initiated within three (3) months of the installation of the interim cap layer. If recolonization of benthic communities occurs during the 3-month time period, the interim cap thickness shall be increased to 18 inches to provide adequate protection from resuspension and contaminant flux as a result of burrowing marine organisms. The Order only allows a six (6)-month window for placement of additional dredged materials from outside the Federal Channels in the CAD, therefore recolonization of benthic organisms is not anticipated between the period of time the interim cap and final cap layers are placed. Vessel anchoring and bottom disturbing activities within the CAD footprint are not allowed. As a result, the Santa Ana Water Board had no significant concern with anchors penetrating the interim cap layer or resuspension of contaminated sediment from propellers.

Comment #	Comment	Response
		However, clarifying language has been added to the final Order that anchoring or any other bottom disturbing activities, not associated with the Project activities, are not allowed within the CAD footprint until the final cap layer has been placed and has been tested to ensure that the final cap layer meets or exceeds three feet in thickness throughout the CAD and that no contaminant flux is occurring. Additionally, as outlined in the Permittee's environmental document, the Permittee will implement short-term restrictions on recreational activities in the immediate area of the CAD during the construction period, inclusive of the 6-month placement period, to avoid disturbance of the interim cap. The commenter is incorrect about the interim cap layer period. Approximately two (2) years following the completion of the dredging of the CAD facility, the placement of material from the Federal Channels in the CAD, and the installation of an interim cap, there would be one 6-month period for the Permittee and its residents to place up to 50,000 cubic yards (CY) of dredged material from outside of the Federal Channels. If the 50,000 CYs of material is not achieved within the 6-month time period, the Permittee would close the CAD facility. There would only be 6 months between the placement of the interim cap and final cap layers.
OCCK-2.2	"Coastkeeper also urges Board staff to think carefully about the potential for bioturbation disturbances. In monitoring the City of Long Beach's pilot North Energy Island Borrow Pit CAD site ten months following cap completion, consultants found 'more burrow mounds present than were expected.' Though the official burrow count and source were both unknown, this finding 'was a subject of concern, since	Please see response to OCCK-2.1 above concerning the interim cap. The Santa Ana Water Board will consider bioturbation in its review and approval of the *Final Cap Placement Plan* and has added a requirement to the Order that bioturbation monitoring be conducted for both the interim and final cap layers, with bioturbation and benthic community monitoring for the final cap to be

Comment #	Comment	Response
	these burrows may have been created by organisms capable of penetrating the [contaminated] material and transporting contaminates to the surface.' In that instance, the contaminated material was covered with a 1.0-1.5 m (approximately 3.3-5.2') cap layer; here, the interim and final cap layers will be 1' and 3', respectively. Coastkeeper has requested from the City and hopes to have the opportunity to review long-term monitoring reports from existing CAD facilities to shed further light on performance decades past completion."	conducted annually for a minimum of 5-years after the project has been completed.
OCCK-2.3	"The Draft 401 notes project activities 'would temporarily displace benthic habitat and infauna from the dredging footprint (348,000 square feet), making the benthic habitat and infauna unavailable for special-status species fish to forage.' Per the Draft 401, 'benthic habitat in this area is expected to recolonize within approximately two years.' The Draft 401 requires the City to compare the pre-construction benthic community to post-construction conditions and, if the City finds post-construction degradation, mitigate impacts at a minimum of 1:1 ratio. Given the interim cap will remain open for approximately two years – enough time for the benthic community to recolonize – before additional placements and final capping, benthic habitat could be displaced twice: once after interim and again after final capping. Thus, Board staff should require benthic habitat monitoring after interim capping as well as final capping to determine effects on	The commenter is incorrect about the interim cap being open for 2 years. Please see response to OCCK-2.2 regarding the interim cap layer period. There would only be one 6-month period between the placement of the interim cap and final cap layers. It is unlikely that benthic communities would be able to completely recolonize the Project site within that time period, especially if additional dredged materials are placed in the CAD as currently proposed. Impacts to benthic habitat are expected to be temporary and limited to the dredging footprint for the CAD facility. However, the Santa Ana Water Board recognizes that there is a potential for benthic communities to be impacted twice if communities are able to recolonize prior to the final cap being placed. The Order has been updated to require bioturbation monitoring during the period of time that the interim cap has been completed but dredged materials have not yet been deposited into the CAD. If recolonization does occur during this time period, the Order may be revised to require a mitigation ratio of

Comment #	Comment	Response
	the benthic community. If the benthic community is twice disturbed, Board staff should adjust the minimum mitigation ratio accordingly.”	2:1 (mitigation:impacts), depending on the degree of recolonization.
OCCK-2.4	“Additionally, given the potential for unsuccessful mitigation due to the impacts of *Caulerpa prolifera*, among other environmental stressors, Coastkeeper requests the Regional Board include a higher mitigation ratio than the Southern California CEMP starting ratio of 1.38:1.”	In 2020, the Permittee conducted harbor-wide eelgrass habitat surveys. According to the surveys, eelgrass is not present in or adjacent to the CAD facility and impacts to eelgrass are not anticipated. The Santa Ana Water Board recognizes there are risks and uncertainties associated with Permittee-responsible compensatory mitigation. It is the intent of the California Eelgrass Mitigation Policy (CEMP) to ensure that there is no loss of eelgrass habitat. As a result, the minimum mitigation to impact ratio of 1.38:1 is recommended to account for the failure risk. The Santa Ana Water Board is not recommending a higher compensatory mitigation ratio for eelgrass. However, impacts to eelgrass, if any, must be mitigated through conformance with the CEMP, which defines the mitigation ratio and other requirements to achieve mitigation for significant eelgrass impacts. Per the CEMP, compensatory mitigation should commence within 135 days following the initiation of the in-water construction resulting in the impact to eelgrass habitat. Delays in mitigation initiation in excess of 135 days warrant an increased final mitigation ratio. Additionally, if compensatory mitigation cannot be completed onsite, the mitigation ratio shall increase to a 3:1 ratio. The Order has been revised to reflect this change.
OCCK-2.5	“Coastkeeper requests a longer post-construction monitoring period than the ten-year period proposed in the Draft 401.”	The Santa Ana Water Board recognizes that the Lower Newport Bay Harbor is very active. Once boating activities resume there is a need to ensure that degradation of waters of the United States does not occur as a result of

Comment #	Comment	Response
		the proposed Project. The Order has been updated to require 15 years of post-construction monitoring.
OCCK-2.6	"Coastkeeper also requests Board staff revise the Draft 401 to include monitoring requirements for the time period following the placement of the interim cap layer, which requirements should include: visual monitoring for burrows or other disturbances, bathymetry surveys, porewater monitoring for metals and total PCBs, and – as discussed above – benthic community monitoring."	The Order requires the Permittee to conduct several bathymetric surveys, including following the placement of the interim cap layer to ensure the material has been placed evenly and at the proper depth. Additionally, the Order requires the Permittee to submit an *Interim Cap Placement Cap Plan,* which includes sediment characterization data of material to be used for the interim cap layer. The Order has been revised to include visual bioturbation monitoring if material outside of the Federal Channels are not placed within the CAD within three (3) months of interim cap placement.
OCCK-2.7	"Finally, given public concerns about the CAD, Coastkeeper requests all reports, notices, notifications, amendments, plans, and other filings contemplated by the Draft 401 be made available to the public proactively without the need for Public Records Act requests."	The majority of the documents relating to the CAD Project will be accessible to the public via the public reports portal for the California Integrated Water Quality System (CIWQS) database. The public may view Project documents following the Facility-At-A-Glance report link and entering the facility name (i.e., Project name) or WDID No. 302021-09 Once the facility report is generated, please follow the instructions below to access public documents: • Select the Place ID No. • In the Regulatory Measure tab, select the link under Order No. Unfortunately, due to limited resources, the Santa Ana Water Board cannot guarantee that all of the requested documents will be readily accessible without a Public Records Act request.

Comment #	Comment	Response
OCCK-2.8	"As a closing remark, Coastkeeper reiterates its concern with continuing outdated, status quo, 'just bury it' practices of addressing toxins in the marine environment, and in our environment generally. Future generations should not continue to be saddled with their ancestors' lack of diligence. Coastkeeper hopes to see the City, USACE, and regulators embrace a paradigm shift in their approach to contaminant clean-up via prioritizing – or, at the very least, considering – treatment over concealment and sediment remediation over burial."	The Santa Ana Water Board acknowledges your comments and directs the commenter to the Permittee's Environmental Impact Report (EIR) that includes the alternative analyses for the Project. The City of Newport Beach certified the EIR on May 25, 2021, concluding that the CAD facility was the preferred alternative and least environmentally damaging practicable alternative (LEPDA). Removal of the accumulated sediment in the Federal Channels is necessary to maintain the required navigation depths. The Project would provide a location to contain contaminated sediment and reduce the risk of resuspension of contaminants within the Federal Channels due to vessel traffic (e.g., propeller disturbance or anchoring).
FNH-1	The Santa Ana Water Board violated the due process rights of the commenter and the public by providing a two-week public comment period on the Draft Certification, which was not sufficient to provide an "opportunity to be heard at a meaningful time and in a meaningful manner." The Board also violated due process by not holding an adoption hearing. "The lack of adequate time to provide meaningful comment, failure to allow the public to provide oral comments at an adoption hearing, and failure to specifically address prior comments, deprives the public of its due process and directly violates the State Water Resources Control Board Procedures governing these actions."	Projects requiring issuance of a Clean Water Act section 401 water quality certification from a Regional Water Board are typically adopted by the Regional Water Board's Executive Officer without a hearing. The Executive Officer of the Santa Ana Water Board is authorized to issue certifications under Water Code section 13223 pursuant to delegated authority from Santa Ana Water Board Resolution R8-2019-0056. California laws regulating the issuance of Clean Water Act section 401 water quality certifications require two different types of written public comment periods, but do not require public hearings. California Code of Regulations, title 23, section 3858 specifies that there must be a 21-day comment period on all applications for a water quality certification; however, the same code section provides that while adoption hearings on certifications "may" be held, it does not require them. For certification applications that receive comments on the underlying application or that have substantial public interest, Section IV.B.6 of the *State Policy for Water*

Agenda Item 17.a
CDP App. No. 5-21-0640
Orange County Coastkeeper
& Surfrider Foundation
Requesting Denial of CDP

October 6, 2022

SENT VIA ELECTRONIC MAIL
Mandy Revell, Coastal Program Analyst
California Coastal Commission, South Coast District Office
301 Ocean Blvd., Suite 300, Long Beach, CA 90802
Mandy.Revell@coastal.ca.gov

To: CDP App. No. 5-21-0640 (City of Newport Beach CAD Facility)

Dear Ms. Revell and Commission Staff:

Orange County Coastkeeper[1] and Surfrider Foundation appreciate the opportunity to submit comments regarding the City of Newport Beach's (the "City's") pending application for the construction of a Confined Aquatic Disposal (CAD) facility in Newport Bay, the ancestral home of the Gabrieleno/Gabrielino Tongva and Juaneño Band of Mission Indians Acjachemen Nation peoples.

While we appreciate Commission staff's thoughtful consideration and sound inclusion of helpful special conditions such as mandatory silt curtains, community concerns persist. As proposed, we do not feel the CAD is the least environmentally-damaging feasible alternative, particularly in a recreational harbor already suffering from *Caulerpa*. Thus, we respectfully request the Commission deny the CDP. If Commissioners are inclined to approve the CDP, we request the Commission include additional conditions and mitigation measures such as a thicker interim cap layer, pre-disposal treatment, and a sediment monitoring plan.

Since submitting prior comments, Coastkeeper engaged Dr. William J. Rogers, an expert environmental toxicologist, to opine on the CAD. Dr. Rogers's report is included in the Appendix to this letter (the "Expert Report"). Coastkeeper thanks Dr. Rogers for his insight and encourages staff and Commissioners to review and consider his report, particularly the "Summary of Opinions." While not an exhaustive list, core concerns are:

1. The City wrongfully characterizes the unsuitable sediment as harmless;
2. The 1.0' thick interim cap layer does not adequately account for bioturbation;
3. The City has not earnestly analyzed alternatives and, in particular, failed to consider (i) additional costs and/or (ii) a two-step process involving treatment; and
4. The City has not developed an adequate sediment monitoring plan.

[1] For background information on Orange County Coastkeeper, our mission, and our members' relationship to Newport Bay, Coastkeeper respectfully directs staff and Commissioners to our previously submitted comment letter, incorporated herein by reference, included in hearing materials "Correspondence Exhibit A."

I. The City Wrongfully Characterizes the Sediment as Harmless.

The City continually misrepresents the unsuitable sediment. In a recently issued fact sheet, the City noted: "[t]he sediment identified for in-harbor placement is not considered hazardous or toxic under the stringent definitions of the EPA. The sediment has been tested and is not toxic or hazardous as defined by state or federal regulations. These terms have very specific regulatory definitions that do not apply to the material being dredged. Rather, the material is considered 'unsuitable' for open ocean disposal at EPA's dredge material disposal site."[2] This is a material mischaracterization.

There is a reason why this material is unwanted at the LA-3 Ocean Dredged Material Disposal Site. The City's 2018 individual core sediment sampling is instructive. The Effects Range Low (ERL)[3] for mercury is 0.15 mg/kg and Effects Range Median (ERM)[4] is 0.71 mg/kg. The City's sampling detected mercury concentrations below the ERL in only 1 instance; concentrations exceeded the ERM in <u>13 of 21</u> samples – over half – with results as high as <u>5 mg/kg</u>. The ERL for Total PCBs is 22.7 ug/kg and ERM is 180 ug/kg. In the City's sampling, Total PCBs were <u>never</u> below the ERL; concentrations exceeded the ERM in <u>3 of 6</u> samples with results as high as <u>403 ug/kg</u>. Coastkeeper recognizes CAD disposal is an EPA-supported method of managing sediment containing <u>low levels of pollutants,</u> but disputes whether the City's results show "low levels."

The City also stated: "[t]esting showed that the unsuitable dredge material was not harmful to aquatic organisms" and "tested species were healthy and not affected or harmed by weeks of direct contact with the unsuitable material."[5] However, Section 3.4.2 of the City's EIR discusses bioaccumulation data comparing chemical concentrations in tissues of organisms exposed to project material to those exposed to reference sediment. Per Section 3.4.2.1, mean PCB congener concentrations were up to <u>**106x**</u> greater in tissues of bent nosed clam (*Macoma nasuta*) - a burrowing organism potentially present in Newport Bay (see below) – exposed to project material versus reference sediment. Per Section 3.4.2.2, mean DDT concentrations were up to <u>**55.4x**</u> greater in sandworm (*Nereis virens*) tissue exposed to project material versus reference sediment. Thus, organisms were affected by the sediment. For a further discussion on ecological risk assessment, please see the attached Expert Report (*see* Summary of Opinions at 4).

II. The 1.0' Interim Cap Does Not Account for Bioturbation.

Preeminent of our concerns with burying untreated, unsuitable sediment is the potential for reintroduction of contaminates into the marine environment, creating the possibility for bioaccumulation, biomagnification, and methylation. Page 26 of the Staff Report notes, "[o]nce the approximately 112,500 cubic yards of contaminated sediment have been placed within the CAD facility, it would be covered with approximately 33,600 cubic yards of clean sediments to form a cap to prevent migration of contaminants into the water column or the surficial sediment layer." This ignores the two year interim period.

The City proposes leaving the unsuitable materials covered by a 1.0' thick interim cap layer for two years, prior to subsequent placements and final capping. Coastkeeper and the Santa Ana Regional

---

[2] City of Newport Beach, *The Facts Behind the City's Dredging Project and In-Harbor Sediment Plan*, https://www.newportbeachca.gov/home/showpublisheddocument/72385/637989365359170000 (last visited Oct. 4, 2022, 4:00 PM).

[3] The effects range low (ERL) indicates the concentration below which toxic effects are scarcely observed or predicted.

[4] The effects range median (ERM) indicates the concentration above which effects are generally or always observed.

[5] City of Newport Beach, *supra* note 2.

Water Quality Control Board (the "Regional Board") "share[ ] concern over the proposed thickness of the interim cap, and the potential resuspension of contaminated sediment materials due to burrowing."[6] While the Regional Board issued a 401, Coastkeeper understands they did so under a mistaken understanding that the interim cap would be present for three months, not two years.

As discussed on page 40 of the Staff Report, the City's consultant "determined the design bioturbation depth by <u>estimating</u> the most extreme burrowing depth of organisms with the potential to reside at the site." The City had to estimate this depth, as it does not know which benthic organisms are likely to be present in the CAD area, let alone their burrowing depth. Commission staff flagged this during the City's CEQA review and requested "quantitative subtidal and biological surveys in and near the proposed project location footprint that would describe the nature of the bottom habitat and fish and invertebrate species populations specific to the project area," as well as "a thorough assessment of potential direct effects on benthic infauna, and also indirect effects that may result from bioaccumulation and biomagnification."[7] Per its response, the City declined to alter course.[8]

The City selected a 6.0" biologically active zone, which the EPA considers *minimal*.[9] A relevant EPA guidance document states: "where contaminated sediments are capped with clean substrate, <u>the thickness of the cap should **exceed** the depth to which infauna burrow</u>, or the depth of the biotic zone, in order to avoid infiltration of contaminants through the cap and into the water column."[10] As discussed above, the City cannot possibly meet this obligation where it does not know burrowing depths. EPA's guidance document lists "Examples of Deep-Burrowing and/or Feeding Benthos,"[11] including some Coastkeeper believes to be present or potentially present in Newport Bay:[12]

- *Pachycerianthus fimbriatus* (Tubedwelling aneomone), sediment depth to 39.3"
- *Neotrypaea caliofrniensis* (Bay ghost shrimp), sediment depth to 29.5"
- *Tagelus californianus* (California Jack Knife Clam), sediment depth to 20"
- *Glycera americana* (American bloodworm), sediment depth to 15.7"
- *Urechis caupo* (fat innkeeper worm). sediment depth to 14"
- *Macoma nasuta* (Bent-nosed clam), sediment depth to 3.9"- 7.8"[13]

Coastkeeper members describe some of the above species as coveted local fishing bait, underscoring bioaccumulation concerns. For a further discussion on bioturbation, please see the attached Expert

---

[6] Santa Ana Regional Water Quality Control Board, *Response to Comments: Draft Clean Water act Section 401 Water Quality Certification and Order for Dredged or Fill Discharges to Waters of the United States (Draft Order) for City of Newport Beach, Permittee, Lower Newport Bay Confined Aquatic Disposal Construction Project (CAD Project)*, at OCCK-2.1 (attached in the Appendix).
[7] EIR (Anchor QEA, *Final Environmental Impact Report: Lower Newport Bay Confined Aquatic Disposal (CAD) Construction Project (PA2019-020)* 14 (2021) (hereinafter, the "EIR") (relevant portion attached in the Appendix).
[8] *Id.* (relevant portion attached in the Appendix hereto).
[9] U.S. EPA, EPA/600/R-15/176: ERASC-015F, *Determination of the Biologically Relevant Sampling Depth for Terrestrial and Aquatic Ecological Risk Assessments*, https://cfpub.epa.gov/ncea/erasc/recordisplay.cfm?deid=310058, 17 (2015) (emphasis added) (hereinafter, the "EPA Guidance Document"); Staff Report p. 40.
[10] EPA Guidance Document.
[11] *Id.* at Table 3.
[12] CA Fish & Wildlife: Back Bay Science Center, *Marine Life Inventory (MLI) Observations*, https://www.anecdata.org/user/BBSC/posts?page=1 (last visited Oct. 5, 2022, 3:30 PM); Newport Bay Conservancy, *Marine Invertebrates*, https://newportbay.org/wildlife/marine-life/marine-invertebrates/ (last visited Oct. 5, 2022, 3:30 PM); Orange County Coastkeeper, *Newport's Eelgrass and its Residents: Mollusks*, https://www.coastkeeper.org/newports-eelgrass-residents-mollusks-2/ (last visited Oct. 5, 2022, 3:30 PM).
[13] As discussed above, the City's EIR notes mean PCB congener concentrations were up to 106x greater in *M. nasuta* tissue exposed to project material versus reference sediment.

Report, "Bioturbation" and Summary of Opinions at 2.

III. The City Has Not Earnestly Analyzed Alternatives.

a. The City Has Not Considered a Two-Step Process Involving Treatment First, then Disposal.

Referencing Coastkeeper's prior request for remediation-based alternatives, the Staff Report states: "in-situ remedial alternatives . . . were not considered because the sediment from the federal channels needs to be removed for navigation, and treating the sediment in place would be counterproductive to that purpose."[14] We do not believe it would be counterproductive to treat the sediment first, then remove and dispose of it. Unfortunately, as discussed on pages 22-24 of the Staff Report, the City has not considered such a two-step process.[15] There is no evaluation of how an additional year of leaving the sediment in place may impact the overall dredging project purpose if the sediment could then be disposed of, post-treatment, nearshore or in a safer CAD. In fact, the U.S. Army Corps of Engineers' (the "USACE's") Draft Environmental Assessment indicates that if the CAD is not approved, they will leave the unsuitable sediment in place (presumably, forever?), thus indicating leaving the sediment where it is for some additional time may in fact, be feasible.

b. The City Has Not Considered the Cost of Additional Permit Conditions in Comparing Alternatives.

It is Coastkeeper's understand that the City rejected alternatives including upland disposal on account of costs. Since the EIR, however, the CAD project has evolved in meaningful ways impacting the bottom line. Sound permitting requirements such as mandatory silt curtain use and monitoring, visual bioturbation monitoring, and additional years of post-construction monitoring all come with a price tag not previously considered. Thus, the City's cost comparison is outdated and alternatives should be re-considered in light of all known project requirements. With this comment, please note that the undersigned are not advocating affirmatively for land-based disposal and share Commission staff's environmental justice concerns. We are, however, advocating for an honest and thorough alternatives comparison based on accurate, up-to-date facts and figures. For example, an honest evaluation may have considered in situ remediation as a primary step that would eliminate contamination altogether. For a further discussion on the City's inadequate alternatives analysis, please see the attached Expert Report (*see* Summary of Opinions at 1, 5-8, and 10).

IV. The City Has Not Developed an Adequate Sediment Management Plan

As discussed in the attached Expert Report (*see* Summary of Opinions at 3-4, and 9), the City has not developed an adequate sediment management plan. Based on the silt/clay composition of the dredged materials, particles are expected to stay suspended for much longer than four hours before settling, if they settle at all. Modeling also indicated contaminated material would be lost to the area outside the CAD. We note Special Condition 5(K) requires clean material to extend beyond the edges of the CAD facility to cover the newly settled material, but wonders: (1) how far beyond the edges of the CAD will clean material be placed and (2) how will the City confirm all newly settled material has been

---

[14] Staff Report, page 4. (Cal. Coastal Comm'n, 5-21-0640, *Staff Report: City of Newport Beach, Lower Newport Harbor CAD,* 4 (Sept. 30th, 2022)).

[15] *See also* EIR, Section 6 (analyzing alternatives including no project, no CAD construction/upland trucking of material, reduced dredging/smaller CAD, and an alternative location CAD and considering, but not analyzing alternatives including electric dredger use and port fill site disposal).

covered? A sediment sampling plan must be included as a better measure of CAD efficacy. Finally, Coastkeeper has the following miscellaneous questions/comments on the Staff Report:

- Staff Report, page 2 lists the volume of unsuitable material to be placed in the CAD from the Federal Channels as both 112,500 cy and 106,900 cy. Which is correct?
- Coastkeeper has reason to believe 9,000 cy is an insufficient volume for a 1.0' cap across the 590' x 590' facility and requests confirmation of the requisite interim cap volume.
- Staff Report, page 20 outlines the CAD facility design to accommodate 199,500 cy of sediment, but 112,500 (unsuitable material from Federal Channels) + 50,000 (additional material from outside Federal Channels) + 9,000 (interim cap) + 33,600 (final cap) = 205,100 cy – i.e., greater than the 199,500 cy the CAD facility is designed to accommodate.
- Special Condition 2 requires the Permittee to submit a Final Cap Placement Plan 90 days prior to the installation of the <u>interim</u> cap. Should this be 90 days prior to the installation of the <u>final</u> cap? Will a similar placement plan be required for the interim cap?
- Special conditions such as silt curtain use and *Caulerpa* monitoring are appreciated and crucial. To the extent the City and its residents will place additional material into the CAD during the 6-month window, how will these crucial conditions be ensured in forthcoming permits and carried out by individual residents?
- We appreciate staff's inclusion of Special Condition 10 regarding cultural monitoring. While we defer to indigenous leaders to best represent their nations and communities, we lament that the USACE denied the Regional Board the opportunity to complete tribal consultations by deeming their 401 review waived for the dredging of material to go into the CAD.
- Staff Report, page 29 quotes the OMMP that "silt curtains may be required to reduce turbidity . . ." We request the OMMP be updated to reflect mandatory silt curtain use.

V. Conclusion

The undersigned understand and agrees with the need to dredge and address the contaminated sediment currently in the Bay. However, we disagree that dredging up burying "away" unsuitable sediment, without full environmental protections, is the best solution. For as painfully, repeatedly demonstrated on our precious planet, there is no such thing as "away." We are grateful for the opportunity to provide these comments. If you have any questions, please feel free to contact Coastkeeper Staff Attorney, Lauren Chase at (714) 850-1965, ex. 1006 or via email at lauren@coastkeeper.org.

Regards,

Lauren Chase
Staff Attorney
Orange County Coastkeeper

Mandy Sackett
California Policy Coordinator
Surfrider Foundation

Michelle Giron
Chair, Newport Beach Chapter
Surfrider Foundation

STATE OF CALIFORNIA - NATURAL RESOURCES AGENCY GAVIN NEWSOM, *GOVERNOR*

CALIFORNIA COASTAL COMMISSION

SOUTH COAST DISTRICT OFFICE
301 E. OCEAN BLVD., SUITE 300
LONG BEACH, CALIFORNIA 90802-4830
(562) 590-5071 FAX (562) 590-5084

WWW.COASTAL.CA.GOV

Date: September 23, 2022

IMPORTANT PUBLIC HEARING NOTICE
COASTAL PERMIT APPLICATION

PERMIT NUMBER **5-21-0640**

APPLICANT(S) City of Newport Beach

PROJECT DESCRIPTION:

Construction of a Confined Aquatic Disposal Facility where dredged sediment unsuitable for open ocean disposal can be contained, including placement of a final 3-foot thick cap layer, deposition of clean sandy sediments along nearshore ocean beaches, and implementation of Operations Management and Monitoring Plan.

PROJECT LOCATION

Within Lower Newport Harbor and Nearshore Ocean Beaches, Newport Beach, CA

HEARING DATE AND LOCATION:

DATE **Friday, October 14, 2022**
TIME **9:00 AM** **ITEM NO: F17a**
PLACE Virtual and in Person. See address below.

PHONE (415) 904-5200

HEARING PROCEDURES:

PLEASE NOTE THAT THIS WILL BE A HYBRID MEETING, WITH BOTH VIRTUAL AND IN PERSON PARTICIPATION ALLOWED. Please see the Coastal Commission's Hybrid Hearing Procedures posted on the Coastal Commission's webpage at www.coastal.ca.gov for details on the procedures of this hearing. If you would like to receive a paper copy of the Coastal Commission's Hybrid Hearing Procedures, please call 415-904-5202.

The in-person hearing will be held at the Best Western Island Palms Hotel, 2051 Shelter Island Drive in San Diego, CA 92106. The Commission strongly encourages continued participation virtually through video and teleconferencing due to changing Covid-19 conditions.

AVAILABILITY OF STAFF REPORT:

A copy of the staff report on this matter will be available no later than 10 days before the hearing on the Coastal Commission's website at http://www.coastal.ca.gov/mtgcurr.html. Alternatively, you may request a paper copy of the report from Mandy Revell, Coastal Program Analyst, at the South Coast District Office.

IMPORTANT PUBLIC HEARING NOTICE
COASTAL PERMIT APPLICATION

SUBMISSION OF WRITTEN MATERIALS:
If you wish to submit written materials for review by the Commission, please observe the following:

- Submit your written materials to the Commission staff no later than 5:00 p.m. on the Friday before the hearing (staff will then distribute your materials to the Commission). Note that materials received after this time will not be distributed to the Commission.

- Mark the agenda number of your item, the application number, your name and your position in favor or opposition to the project on the upper right hand corner of the first page of your submission. If you do not know the agenda number, contact the Commission staff person listed on page 2.

- A current list of Commissioners' names and addresses is available on the Coastal Commission's website at http://www.coastal.ca.gov/roster.html. If you wish to submit materials directly to Commissioners, we request that you mail the materials so that the Commissioners receive the materials no later than Thursday of the week before the Commission meeting. You must provide Commission staff with a copy of any materials that you provide to Commissioners. Please mail the same materials to all Commissioners, alternates for Commissioners, and the three non-voting members on the Commission with a copy to the Commission staff person listed on page 2.

- You are requested to summarize the reasons for your position in no more than two or three pages, if possible.

Please note: While you are not prohibited from doing so, you are discouraged from submitting written materials to the Commission on the day of the hearing, unless they are visual aids, as it is more difficult for the Commission to carefully consider late materials. The Commission requests that if you submit written copies of comments to the Commission on the day of the hearing, that you provide 20 copies.

ALLOTTED TIME FOR TESTIMONY:
Oral testimony may be limited to 3 minutes or less for each speaker depending on the number of persons wishing to be heard.

ADDITIONAL PROCEDURES:
The above item may be moved to the Consent Calendar for this Area by the Executive Director when, prior to Commission consideration of the Consent Calendar, staff and the applicant are in agreement on the staff recommendation. If this item is moved to the Consent Calendar, the Commission will either approve it with the recommended actions in the staff report or remove the item from the Consent Calendar by a vote of three or more Commissioners. If the item is removed, the public hearing described above will still be held at the point in the meeting originally indicated on the agenda.

No one can predict how quickly the Commission will complete agenda items or how many will be postponed to a later date. The Commission begins each session at the time listed and considers each item in order, except in extraordinary circumstances. Staff at the appropriate Commission office can give you more information prior to the hearing date.

Questions regarding the report or the hearing should be directed to Mandy Revell, Coastal Program Analyst, at the South Coast District Office.

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 2:33 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Salli

Date: October 7, 2022
Time: 9:33 pm
Page URL:
https://friendsofnewportharbor.org/?utm_source=social&utm_medium=paid&utm_campaign=save%20the%20bay&hsa_acc=515797409268691&hsa_cam=23851717150640773&hsa_grp=23851717150660773&hsa_ad=23851717150700773&hsa_src=ig&hsa_net=facebook&hsa_ver=3&fbclid=PAAabTlgFlPMm-p4CE2_eThH5w1saKInuqDhEzQJxNWJNZRfw-uFy3cBJPaF4_aem_AS54h_SfQ8tFTUiOYDridDM9DyiFl9_Qiv3pCKYtU_wUeJd77MXrivlz-4qhm8Ilos0CvVju9hEBwPoUaxZ6_ZNdNQ9GEDUG0qEaF0HXJzGw4adppUgRcpILvdPAyFZYFWow4WvbzJ4C1JJSjGccD_bi
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0_2 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/15E148 Instagram 255.1.0.18.105 (iPhone12,3; iOS 16_0_2; en_US; en-US; scale=3.00; 1125x2436; 405816327)
Remote IP: 108.184.70.23
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 2:32 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Vickie

Date: October 7, 2022
Time: 9:32 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 104.34.18.221
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 2:13 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Kathleen Masenga

Date: October 7, 2022
Time: 9:13 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Mobile/15E148 Safari/604.1
Remote IP: 64.147.3.98
Powered by: Elementor

Revell, Mandy@Coastal

From: blair@blairam.com
Sent: Friday, October 7, 2022 1:58 PM
To: SouthCoast@Coastal; Revell, Mandy@Coastal
Subject: CAD project

Living in close proximity to the proposed burying site for this toxic waste, my family would be acutely affected by this decision. My kids swim and sail in the bay directly adjacent to the site almost daily in the Summer. There are numerous public beaches that have a view of the site located just a hundred yards from where highly toxic waste would be placed. You could literally not pick a busier part of the bay for this proposal. I also don't understand the advantages of dumping this waste in a very popular swim area that gets a fraction of the water circulation compared to an open water solution. The best solution would be to truck the sediment to a landfill where it won't cause harm to the hundreds of thousands of residents and tourists who use our beautiful bay every year.

It is for these reasons I am strongly against the CAD project as it currently stands.

Thank you,
Blair Dickerson
Newport Beach Resident and Tax Payer

From: the Mackels <teammackel@gmail.com>
Sent: Friday, October 7, 2022 1:57 PM
To: SouthCoast@Coastal; Revell, Mandy@Coastal
Subject: Coastal Commission regarding the CAD

Drew Mackel
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

Coastal Commission, SouthCoast@coastal.ca.gov and **Mandy.Revell@coastal.ca.gov**

regarding the CAD, I AM OPPOSED.

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 1:12 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Vicki Serra

Date: October 7, 2022
Time: 8:12 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 107.77.227.90
Powered by: Elementor

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 1:07 PM
To: Revell, Mandy@Coastal
Subject: FW: Letter to Coastal Commission
Attachments: Kono_Letter to CCC.pdf

From: Audrey Kono <audreyko@usc.edu>
Sent: Thursday, October 6, 2022 6:24 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Letter to Coastal Commission

Project Name and Application Number: Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

Nature of Communication (In Person, Telephone, Other): Letter via email

Hello,

My name is Audrey Kono and I live and attend school in Southern California. I've attached my letter to the Coastal Commission with my thoughts on the city of Newport Beach's plan to construct a Confined Aquatic Disposal Facility (CAD) in the center of Lower Newport Harbor.

Thank you,
Audrey

October 6, 2022

California Coastal Commission
455 Market Street, Suite 300
San Francisco, CA 94105

Subject: Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

Dear Commissioners,

My name is Audrey Kono, and I am a concerned student and resident writing to you about the city of Newport Beach's plans to construct a Confined Aquatic Disposal Facility (CAD) in Lower Newport Harbor. I care for the health of Newport Bay and want it to be safe for the people who use it for recreation and business, the marine organisms that live there, and the habitat where they live. I urge you to deny the city's permit request for the project.

Newport Beach says that a CAD is the most practical, cost-effective, and environmentally way to clear the harbor's channels and keep the contaminated sediment out of open waters[1]. However, I agree with local clean water organization Orange County Coastkeeper's position on the issue that further analysis of environmental impact is needed and that the city should look into potential options for cleaning the contaminated sediment. The city needs to conduct further investigation into the impact and likelihood of dredging and CAD construction activity potentially releasing harmful chemicals into the bay. I find difficulty in believing that building the CAD facility would not result in impacts to the bay's water quality and that there is no potential for the release of hazardous materials, as the city's EIR states[2]. There is no question that we need to dredge the channels in the harbor, but we should not immediately turn to a solution that clearly warrants further investigation in this moment.

Before this project can move forward, the Army Corps of Engineers should conduct further analysis on the impact that dredging and CAD construction will have on the environment, including endangered species like the green sea turtle. Green sea turtles reside in Southern California bays, lagoons, and coastal inlets. They eat eelgrass and invertebrates that live in eelgrass beds[3], which Newport Bay has an increasing amount of, thanks to Coastkeeper's restoration work. Green sea turtles have been seen in Newport Harbor[4], so we must consider how CAD construction will affect turtles that are present in the bay.

Like many other local community members and organizations, I am concerned that the dredging activity and the process of moving the contaminated sediment into the CAD will stir and allow harmful chemicals to spread into harbor waters and beyond. The contaminated sediment contains

---

[1] Orange County Register, 2022
[2] Anchor QEA, Prepared for City of Newport Beach, 2021
[3] NOAA Fisheries, 2022
[4] Orange County Register, 2019

elevated levels of mercury and DDT, and some sediment samples contained five times more mercury than the amount we consider safe[5].

Mercury is a neurological poison to fish, other wildlife, and humans. We can absorb mercury by touch, inhalation, and consumption. The ease with which we can be exposed to mercury and its high level of poison is concerning. If mercury gets released into the bay, it can easily enter and poison the food web, as concentrations of the metal increase as larger marine organisms consume smaller ones[6]. The bioaccumulation results in high levels of mercury in the fish humans eat.

DDT poisons birds and fish. We also know that DDT affects the health of sea lions, endangered condors, and generations of women, and not all possible harms are known to use yet[7]. Exposure to the chemical has been linked to obesity, birth defects, reduced fertility, and testicular cancer[8]. U.S. and international authorities consider it a probable carcinogen[9]. A 2020 study found that sea lions with higher concentrations of DDT in their blubber were more prone to were more prone to the impacts of an aggressive cancer[10]. Wild animals rarely get cancer[11]; the widespread cancer among sea lions speaks to the powerful toxic effect of DDT. DDT in the ocean from previous decades of chemical dumping spreads through marine ecosystems and accumulates in condors that consumer marine organisms, such as dolphins and sea lions[12].

Keeping sediment with such high levels of contamination in the middle of the harbor could be dangerous. Newport Bay is a hub of human activity and home to marine organisms, and 112,500 cubic yards of sediment are contaminated[13]. We must consider whether we want to have a site in the bay that will be forever contaminated. The sediment from dredging the bay a decade ago sits under stacks of containers at the Port of Long Beach[14], but the center of Lower Newport Bay is an area that people actively use. We are not in the same situation that we were ten years ago, and we must remember that as we handle this issue.

Furthermore, the CAD project has the potential to exacerbate the ongoing invasion of *Caulerpa prolifera* in Newport Bay, for which local authorities have limited funds to combat. *C. prolifera* is a fast-growing alga that Coastkeeper first identified in China Cove of the bay in 2021. This finding is the first time that the species has been identified in California's waters. *C. prolifera* outcompetes native plants for nutrients and space anywhere that the species is introduced, leading to the displacement of wildlife and changes to the local ecosystem. The species contains toxins that repel fish which do not inhabit its native range; this drives fish away from their local habitat. If it continues to spread, *C. prolifera* will likely damage the eelgrass habitat that Coastkeeper has worked to restore over the last several years[15]. CAD activity would be in an area

---

[5] Orange County Register, 2022
[6] USGS Water Science School, 2018
[7] Los Angeles Times, 2022
[8] Los Angeles Times, 2021
[9] Centers for Disease Control and Prevention, 2009
[10] Gulland et al., 2020
[11] Los Angeles, 2021
[12] Los Angeles Times, 2022
[13] Orange County Register, 2022
[14] Orange County Register, 2022
[15] Orange County Coastkeeper, n.d.

where *C. prolifera* is invading. We should exercise extreme caution with major activities like building a CAD in the central area of the bay to ensure we do not promote the spread of the species. Coastkeeper and its partner are in the process of removing the species from the bay—we should not jeopardize that work.

To protect the resources and recreation of the coast in Newport Beach, please deny this permit request for the CAD project.

Sincerely,
Audrey Kono

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 1:05 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach Item 17a - ApplicationNo. 5-21-0640

-----Original Message-----
From: David Kitchens <davidkitchens@gmail.com>
Sent: Friday, October 7, 2022 7:35 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach Item 17a - ApplicationNo. 5-21-0640

To whom it may concern:

I support the CAD & Dredging Project in Newport Beach Item 17a - ApplicationNo. 5-21-0640

I support the proposed dredging project proposed forvNewport Harbor. The Harbor is shoaled up considerably and the amount of mercury contaminant present in certain samples is insignificant. Thank you for your attention!

Sincerely

David B Kitchens
437 Tustin Ave
Newport Beach, CA
92446

702-460-9023 cel

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Friday, October 7, 2022 1:02 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Isabel Villacorta <isabelvillacortapa@gmail.com>
Sent: Friday, October 7, 2022 12:29 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

To the California Coastal Commission:

Walking Softer Foundation Is a national non-profit organization based in Newport Beach with the ambition to help preserve and clean up our environment so future generations and other species can enjoy our beautiful home we call earth.

We support the CAD and the dredging project. Anything that can be done to improve the quality of the water for all those that come in contact with our Harbor is beneficial, but we must do things with real cost constraints in mind. Removing unsuitable material from the seafloor and disposing of it in the CAD and then its capping appears to be a viable, safe, and economical way to accomplish the much-needed work. It's amazing that we have waited 80 years for this project. Let's deliver another 80 wonderful years for the residents and visitors of Newport harbor.

I have been a user of the harbor over the years and as everyone that uses the harbor we appreciate its beauty and it's a major asset to our town.

Much of our infrastructure is deteriorating across the nation. Let's put Newport out in front on this issue.

Sincerely,

Vincent Smith
Vinny@vcsgrp.com
--
Isabel Villacorta | Executive Personal Assistant
IsabelVillacortaPA@gmail.com
Personal: 972.897.5039

Schedule a meeting

Revell, Mandy@Coastal

From: bmardian pienvironmental.com <bmardian@pienvironmental.com>
Sent: Friday, October 7, 2022 12:56 PM
To: Revell, Mandy@Coastal
Cc: Jennifer Novak; Kim Lewand-Martin
Subject: Comments for Application #5-21-0640
Attachments: Mardian_comment_App-5-21-0640.pdf

Importance: High

Good afternoon Mandy. Attached is my comment letter, in adamant opposition to the CAD. There has been significant new information presented here , which not only counters the City's narrative of… don't believe your lying eyes, but includes the discovery of a sperate testing manual for the specific action of Capping, new and recent sediment data collected by our team in the aeras of unsuitability, and a reiteration of some of our arguments that have yet to be addressed. Also, I made a special point to address the City narrative that other testing, specifically addresses the need to test the elutriates from the <u>contaminated material only</u>, which has still yet to be done or assessed for CAD placement suitability.

I am sorry the City and their consultant put the commission staff, the Board, and the Commissioners in such a bad position as having to make a yay/nay vote on this such a bad project plan, that clearly suffers from a severe lack of testing data, a lack of thorough alternatives analysis, and even fails to recognize compliance with national technical guidance governing these activities.

Let me know if you would like to discuss anything within this comment letter directly. But based on our recent testing results, the review of existing data, and the need for the City to ensure consistency with federal guidance, there is only one option here, and that is to deny this permit application.

In many ways what the City (with support from the Corps) has done here is totally unfair to the commissioners and their staff, and they have egregiously violated their responsibility and positions they have been entrusted with. To strongarm the Commission and their staff with a false narrative of untested environment benefits, is unacceptable for any agency to do. However, what should be a really positive sign to the Commission and staff, is that there is a growing contingent of people and NGOs who already care about Newport Bay, and are now paying attention…. and just in time to save it too 😊

From a practical matter, the open water testing and nearshore components of this project have properly met suitability testing based on the relevant guidance documents, therefore the Corps is able to construct a plan to dredge the clean stuff and nearshore material, if they were so inclined. But they won't, because they are acting like spoiled children, and unlike professionals entrusted with a federal responsibility, as they are hold the other dredging components hostage for an approval. Shame on the Corps.

However, and fortunately for the Commission and users of the Bay, we are not data adverse to data, and are 100% open to suggestions and creative ideas that results in sustainable sediment management.

That said, and based on recent sediment data collected in the areas of contaminated material that the City has refused to recharacterize, the threat from the re-exposure of legacy contaminants and dissolved contaminate release from the contaminated material only has not been fully evaluated in accordance with federal guidance, or even common-sense. Therefore, this project cannot be permitted by the Coastal Commission until more data and additional testing is conducted.

Thanks Mandy,
Brent

Brent Mardian
Senior Marine Scientist
Pi Environmental, LLC
O:760.593.3141
C:805.705.5632
www.pienvironmental.com

Pi Environmental

AN ENVIRONMENTAL CONSTANT

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

October 7, 2022

Mandy Revell
California Coastal Commission
South Coast Area Office
301 East Ocean Blvd Suite 300
Long Beach, CA 90802-4302
(562) 590-5071

Dear Commissioners and Staff,

This comment letter is a continuation of previous comments, objections, and concerns expressed about the City of Newport Beach proposal to stockpile contaminants in the middle of Newport Bay. Several significant and irrefutable shortcomings of this project have been raised by the Friends of Newport Harbor LLC, myself individually, and other concerned citizens, NGOs, and environmental groups who have been following this effort since the first CEQA public meetings.

Ever since the early days of this effort, there was a consistent glossing over of very key components of testing and analysis, and the alternatives analysis conducted for the CAD plan. Personally, as a marine science practitioner, I have been very adamant that a singular consultant should not be allowed to plan, design, sample, and then also singularly conduct the CEQA analysis, particularly when that Consultant has and will charge millions of dollars in what can only be perceived as an extreme conflict of interest trying to permit their own idea. But, there is not regulation with the City that requires a conflict of interest check on these efforts, but it hasn't gone unnoticed by those following this process.

Also clear, is that no tangible or documented process for a comprehensive alternatives evaluation was presented, besides a CEQA analysis that included options like a CAD here, a CAD there, and two other smaller CADs in other places. The obvious lack of alternatives caused people, who were without any classic scientific or engineering background, to question the thoroughness of the alternatives analyzed, questions the City summarily dismissed. The City has not looked at additional sediment management alternatives besides dumping contaminated material next to people's homes, a first in the Nation.

Also dismissed by the City was any suggestion that there had not been enough sediment testing and analysis conducted, and specifically on the contaminated material identified for CAD placement.

As described in the City EIR and associated response(s) to comments from the City, these areas of unsuitability have been determined based on one or two archived core samples collected in 2019, and through statistical interpolation (i.e., Kriging), the sediment within these areas mathematically was determined unsuitable by the City, and approved by the agencies.

The City and their consultants have been successful at convincing regulators to accept that a single sample input into a water quality model can accurately be used to estimate the potential effects near people's homes, and that their 'rigorous and robust' testing approach provided enough assurance that kids playing on the beach will not be exposed to dissolved contaminants.

A large part of the reason the City plan has gotten this far is thanks to the USACE, in this case a construction company masquerading as a federal agency, and them exerting behind the scenes pressure for this effort. Even going so far as to hold the federal dredging as hostage, stating in their EA that if is there is no CAD, they will take their dredge project and go home.

But the option to not dredge and maintain the federal channels is not a decision for planners and scientists who are employed by the LA District; rather, it is national mandate, and a required part of the USACE mission. So, the federal channels in Newport will get dredged. When and how that maintenance happens is the real question, which can only be answered with field collected data and a sustained commitment to find the most beneficial and least deleterious ways to dredge the federal channels.

Well, shame on the City for not performing the adequate analysis, listening to the concerns of their constituents, consulting the right regulatory documents, and engaging in the due diligence necessary for placing and storing contaminated material in a REC-1 system. And due to the City's lack of analysis and cursory review approach to this project, the City is asking the Coastal Commission to approve a really bad project, and bow to the collective weight of regulatory approvals which all are based on a faulty premise that everything has been done to address the multitude of environmental concerns from contaminated sediment disposal in the middle of Lower Newport Bay, adjacent to homes, an MPA, and the site of a variety of contract recreation activities that make Newport, well, Newport.

It is possible to send the City back to the drawing board, and based on the information presented further in my comment letter, the Coastal Commission has the responsibility to do so.

The primary concerns expressed about the City environmental data analysis have included:

- Potential sediment contaminant concentration heterogeneity within areas of contaminated material. As the City has resisted any suggestion of retesting the unsuitable areas, the sediment dataset for sediment testing consists of roughly one core sample every 400 ft., and only 1 to 2 cores in the contaminated areas. In most cases, 1 sample within the contaminated areas are being described as being representative of over 20,000 cubic yards of material to be placed in the CAD.
- Lack of vertical characterization. Core data was not split along strata or section of the dredge depths (dredge vs over dredge) to identify where in the sediment column the contaminants exist. This data is critical to the understanding of the source of contamination and if it is from recent or historical activities in the Bay. Split analysis also helps identify potential disposal alternatives through dual management options which may be realized only after sampling the areas of unsuitability.
- Lack of sediment data on the newly exposed bottom surface layer (i.e., Z-layer). As these negotiated areas represent areas of contamination and have overlying material that is too ‘dirty’ to be disposed of offshore, more information on what is being exposed by dredging needed to be collected and analyzed by the City. While samples of the Z-layer were taken in 2019, they were never analyzed as part of this project, even after a determination of unsuitability was made. Questions as to the quality of the sediment to be dredged still remain unanswered. The decision to not test the Z-layer samples was singularly made by the City.
- Estimates of water quality impacts from the contaminated material have not been fully evaluated. STFate numerical modeling and open-ocean bioassay elutriate analysis is not the appropriate analysis nor representative of the potential impacts to water quality from the contaminated material.

So, on 27 September 2022 we engaged in an opportunistic sediment sampling event to further characterize the areas of unsuitability. These areas of unsuitable sediment are presented in the City EIR as being above the 1.5 mg/kg concentration of mercury negotiated by the City with the DMMT, and are therefore scheduled to be disposal of in the proposed Lower Newport Bay CAD. As our questions were not being answered by the public agency entrusted to protect the health of the environment and citizens of Newport Bay with respect to the need for additional testing data, we were bound by intellectual curiosity and the protection of all who enjoy Newport Bay to use all the tools at our disposal to help understand environmental impacts to the Bay from this project. Even if the City wouldn’t.

The sediment data collected and described herein were collected exclusively within the negotiated contaminated areas above the 1.5 mg/kg concentration of mercury. This included the unsuitable areas of the Main Channel North 1 (MCN1) and Main Channel North 2 (MCN2) dredge units, and Newport Channel 1 (NC) (Figure 1).

These contaminated areas collectively account for approximately 87,000 cubic yards (CY) of the 106,000 CY of sediment to be disposed of in the CAD during the first fill event and covered for at least 2 years with a 1-foot sand layer, with the source yet to be identified.

The sediment samples were sampled from our scientific grade research vessel, using an electrically powered vibracore, the preferred type of equipment for this type of sediment collection. All cores sampled from the surface of the sediment to the bottom of the dredge design, including the 2-ft over dredge allowance. In the main channel areas the total depth of collection was -22 ft MLLW (-20-ft + -2-ft over dredge), and in the NC1 dredge area, -17 Ft MLLW (-15 ft+ -2 ft over dredge).

Core samples were collected from two locations within each area of unsuitability for a total of six cores. Recovered core samples were sub-sampled to analyze the dredge material and over dredge material separately. A process not conducted by the City.

Laboratory testing was completed by Eurofins-Calscience, in Tustin, CA. Eurofins-Calscience is a state certified laboratory who specializes in the testing of marine sediment samples. Laboratory analysis included mercury testing only, using EPA method 7471. Dry weight sediment testing results are provided in Table 1. The laboratory results of the mercury analysis are also attached to the end of this comment letter.

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

Figure 1. September 2022 Sediment Sampling Locations

Table 1. Dry Weight Mercury Results

Dredge Unit	Material Type	Sample ID	Sample Depth (ft below surface)	Mercury (mg/kg)
Newport Channel 1	Dredge	NC1	0-2	**2.91**
	Dredge		2-3.2	**5.81**
	Over Dredge		3.2-3.8	**3.69**
	Dredge	NC1-2	0-3	**4.91**
	Over Dredge		3-4.6	0.0398J
Main Channel 1	Dredge	MC1-1	0-2.5	0.703
	Over Dredge		2.5-5.0	**9.32**
	Dredge	MC1-2	0-3.5	0.782
	Over Dredge		3.5-5.5	**3.6**
Main Channel 2	Dredge	MC2-1	0-2.5	0.402
	Over Dredge		2.5-5.0	**1.52**
	Dredge	MC2-2	0-2	0.275
	Over Dredge		2-4	**2.03**

J= sample results were above the Method Detection Limit (MDL), but below the Reporting Limit (RL), estimated
Bold values are above 1.5 mg/kg
Maximum concentration measured

Main Channel North Areas 1 and 2 Results

The results of main channel sediment testing within the contaminated areas, are suggestive that much of the material above the federal maintenance dredge depths would meet the project open-water disposal concentration of 1.5 mg/kg of mercury. This indicates that if unsuitable material was retested with higher resolution sampling approach, there could be a significant volume reduction from both of these areas, which collectively adds 40,000 CY to the CAD storage volume, as our team has argued repeatedly.

The exploratory sediment investigation further indicates that in the main channel areas, mercury concentrations are significantly higher in the over dredge material than the material above the dredge depth. The highest concentration measured was 9.32 mg/kg at station MC1-1, found at a depth between 2.5 and 5 ft, below the depth required for safe navigation. Each of the over dredge samples collected within the main channel areas exceeds the mercury concentration of 1.5 mg/kg.

Being that the over dredge material has such high levels of mercury at depth, the contamination is likely from legacy contaminants, and not recent deposition. This data indicates that the newly exposed bay bottom after dredging, or Z-layer, has concentrations of contaminants that far exceed the surface level concentrations that are being dredged, and is not consistent with the 1 core sample the City analyzed as part of their rigorous and robust analytic process. The potential Z-layer concentrations, if exposed, would negate any perceived benefits from stockpiling contaminants in the middle of Newport Bay, putting benthic animals, fish, and birds back at risk from contaminates buried decades ago.

Further, as mercury was used only as an indicator chemical for this exploratory sampling event, it is possible that other chemicals of concern like PCBs and DDX are co-located with mercury and also pose a similar risk to the Bay from exposure via dredging. Without resampling, this obvious signature of contamination is not immediately apparent because when the City homogenized (uniformly mixed) the entire length of the core during their 1 sampling event, and then mixed again (composited) with clean material, they diluted the test sample for both chemical and bioassay testing with substantial portions of suitable material.

Newport Channel 1

The Newport Channel 1 area also exhibited higher than 1.5 mg/kg concentrations of mercury at all depths at station NC1, the closest sample to the Rhine Channel. This result is not surprising, since the Rhine channel was historically used for all sorts of commercial marine activities, including military boat building during World War II. All strata tested at NC1 exceeded City sampling results collected as part of the 2019 event. Highlighting the need for additional characterization.

Within the same dredge unit, station NC1-2 had a very distinct transition from silt and clay to poorly graded sand (Figure 2). As would be expected, the concentration of mercury in the dredge material also transitioned from 4.91 mg/kg in the dredge material, and in the over dredge part of the core, 0.0389J mg/kg, the lowest mercury concentration measured.

We have long argued that a dual management option in this area may be possible, given the proximity to the beach and likelihood of sand somewhere within the sediment column. The current sampling results confirm this comment, and that in some parts of the Newport Channel 1 area, dredge and over dredge material could be managed separately to reduce volumes and offer additional beneficial reuse alternatives for some of the material.

The results of exploratory sediment investigation have confirmed many of the questions we have posed to the City, and present a very different picture of these contaminated areas.

The sediment testing results highlight the heterogeneity within the mathematically derived unsuitable areas, and the limits of resolution that exist within the City's data characterization, with respect to Z-layer concentrations, the representativeness by only having a single sample for analysis in many cases, and the spatial and vertical distribution of contaminates.

With additional DMMT approved sampling and analysis, the City could not only develop a better understanding of the contaminant concentrations in the dredge material management areas, but also ensure they have performed the proper due diligence when opting for in bay disposal in a Rec-1 system a few hundred feet from people's homes and play beaches.

Figure 2. Station NC1-2 Sediment Core Photo

Based on the results of our September 2022 testing and analysis, there are several potential volume reduction options that could be explored with additional data from these contaminated areas, if evaluated for a specific disposal alternative and through a creative approach to dredge material management.

Also, based on our split core sampling approach, that singularly looked at the chemistry from the unsuitable areas and within the dredge and over dredge material, dredging has a high degree of certainty to expose deleterious concentrations of contaminants, more than what is in the surface sediment currently.

The data collected supports previous assertions that additional testing and analysis is needed within the contaminated areas before a CAD should be considered as an alternative for placement.

Potential for Water Quality Impacts

As mentioned previously, a critical suitability component for the CAD material has not been addressed by the City's EIR, and the potential for water quality impacts from just the unsuitable material has been improperly evaluated.

There is existing national testing and engineering guidance on the matter of CAD construction, called the Guidance for Subaqueous Capping of Dredged Material, promulgated by the USACE. The manual states clearly on page 2, '*The technical guidance in this report is intended for use by USACE and EPA personnel, State regulatory personnel, as well as dredging permit applicants and others (e.g., scientists, engineers, managers, and other involved or concerned individuals).'*

The guidance goes on to state*, 'Chemical characterization of contaminated sediment may include a sediment chemical inventory and standard elutriate test results. The chemical sediment inventory is useful in determining contaminants of concern and in the development of appropriate chemical elements of a monitoring program to determine capping effectiveness. Elutriate data are used in estimating the potential effects on water quality due to placement of the contaminated material*.'

The guidance goes on to reference other sections of the document for additional information on sediment dispersion during placement for the assessment of potential water quality impacts, and states unequivocally, '*The contaminant release is predicted by an elutriate test, and results are compared with applicable water-quality criteria or standards as appropriate.'*

The City has argued that they have the discretion to substitute the bioassay elutriate and STFATE modeling for the elutriate testing requirement in this manual, and that other guidance designed for inland or open water placement is how they met the testing requirements of this Capping guidance, while never referring to it as a testing manual for suitability. However, this is erroneous and inconsistent with the federal guidance that covers projects like the CAD for two significant reasons*:*

1- The bioassay elutriate samples are based on composite sediment tests and therefore include a significant portion of 'clean' material. Because of this, the resulting concentrations of the composite bioassay elutriate is not representative of the 9% of unsuitable material actually going to the CAD. As per the Capping guidance: *If water column effects during placement of the contaminated material are of concern, an evaluation of the suitability of the material from the standpoint of water column effects **must** be performed.* And goes on to state that, '*Elutriate data are used in estimating the potential effects on water quality due to placement of the contaminated material.'*

2- The second reason the bioassays elutriate results are not a substitute here, is because the guidance specifically states you cannot substitute other testing for the evaluation of the potential water quality effects. More specifically, '*Capping as a control measure is normally considered only after sediment to be dredged is found to be contaminated. In* *order to make such a determination, some chemical and biological characterization of the contaminated sediment is normally performed as a part of the overall evaluation for suitability for open-water placement (EPA/USACE 1991; EPA/USACE 1998). It should be noted that even though capping is being considered because of a determination of potentially unsuitable benthic effects, the data necessary for evaluation of potential water column effects are still required.*

Another talking point by the City is that the testing fully complies with the USACE guidance, however, to further evaluate water column impacts during placement, a USACE developed model (i.e., STFATE) was also used to predict compliance with applicable water quality criteria.

The question of the STFATE model applicability was never whether the sediment spreading estimates were accurate or not, but whether the STFATE model was the appropriate measure of potential water quality impacts. Particularly when disposing of contaminated materials near children play beaches and homes.

As per the Capping manual, which requires elutriate testing in the event of possible water quality impacts, it also includes a discussion of the STFATE model right below the discussion of elutriate testing.

As a point of fact, there is no language or provision within the Capping technical guidance which allows for, or implies substitution of the STFATE model for elutriate analysis within the sediment disbursement section of the guidance. It does, however, recommend the STFATE model for spreading and loss estimates, consistent with the ERDC response.

We also believe the STFATE model results were calculated incorrectly for this project. As described in the Capping manual appendix relevant to the STFATE, there are two critical pieces of information needed for properly running the STFATE model: the sediment chemistry data, and the elutriate concentration (Figure 3). The significant question as to the representativeness of a single archived core sample used for modeling notwithstanding, as confirmed by the EPA, the elutriate data is based on the bioassay elutriate, which includes a significant proportion of clean material as part of the testing. As described earlier, the city sediment testing approach diluted the composite testing results through homogenizing the length of the core, and also by compositing with other clean material.

What this really means, is that the elutriate data used for model input is not the elutriate concentrations related to the contaminated material only. Rather, the elutriate is from a mixed sample, and that is inconsistent with the guidance which requires the testing of the contaminated material only, which as of the time of this comment letter, has still not been analyzed by the City as part of this project.

That said, even if the STFATE model was identified as an allowable substitution by the Capping manual (which it is not), the modeling would need to be completed on unsuitable material only.

Using contaminated core chemistry and composite elutriate results is an improper use of the STFATE model.

In pragmatic terms, the STFATE modeling comes after the standard elutriate testing of the contaminated material, not before. But the City didn't follow the proper guidance, because their 'expert's knew more that the national guidance on the matter. And have caused the entire regulatory process, to have egg on its face. A diagram of the testing and analytical process that should have been followed by this project had they addressed the correct technical guidance, included as Figure 4.

Table D1
STFATE Model Input Parameters

Parameter	Disposal Operation Types[1]	Units	Options[2]
Contaminant Selection Data			
Solids concentration of dredged material		g/L	
Contaminant concentration in the bulk sediment		μg/kg	
Contaminant concentration in the elutriate		μg/L	
Contaminant background concentration at disposal site		μg/L	
Contaminant water quality standards		μg/L	
Site Description			
Number of grid points (left to right)	H, B		
Number of grid points (top to bottom)	H, B		

Figure 3. STFate Model Parameters

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

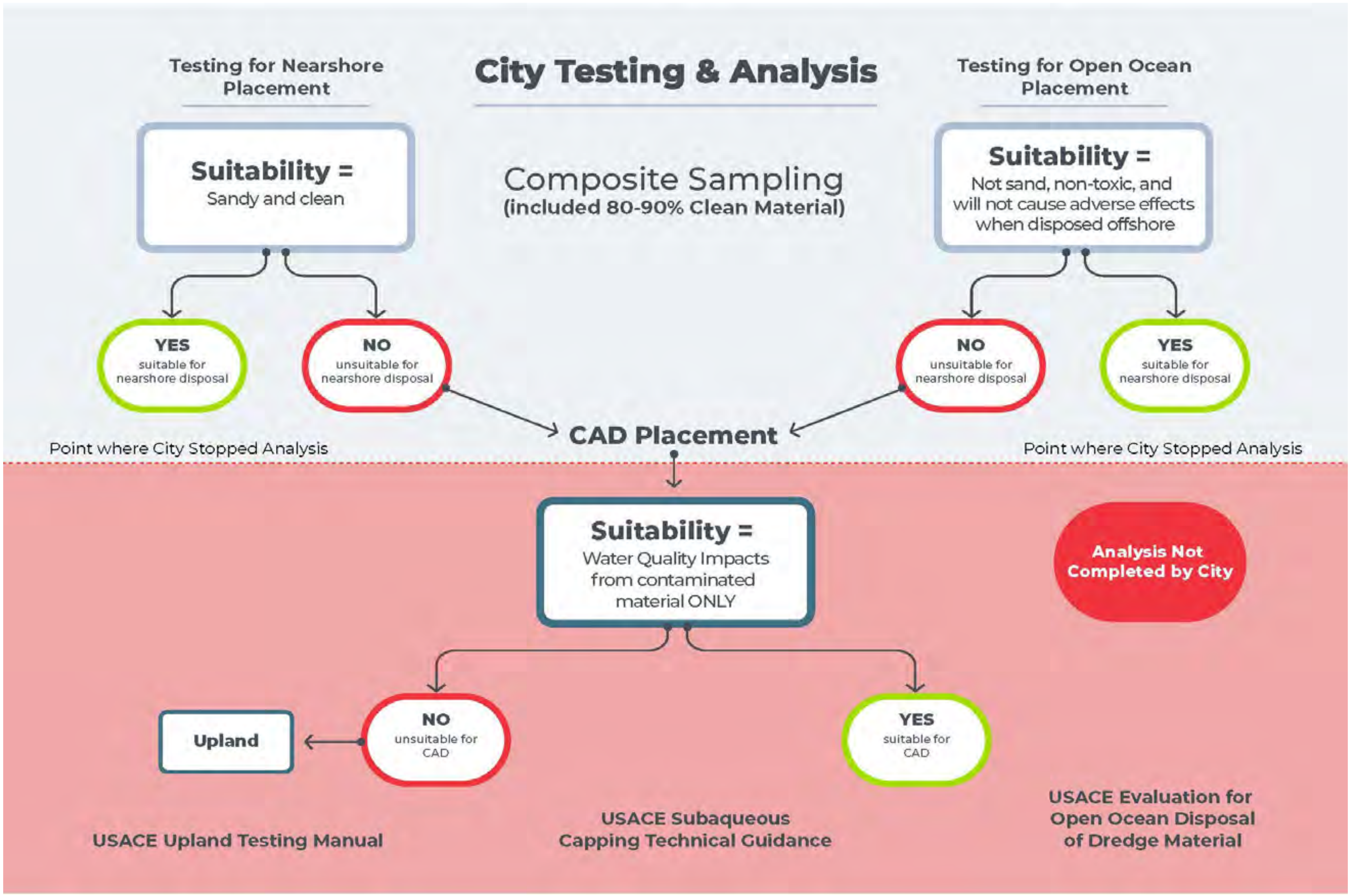


Figure 4. Testing and Analysis Flow Chart for Permitting A CAD

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

As I mentioned earlier, I am a practitioner, a life-long marine scientist, and genuinely concerned for my industry and the regulatory process based on what I have seen transpire on this project, the collusion within agencies, the gorilla-type force that can and will be exerted by Federal agencies when they don't get their way, and the finger pointing that creates of a round robin of approvals.

As a scientist, I believe that data is where the rubber meets the road. And in this case, more data needs to be evaluated to guide the decision-making process and ensure that the thoroughness in project planning results in effective implementation and the preservation of beneficial uses in Newport Bay.

Without the proper data to support a suitability determination a project cannot be permitted. Just as a suitability determination for dredge material identified to go to the nearshore area could not be permitted without grain size analysis, the disposal of contaminants within a CAD have to meet the required elutriate water quality testing and suitability analysis conducted according to the relevant federal guidance.

It is not the residents or users of the Bay who have not addressed the required technical guidance and analysis, but they will be the ones at risk when the untested material starts to leech into the receiving waters, around their homes and beaches.

There is no stop work requirement in any of the permits attached to this project. So, once the process of digging the CAD and filling it with contaminated material has begun, there is no stopping it. Even if/when water quality samples are found in exceedance of established numerical objectives, the polluting of the bay will continue, 6 days a week for months.

The City analysis (or lack thereof) and our own sediment characterization data suggest a very real scenario for this project, where this project is releasing dissolved contaminants at a much higher concertation than predicted by the composite testing and the unallowable modeling of 'clean' and 'dirty' material, which will be coupled with the re-exposure of legacy contaminates in the bottom layers of the dredge areas, which have significantly higher concentrations that what the singular sample used for analysis suggests.

This project could set the environmental clock back in Newport Beach 25 years!!

As a purely common-sense plea, please help the residents, contact recreation users, and concerned NGOs who advocate for sustainable resource management, protect and preserve the beneficial uses of the Newport Bay. There are clearly enough data uncertainties here to require the City to retest and reanalyze the contaminated areas of this project with respect to CAD suitability.

Brent Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

As a matter of fact, if the City had listened to the residents and retested these areas of contaminated material when the original objections were raised, the project would not be in this position, and maybe more importantly, neither would the Coastal Commission. But the City has dug their heels in, and has decided under no circumstances are they going to retest the material, or reanalyze or revisit any of their previous decisions or testing, in spite of the relevant technical guidance and commons sense screaming they should.

Please don't make the hundreds of thousands of users of Newport Bay pay the price for inadequate testing and analysis, and City egos. This project has failed to meet the even the bare minimum testing requirements to attain a suitability determination for the material going to the CAD, much less the thoroughness and high standard of testing and analysis that would support the due diligence required by such a plan, so close to people's homes.

Thank you for your time, and again, please deny this application in the name of common sense, science-based decision making, and the protection and preservation of Newport Bay.

Respectfully,

Brent Mardian
Senior Marine Scientist
Pi Environmental, LLC

Environment Testing America

ANALYTICAL REPORT

Eurofins Calscience
2841 Dow Avenue, Suite 100
Tustin, CA 92780
Tel: (714)895-5494

Laboratory Job ID: 570-111306-1

Client Project/Site: Privileged and Confidential: FONH Newport Bay

For:
Pi Environmental
426 Palm Road
San Marcos, California 92069

Attn: Brent Mardian

Authorized for release by:
10/3/2022 2:44:29 PM

Carla Hollowell, Project Manager I
(714)895-5494
Carla.Hollowell@et.eurofinsus.com

LINKS

Review your project results through myEOL

Have a Question? Ask The Expert

Visit us at: www.eurofinsus.com/Env

Table of Contents

Qualifiers

Metals

Qualifier	Qualifier Description
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Case Narrative

Client: Pi Environmental | Job ID: 570-111306-1
Project/Site: Privileged and Confidential: FONH Newport Bay

Job ID: 570-111306-1

Laboratory: Eurofins Calscience

Narrative

Job Narrative
570-111306-1

Comments
No additional comments.

Receipt
The samples were received on 9/27/2022 7:15 PM. Unless otherwise noted below, the samples arrived in good condition, and where required, properly preserved and on ice. The temperature of the cooler at receipt was 1.9º C.

Metals
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

General Chemistry
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Method: 7471A - Mercury (CVAA)

Client Sample ID: NC1-2 3-4.6 OD
Lab Sample ID: 570-111306-5
Date Collected: 09/27/22 10:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.0318	J	0.0989	0.0160	mg/Kg	☼	09/29/22 21:45	09/30/22 13:14	1

Client Sample ID: MC1-1 0-2.5
Lab Sample ID: 570-111306-6
Date Collected: 09/27/22 11:00
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.703		0.201	0.0326	mg/Kg	☼	09/29/22 21:45	09/30/22 13:16	1

Client Sample ID: MC1-2 0-3.5
Lab Sample ID: 570-111306-8
Date Collected: 09/27/22 12:00
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.782		0.195	0.0315	mg/Kg	☼	09/29/22 21:45	09/30/22 13:20	1

Client Sample ID: MC1-2 3.5-5 OD
Lab Sample ID: 570-111306-9
Date Collected: 09/27/22 12:00
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	3.60		0.661	0.107	mg/Kg	☼	09/29/22 21:45	09/30/22 13:54	5

Client Sample ID: MC2-1 0-2.5
Lab Sample ID: 570-111306-10
Date Collected: 09/27/22 13:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.402		0.174	0.0281	mg/Kg	☼	09/29/22 21:45	09/30/22 13:23	1

Client Sample ID: MC2-1 2.5-4.5 OD
Lab Sample ID: 570-111306-11
Date Collected: 09/27/22 13:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	1.52		0.157	0.0255	mg/Kg	☼	09/29/22 21:45	09/30/22 13:25	1

Client Sample ID: MC2-2 0-2
Lab Sample ID: 570-111306-12
Date Collected: 09/27/22 14:45
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.275		0.182	0.0295	mg/Kg	☼	09/30/22 16:00	09/30/22 18:03	1

Client Sample ID: MC2-2 2-4 OD
Lab Sample ID: 570-111306-13
Date Collected: 09/27/22 14:45
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	2.03		0.173	0.0281	mg/Kg	☼	09/30/22 16:00	09/30/22 18:09	1

Client Sample Results

Client: Pi Environmental
Job ID: 570-111306-1
Project/Site: Privileged and Confidential: FONH Newport Bay

Method: 7471A - Mercury (CVAA) - DL

Client Sample ID: NC1 0-2
Lab Sample ID: 570-111306-1
Date Collected: 09/27/22 09:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	2.91		0.958	0.155	mg/Kg	☼	09/29/22 21:45	09/30/22 13:45	5

Client Sample ID: NC1 2-3
Lab Sample ID: 570-111306-2
Date Collected: 09/27/22 09:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	5.81		0.905	0.147	mg/Kg	☼	09/29/22 21:45	09/30/22 13:47	5

Client Sample ID: NC1 3.2-3.8 OD
Lab Sample ID: 570-111306-3
Date Collected: 09/27/22 09:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	3.68		0.631	0.102	mg/Kg	☼	09/29/22 21:45	09/30/22 13:49	5

Client Sample ID: NC1-2 0-3
Lab Sample ID: 570-111306-4
Date Collected: 09/27/22 10:30
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	4.91		0.895	0.145	mg/Kg	☼	09/29/22 21:45	09/30/22 13:50	5

Client Sample ID: MC1-1 2.5-5 OD
Lab Sample ID: 570-111306-7
Date Collected: 09/27/22 11:00
Matrix: Sediment
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	9.32		1.57	0.255	mg/Kg	☼	09/29/22 21:45	09/30/22 13:52	10

General Chemistry

Client Sample ID: NC1 0-2 **Lab Sample ID: 570-111306-1**
Date Collected: 09/27/22 09:30 **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	44.4		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: NC1 2-3 **Lab Sample ID: 570-111306-2**
Date Collected: 09/27/22 09:30 **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	47.0		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: NC1 3.2-3.8 OD **Lab Sample ID: 570-111306-3**
Date Collected: 09/27/22 09:30 **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	66.0		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: NC1-2 0-3 **Lab Sample ID: 570-111306-4**
Date Collected: 09/27/22 10:30 **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	45.6		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: NC1-2 3-4.6 OD **Lab Sample ID: 570-111306-5**
Date Collected: 09/27/22 10:30 **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	86.0		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: MC1-1 0-2.5 **Lab Sample ID: 570-111306-6**
Date Collected: 09/27/22 11:00 **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	42.3		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC1-1 2.5-5 OD **Lab Sample ID: 570-111306-7**
Date Collected: 09/27/22 11:00 **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	50.9		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC1-2 0-3.5 **Lab Sample ID: 570-111306-8**
Date Collected: 09/27/22 12:00 **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	42.8		0.1	0.1	%			09/30/22 15:54	1

General Chemistry

Client Sample ID: MC1-2 3.5-5 OD | **Lab Sample ID: 570-111306-9**
Date Collected: 09/27/22 12:00 | **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	60.6		0.1	0.1	%			09/30/22 10:24	1

Client Sample ID: MC2-1 0-2.5 | **Lab Sample ID: 570-111306-10**
Date Collected: 09/27/22 13:30 | **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	47.0		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC2-1 2.5-4.5 OD | **Lab Sample ID: 570-111306-11**
Date Collected: 09/27/22 13:30 | **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	52.0		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC2-2 0-2 | **Lab Sample ID: 570-111306-12**
Date Collected: 09/27/22 14:45 | **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	46.7		0.1	0.1	%			09/30/22 15:54	1

Client Sample ID: MC2-2 2-4 OD | **Lab Sample ID: 570-111306-13**
Date Collected: 09/27/22 14:45 | **Matrix: Sediment**
Date Received: 09/27/22 19:15

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Sample Homogenized	yes				NONE			09/29/22 12:22	1
Percent Solids	50.1		0.1	0.1	%			09/30/22 15:54	1

Client: Pi Environmental
Job ID: 570-111306-1
Project/Site: Privileged and Confidential: FONH Newport Bay

Method: 7471A - Mercury (CVAA)

Lab Sample ID: MB 570-268657/1-A
Client Sample ID: Method Blank
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268657

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.0868	0.0141	mg/Kg		09/29/22 21:45	09/30/22 12:34	1

Lab Sample ID: LCS 570-268657/2-A
Client Sample ID: Lab Control Sample
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268657

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	0.400	0.3792		mg/Kg		95	80 - 120

Lab Sample ID: LCSD 570-268657/3-A
Client Sample ID: Lab Control Sample Dup
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268657

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Mercury	0.417	0.3909		mg/Kg		94	80 - 120	3	10

Lab Sample ID: MB 570-268696/1-A
Client Sample ID: Method Blank
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.0868	0.0141	mg/Kg		09/30/22 16:00	09/30/22 17:58	1

Lab Sample ID: LCS 570-268696/2-A
Client Sample ID: Lab Control Sample
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	0.417	0.4402		mg/Kg		106	80 - 120

Lab Sample ID: LCSD 570-268696/3-A
Client Sample ID: Lab Control Sample Dup
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Mercury	0.408	0.4339		mg/Kg		106	80 - 120	1	10

Lab Sample ID: 570-111306-12 MS
Client Sample ID: MC2-2 0-2
Matrix: Sediment
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Mercury	0.275		0.856	1.179		mg/Kg	☼	106	80 - 120

Lab Sample ID: 570-111306-12 MSD
Client Sample ID: MC2-2 0-2
Matrix: Sediment
Prep Type: Total/NA
Analysis Batch: 268996
Prep Batch: 268696

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Mercury	0.275		0.892	1.192		mg/Kg	☼	103	80 - 120	1	20

Method: Moisture - Percent Moisture

Lab Sample ID: 570-111306-5 DU — **Client Sample ID: NC1-2 3-4.6 OD**
Matrix: Sediment — **Prep Type: Total/NA**
Analysis Batch: 268928

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Percent Solids	86.0			85.9		%				0.1	10

Lab Sample ID: 570-111306-8 DU — **Client Sample ID: MC1-2 0-3.5**
Matrix: Sediment — **Prep Type: Total/NA**
Analysis Batch: 268937

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Percent Solids	42.8			42.7		%				0.3	10

Laboratory: Eurofins Calscience

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
California	State	3082	07-31-23

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
Homogenization		Sediment	Sample Homogenized
Moisture		Sediment	Percent Solids

Method Summary

Method	Method Description	Protocol	Laboratory
7471A	Mercury (CVAA)	SW846	EET CAL 4
Homogenization	Homogenization	None	EET CAL 4
Moisture	Percent Moisture	EPA	EET CAL 4
7471A	Preparation, Mercury	SW846	EET CAL 4

Protocol References:

EPA = US Environmental Protection Agency

None = None

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

EET CAL 4 = Eurofins Calscience Tustin, 2841 Dow Avenue, Tustin, CA 92780, TEL (714)895-5494

Sample Summary

Client: Pi Environmental
Project/Site: Privileged and Confidential: FONH Newport Bay

Job ID: 570-111306-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
570-111306-1	NC1 0-2	Sediment	09/27/22 09:30	09/27/22 19:15
570-111306-2	NC1 2-3	Sediment	09/27/22 09:30	09/27/22 19:15
570-111306-3	NC1 3.2-3.8 OD	Sediment	09/27/22 09:30	09/27/22 19:15
570-111306-4	NC1-2 0-3	Sediment	09/27/22 10:30	09/27/22 19:15
570-111306-5	NC1-2 3-4.6 OD	Sediment	09/27/22 10:30	09/27/22 19:15
570-111306-6	MC1-1 0-2.5	Sediment	09/27/22 11:00	09/27/22 19:15
570-111306-7	MC1-1 2.5-5 OD	Sediment	09/27/22 11:00	09/27/22 19:15
570-111306-8	MC1-2 0-3.5	Sediment	09/27/22 12:00	09/27/22 19:15
570-111306-9	MC1-2 3.5-5 OD	Sediment	09/27/22 12:00	09/27/22 19:15
570-111306-10	MC2-1 0-2.5	Sediment	09/27/22 13:30	09/27/22 19:15
570-111306-11	MC2-1 2.5-4.5 OD	Sediment	09/27/22 13:30	09/27/22 19:15
570-111306-12	MC2-2 0-2	Sediment	09/27/22 14:45	09/27/22 19:15
570-111306-13	MC2-2 2-4 OD	Sediment	09/27/22 14:45	09/27/22 19:15

Chain of Custody Record

557228 eurofins Environment Testing TestAmerica 111306

Address ______

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

TAL-8210

Client Contact	**Project Manager:**	**Site Contact:**	**Date:**
Company Name P. Environmental	**Tel/Email:**	**Lab Contact:**	**Carrier:**
Address 426 Palm Rd	**Analysis Turnaround Time**		
City/State/Zip San Marcos CA	☐ CALENDAR DAYS ☐ WORKING DAYS		
Phone 760 893-3141	TAT if different from Below ASAP		
Fax	☐ 2 weeks		
Project Name FONH	☐ 1 week		
Site Newport Bay	☒ 2 days		
P O #	☐ 1 day		

COC No ______ of ______ COCs

Sampler:

For Lab Use Only: Walk-in Client: Lab Sampling

Job / SDG No

570-111306 Chain of Custody

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)	Hg - D	Sample Specific Notes
NC1 0-2	9/27	09:30	core	sed	1			X	1
NC1 2-3		09:30						X	2
NC1 3.2-3.8 OD		09:30						X	3
NC1-2 0-3		10:30						X	4
NC1-2 3-4.6 OD		10.30						X	5
MC1-1 0-2.5		11.00						X	6
MC1-1 2.5-5 OD		11.00						X	7
MC1-2 0-3.5		12.00						X	8
MC1-2 3.5-5 OD		12.00						X	9
MC2-1 0-2.5		13:30						X	10
MC2-1 2.5-4.5 OD		13:30						X	11
								X	

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample

☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☒ Disposal by Lab ☐ Archive for ______ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☐ No | Custody Seal No | Cooler Temp (°C) Obs'd ______ Corr'd ______ | Therm ID No ______

Relinquished by	Company	Date/Time	Received by	Company	Date/Time
[signature]	P.	15:00 9/27	William Rivera	FC	9/27/22 1500
William Rivera	FC	9/27/22 1915	Olga Orrelus	FC	9/27/22 1915
Relinquished by	Company	Date/Time	Received in Laboratory by	Company	Date/Time

1.6/1.9 SC11

Chain of Custody Record

557229

eurofins | Environment Testing TestAmerica

111306

Address ____________________

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

TAL-8210

Client Contact		
Company Name	P. Environmental	
Address	426 Palm Rd	
City/State/Zip	San Marcos, CA	
Phone	760-593-3141	
Fax.		
Project Name		
Site		
P O #		

Project Manager:
Tel/Email:

Analysis Turnaround Time
☐ CALENDAR DAYS ☒ WORKING DAYS
TAT if different from Below ASAP
☐ 2 weeks
☐ 1 week
☒ 2 days
☐ 1 day

Site Contact:
Lab Contact:
Date:
Carrier:

COC No
____ of ____ COCs
Sampler:
For Lab Use Only:
Walk-in Client:
Lab Sampling
Job / SDG No

Analysis: TPH-D

Sample Identification	Sample Date	Sample Time	Sample Type (C=Comp, G=Grab)	Matrix	# of Cont.	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)	TPH-D	Sample Specific Notes
MC2-2 0-2	9/27	1415	Core	Soil	1			X	12
MC2-2 2-4 OD	⊥	⊥	Core	Soil	1			X	13

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ____________

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample

☒ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ Return to Client ☒ Disposal by Lab ☐ Archive for ________ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☐ No | Custody Seal No | Cooler Temp (°C) Obs'd ________ Corr'd ________ | Therm ID No ________

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
[signature]	P.	1500/9-27	William Rivera	EC	9/27/22 1500
William Rivea	EC	9/27/22 1915	Olga Oneka	EC	9/27/22 1915
Relinquished by	Company:	Date/Time	Received in Laboratory by:	Company	Date/Time:

1.6°/1.9° SC11

Login Sample Receipt Checklist

Client: Pi Environmental | Job Number: 570-111306-1

Login Number: 111306 | **List Source: Eurofins Calscience**
List Number: 1
Creator: Patel, Jayesh

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Revell, Mandy@Coastal

From: Chris Cummings <ccummings69@gmail.com>
Sent: Friday, October 7, 2022 12:45 PM
To: Revell, Mandy@Coastal
Subject: Fwd: Application5-21-0640_Agenda F17a
Attachments: Application5-21-0640_Agenda F17a.pdf

Correction... The attached document is a .**pdf file** of the Word Doc. My apologies for any confusion. Thank you.

---------- Forwarded message ---------
From: **Chris Cummings** <ccummings69@gmail.com>
Date: Fri, Oct 7, 2022, 12:30 PM
Subject: Application5-21-0640_Agenda F17a
To: <mandy.revell@coastal.ca.gov>

Please note that the following letter/email is also repeated in the **attached PDF document below** for the October 14th meeting agenda. Thank you.

Christine Cummings
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

October 7, 2022

Mandy Revell
California Coastal Commission
South Coast Area Office
301 East Ocean Blvd Suite 300
Long Beach, CA 90802-4302
(562) 590-5071

Dear Ms. Revell,

Please save Newport Bay from becoming an aquatic landfill. I am very worried about the City of Newport Beach's proposal to bury contaminated material in the Bay where people, including children, swim and paddle board.

Within the attached PDF document is a photo of my family/children swimming in Newport Bay very near the planned toxic dumping site. The photo shows the bridge to a tiny private island that's mostly between Lido Isle and Balboa Island and adjacent to the planned dumping site. I swam around that tiny island which would be right into the edge of the planned site for the toxic dumping!!

This project needs to be paused while other places to store this contaminated sediment can be found. PLEASE stop the permitting of this project while other options can be explored and more data collected. We need to see evidence that the City is protecting us and our children from the toxins they are planning to stockpile in the Bay.

Thank you so much for seriously considering this before your meeting. (Please see attached Agenda Application **Pdf'd** Word Doc below).

Sincerely,
Christine Cummings

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 12:29 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Cynthia Harder

Date: October 7, 2022
Time: 7:28 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 73.25.215.49
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 12:28 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Cynthia Harder

Date: October 7, 2022
Time: 7:28 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 73.25.215.49
Powered by: Elementor

Revell, Mandy@Coastal

From: Carla Mardian <mrscarlamardian@gmail.com>
Sent: Friday, October 7, 2022 12:27 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640 | Agenda F17a | Opposed
Attachments: Application5-21-0640_Agenda F17a_Opposed.pdf

Dear Ms. Revell, please see my attached letter. Also my comment is pasted below.

Carla Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

October 7, 2022

Mandy Revell
California Coastal Commission
South Coast Area Office
301 East Ocean Blvd Suite 300
Long Beach, CA 90802-4302
(562) 590-5071

Dear Ms. Revell,

I am writing to state my opposition to a CAD being put into the residential harbor of Newport Bay where people recreate and swim. My family is from Southern California and has memories of vacationing and swimming in Newport Bay going back 60 years. I don't even know how we could explain why we dumped contaminated material in the bay to future generations, 60 years from now and beyond, when in 2022, there are other viable options.

It is such a waste that Newport is made up of residents with so many resources, business connections, land, creative ideas, etc., more so than any other city in this country, and this was never tapped into for collaboration and partnerships in the beginning stages of this process, before the CAD was just presented as the only option. I've seen how the CEQA process works in other Southern California coastal cities I've lived in, that have residents with much less to offer as far as resources, just their ideas, but they were heard, seriously considered, and even accommodated, and this is not what I saw happen for this project.

For something potentially going in a residential harbor as nice as Newport, as opposed to the ports CADs normally go in, you would think that they would have done everything they could as far as extensive testing to figure out ways to NOT have to put it in the bay or to totally ensure it was safe to dispose in the bay. I am surprised that there are not stricter testing requirements for putting a CAD in a residential harbor with contact recreation, or even if there aren't, that they would not just do more. But they did the very bare minimum, and in some aspects, not even what was required, and refused to do more. So much more data could have been collected in the time that has passed to give a more complete picture, but it wasn't.

Please do not approve this project. The associated data is incomplete and inaccurate, and alternatives have not been explored in good faith.

Respectfully,
Carla Mardian

Carla Mardian
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

October 7, 2022

Mandy Revell
California Coastal Commission
South Coast Area Office
301 East Ocean Blvd Suite 300
Long Beach, CA 90802-4302
(562) 590-5071

Dear Ms. Revell,

I am writing to state my opposition to a CAD being put into the residential harbor of Newport Bay where people recreate and swim. My family is from Southern California and has memories of vacationing and swimming in Newport Bay going back 60 years. I don't even know how we could explain why we dumped contaminated material in the bay to future generations, 60 years from now and beyond, when in 2022, there are other viable options.

It is such a waste that Newport is made up of residents with so many resources, business connections, land, creative ideas, etc., more so than any other city in this country, and this was never tapped into for collaboration and partnerships in the beginning stages of this process, before the CAD was just presented as the only option. I've seen how the CEQA process works in other Southern California coastal cities I've lived in, that have residents with much less to offer as far as resources, just their ideas, but they were heard, seriously considered, and even accommodated, and this is not what I saw happen for this project.

For something potentially going in a residential harbor as nice as Newport, as opposed to the ports CADs normally go in, you would think that they would have done everything they could as far as extensive testing to figure out ways to NOT have to put it in the bay or to totally ensure it was safe to dispose in the bay. I am surprised that there are not stricter testing requirements for putting a CAD in a residential harbor with contact recreation, or even if there aren't, that they would not just do more. But they did the very bare minimum, and in some aspects, not even what was required, and refused to do more. So much more data could have been collected in the time that has passed to give a more complete picture, but it wasn't.

Please do not approve this project. The associated data is incomplete and inaccurate, and alternatives have not been explored in good faith.

Respectfully,

Carla Mardian

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 12:14 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Carlita Fuller

Date: October 7, 2022
Time: 7:13 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_5 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.5 Mobile/15E148 Safari/604.1
Remote IP: 108.85.196.113
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 12:13 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Carlita fuller

Date: October 7, 2022
Time: 7:12 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_5 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.5 Mobile/15E148 Safari/604.1
Remote IP: 108.85.196.113
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 12:09 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Sharon McKinnon

Date: October 7, 2022
Time: 7:08 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 174.243.217.42
Powered by: Elementor

Revell, Mandy@Coastal

From: Dana Jacobsen <dnjake@pacbell.net>
Sent: Friday, October 7, 2022 11:58 AM
To: Revell, Mandy@Coastal
Subject: Newport Harbor CAD

Subject: #5-21-0640 Agenda W13b

Dear Coastal Commission,

I am writing to you regarding my concerns of the proposed CAD in Newport Harbor. I am opposed to the proposal to bury material that is unsuitable for disposal in the open ocean in Newport Harbor. I hope that we explore other alternatives and conduct additional testing before we rush into this project on the basis of Federal funding currently being available. Another major concern is that the proposed site of the CAD, Newport Harbor's turning basin, will not be able to be dredged in the future. The project in general seems very shortsighted to me.

Thank you for your time,

Dana Jacobsen

528 Redlands Ave

Newport Beach, CA

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 11:52 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Brooke Huey

Date: October 7, 2022
Time: 6:52 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 Safari/604.1
Remote IP: 98.184.238.192
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 11:24 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Mary Lee

Date: October 7, 2022
Time: 6:23 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 76.219.196.49
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 11:04 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Alex Terry

Date: October 7, 2022
Time: 6:03 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/15E148 Instagram 255.1.0.18.105 (iPhone11,2; iOS 16_0; en_US; en-US; scale=3.00; 1125x2436; 405816327) NW/3
Remote IP: 184.57.49.105
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 10:56 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Jackie Bouchey

Date: October 7, 2022
Time: 5:56 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 76.219.196.49
Powered by: Elementor

Revell, Mandy@Coastal

From: rondaclark09@gmail.com
Sent: Friday, October 7, 2022 9:53 AM
To: Revell, Mandy@Coastal
Subject: OPPOSITION To Application #5-21-0640; Agenda F17a; October 14, 2022 Meeting

Ronda Clark

OPPOSED

Application #5-21-0640

Agenda F17a

October 14, 2022

Mandy Revell,

As a resident of Newport Beach, please note my **OPPOSITION to the CAD** approval. The contamination risk associated with a CAD is an unacceptable risk for the residents of the area and to the many visitors to our public beaches adjacent to the anchorage and lining the harbor, from Balboa Peninsula and the various islands, to Corona Del Mar. There are other solutions that must be studied further and implemented. Please for the safety of our residents and protection of this natural resource **do not approve the CAD**.

Best Regards,
Ronda Clark
Newport Beach Resident and Registered Voter

Revell, Mandy@Coastal

From: Bryn Evans <evans_bryn@yahoo.com>
Sent: Friday, October 7, 2022 9:37 AM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640-Agenda F17a -October 14, 2022

Bryn Evans

Opposed

Application #5-21-0640

Agenda F17a

October 14, 2022

Mandy.Revell@coastal.ca.gov

California Coastal Commission

South Coast Area Office

301 East Ocean Blvd. Suite 300

Long Beach, CA. 90802-4302

(562) 590-5071

Coastal Commissioners-

I support growing concern about the subject project Agenda Item Wednesday 13b - Application No. 5-21-0640 (City of Newport Beach, Newport Beach). Based on available information, there appears to be serious administrative and technical issues with the project design and permitting approach.

Newport Bay is one of southern California's most sensitive environmental and recreational resources. Additional environmental review and planning is needed to better understand the actual environmental impacts of the proposed confined aquatic disposal (CAD) facility. The project description, used as part of the City of Newport Beach California Environmental Quality Act (CEQA) document, states the CAD serves "as a solution for sediment dredged from within Lower Newport Harbor not suitable for open ocean placement or nearshore disposal. The location of the CAD facility would be in the central portion of the harbor between Bay Island and Lido Isle". This description alone is evidence enough that the highest level of environmental review and planning should be used to evaluate the impacts, costs, and potential benefits of this project. Requiring anything less than highest standard of environmental review has serious consequences to the vital social, environmental, and economic characteristics of Newport Bay.

Please stop the permitting of this project and direct the City of Newport Beach to provide additional technical data and evaluate all potential options for dredge sediment management in Newport Bay. Additional information is needed to ensure Newport Bay's irreplaceable resources are protected from harmful pollutants for generations to come.

Thank you,

Bryn Evans

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 8:45 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Carla Mardian

Date: October 7, 2022
Time: 3:45 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 98.176.104.216
Powered by: Elementor

Revell, Mandy@Coastal

From: Deon Macdonald <deonm@tenant-works.com>
Sent: Friday, October 7, 2022 8:29 AM
To: Revell, Mandy@Coastal
Subject: Newport Harbor CAD Application 5-21-0640

Deo
n Macdonald

Appl
ication: #5-21-0640

Age
nda F17a

October 14, 2022

I am opposed to the proposal to bury material that is unsuitable for disposal in the open ocean and bury it in the Newport Beach Harbor.

Additional Points for Pausing:

1. Instead of cleaning up the contaminated material and disposing it on land, they plan to take the highly concentrated contaminated material in our residential recreational harbor out of the water and put it back into the water.

#2. Accepting the permit is premature as there is ongoing sediment sampling that has not been completed to give an accurate determination of the amount of material that is suitable or unsuitable for ocean disposal.

#3. Despite being a stated benefit of the plan, the CAD proposal doesn't guarantee the residents the ability to dispose of their unsuitable material in the CAD.

#4. The proposal includes a relocation of the boat anchorage for an undetermined time. The project is estimated to take 2 to 4 years.

#5. Despite having the City Council vote 6-1 to allow the Friends of Newport Harbor to proceed concurrently as an alternative to the CAD, there is no indication that the Coastal Commission is looking at the viable alternatives.

#6. The CAD proposal includes dredging on the weekends which is disruptive to recreational use and residents' lives when it is NOT necessary. We don't need little sabots and sailboats competing with tugs and dump scows on the weekends.

#7. They don't know how far down the contamination goes.

#8. There are still too many unknowns and the CA Coastal Commission needs to take more time to do its job to protect the health and well being of the bay and its residents.

Revell, Mandy@Coastal

From: Sullivan, Scott <ssullivan@insightinvestments.com>
Sent: Friday, October 7, 2022 8:24 AM
To: Revell, Mandy@Coastal
Subject: CAD Opposition
Attachments: CAD.docx

Attached is my letter in opposition to the proposed CAD project in Newport Harbor.
Thank you,
Scott

Revell, Mandy@Coastal

From: Mia Alexis <alexis_mia@hotmail.com>
Sent: Friday, October 7, 2022 7:32 AM
To: Revell, Mandy@Coastal
Subject: Opposed

Marc and Mia Alexis
Opposed
Application #5-21-0640
Agenda F17a
October 14,2022

We are opposed to burying toxic material in the Newport Bay where it can potentially escape and negatively impact our community.

Thank you,
Marc and Mia Alexis

Sent from my iPhone

Scott Sullivan
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

California Coastal Commission
Mandy Revell
South Coast Area Office
301 East Ocean Blvd.
Suite 300
Long Beach, CA. 90802

Mandy,

I am writing this letter in opposition to the CAD project being proposed in Newport Harbor and urge you and the Commission to evaluate alternative plans.

Thank You,
Scott Sullivan

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 7:18 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Marie Westphal Morales

Date: October 7, 2022
Time: 2:17 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 174.193.136.135
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 5:40 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Philip Thompson

Date: October 7, 2022
Time: 12:40 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36 Edg/105.0.1343.53
Remote IP: 174.212.106.195
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Friday, October 7, 2022 5:17 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Michael Tartaglia

Date: October 7, 2022
Time: 12:17 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 8.47.103.106
Powered by: Elementor

Revell, Mandy@Coastal

From: Erin J Anderson <erinjanderson@agaff.org>
Sent: Thursday, October 6, 2022 11:32 PM
To: Revell, Mandy@Coastal
Subject: Opposed

Erin Anderson
Opposed
Application #5-21-0640
Agenda F17a
October 14,2022

Erin J. Anderson
President/CEO/Founder
A. Gary Anderson Family Foundation
17772 Cowan
Irvine, CA 92614
erinjanderson@agaff.org
(949)242-5050 office
(714)745-3500 cell

Revell, Mandy@Coastal

From: Nancy Skinner <jskinnermd@aol.com>
Sent: Thursday, October 6, 2022 10:21 PM
To: Revell, Mandy@Coastal
Subject: Permit No. 5-21-0640 (City of Newport Beach)

Agenda No. F17a
Permit No. 5-21-0640 (City of Newport Beach)
Nancy Skinner
Support

To the California Coastal Commissioners:

I have had a chance to study and learn about Newport Beach's planned CAD dredging proposal and I support the proposal. In my opinion, this is a good option for completing a much-needed dredging in an environmentally safe, cost-effective and interesting way. I hope you will approve the request.

Sincerely,

Nancy Skinner
1724 Highland Drive
Newport Beach, CA 92660

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 9:49 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Conrad Tona

Date: October 7, 2022
Time: 4:49 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/15E148 Instagram 255.0.0.16.105 (iPhone14,3; iOS 16_0; en_US; en-US; scale=3.00; 1284x2778; 404463847) NW/3
Remote IP: 108.196.85.17
Powered by: Elementor

Revell, Mandy@Coastal

From: ljohnson@coastalshred.com
Sent: Thursday, October 6, 2022 8:05 PM
To: Revell, Mandy@Coastal
Cc: johnsonlido@sbcglobal.net
Subject: Newport Beach, CAD *Strongly Oppose*

Lisa Grundy Johnson
Opposed
Application #5-21-0640
Agenda 17a

Dear Mandy and Commissioners

STOP !! STOP !! STOP !! the CAD !! Turning one of the loveliest harbors into a HUGE UNDERWATER DUMP SITE goes against every part of the word STEWARDSHIP !! This Newport Harbor brings goodness
to millions of people each year. It is one of the Largest, Prettiest, and Active Pleasure Boat Harbors in the World !! What on Earth are You Possibly Thinking to Consider something so insidious ??!!
My family came to Balboa, CA over One Hundred years ago to be the First Physician during the Bird Flu Pandemic of 1919. My Grandfather, Dr Grundy, saved many lives and started Newport Beach's First
Hospital. We are enjoying this lovely harbor today not because people purposefully buried Toxic Waste but because they were good Stewards of our Harbor !!
"With every action … There is a consequence " My mother's Mantra to all of her kiddos !!! Where is the Common Sense in this decision ?? There is NONE !!
You ARE NOT BETTERING OUR Harbor (that most of us are trying to be good stewards of) by this CAD system !!! It really should never have gotten off of the drawing board !! I am super disappointed in my
Newport Beach City leaders that this is their best effort ?!!! This is NO Effort At All !! Just brainstorming with my neighbor we came up with at least three different options to dispose of the sandy 'toxic'
Waste.
Please decline this questionable CAD system and make Newport Beach return my Federal Tax Dollars for Dredging back until the Adults in the Room can Enter with Common Sense !!!

Thank You in Advance !!

Lisa Johnson

COASTAL SECURE SHREDDING

Lisa G. Johnson
President
Coastal Secure Shredding, Inc.
1765 Placentia Avenue, Unit A

Costa Mesa, CA 92627
949-515-6270
949-515-6207 Fax
ljohnson@coastalshred.com

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 7:32 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Angela Iversen

Date: October 7, 2022
Time: 2:32 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 172.116.137.74
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 7:17 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Mike Bullock

Date: October 7, 2022
Time: 2:16 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 104.0.83.125
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 6:57 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Justin Beget

Date: October 7, 2022
Time: 1:56 am
Page URL:
https://friendsofnewportharbor.org/?utm_source=social&utm_medium=paid&utm_campaign=save%20the%20bay&hsa_acc=515797409268691&hsa_cam=23851717150640773&hsa_grp=23851717150660773&hsa_ad=23851717150700773&hsa_src=ig&hsa_net=facebook&hsa_ver=3&fbclid=PAAaaeiXaiW-z42i9JbMKIdvru6xafkNjeWOz-TTNyGGnNHjhqCU5h056OJME_aem_AeDNSl_8HXMcQQSrByzWGcnWTI-RqsrW8e3rjH6oIuJwSYATTNKz0LcSJ9Gf8CKgkodR6PFLa3KrOvzUFQkudUceGLDHI4aFsCMcIZNdLai9mx3Fzqk0V9Fl7SX4tiWayhv0DGWX8s-wQI1JCM8XtA1M#elementor-action%3Aaction%3Dpopup%3Aopen%26settings%3DeyJpZCI6IjEyMCIsInRvZ2dsZSI6ZmFsc2V9
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0_2 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Mobile/15E148 Safari/604.1
Remote IP: 76.169.232.221
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 6:56 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Brenda Tartaglia

Date: October 7, 2022
Time: 1:56 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0_2 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Mobile/15E148 Safari/604.1
Remote IP: 8.47.103.106
Powered by: Elementor

Revell, Mandy@Coastal

From: monalanda2@gmail.com
Sent: Thursday, October 6, 2022 6:52 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640

$
]syv$Req i$Q sre$Perhe$
Sttswih$
Ettpmgexmsr$'916514:84$
Ekirhe$J5;e$
Sgxsfiv$580$6466$

Mona Landa
Monalanda2@gmail.com
714-964-2616

Gepmjsvrme$Gsewxep$Gsqqmwwmsr$
Wsyxl$Gsewx$Evie$Sjjmgi$

745$Iewx$Gsier$Fpzh$Wymxi744
Psrk$Fiegl0$GE2$=4<4618746$
,9:6-$9=4194;5$
$$

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 6:45 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Mona Landa

Date: October 7, 2022
Time: 1:44 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/106.0.0.0 Safari/537.36
Remote IP: 172.112.43.83
Powered by: Elementor

Revell, Mandy@Coastal

From: escapeartist55 (null) <escapeartist55@aol.com>
Sent: Thursday, October 6, 2022 6:42 PM
To: Revell, Mandy@Coastal
Subject: I support the dredging BUT I DO NOT SUPPORT THE CAD project

> Subject: I support the Dredging BUT I DO NOT SUPPORT THE CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640
> Email Body: I support the Dredging and BUT I DO NOT SUPPORT THE CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

PUT THE TOXIC WASTE SOMEWHERE ELSE.
DON'T SPOIL OUR TURNING BASIN AND PUT THE RESIDENTS IN TURMOIL FOR THE NEXT FEW YEARS

SARA Abraham. Resident
908 West Bay Ave, Newport Beach
Sent from my iPhone

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 6:32 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Kevin Dunlap

Date: October 7, 2022
Time: 1:31 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 104.0.83.186
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 5:59 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Todd

Date: October 7, 2022
Time: 12:59 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0_2 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/15E148 Instagram 255.1.0.18.105 (iPhone12,1; iOS 16_0_2; en_US; en-US; scale=2.00; 828x1792; 405816327) NW/3
Remote IP: 172.250.23.87
Powered by: Elementor

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 5:38 PM
To: Revell, Mandy@Coastal
Subject: FW: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

Krysten Tomaier | Coastal Program Analyst

CALIFORNIA COASTAL COMMISSION

South Coast District Office

301 E. Ocean Blvd, Suite 300

Long Beach, CA 90802

(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: nancy gardner <nlgardner@outlook.com>
Sent: Thursday, October 6, 2022 5:00 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

I support the City's request for approval of the CAD. The project has been closely scrutinized and approved by various agencies and is a methodology that has been used safely at other sites. Nancy Gardner, former Mayor, Newport Beach; former President, Surfrider Foundation
Sent from Mail for Windows

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 5:24 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Nicole Foster

Date: October 7, 2022
Time: 12:23 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.5 Safari/605.1.15
Remote IP: 172.116.131.184
Powered by: Elementor

Revell, Mandy@Coastal

From:	SouthCoast@Coastal
Sent:	Thursday, October 6, 2022 4:28 PM
To:	Revell, Mandy@Coastal
Cc:	Hillard, Simone@Coastal; Hammonds, Rebecca@Coastal
Subject:	FW: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

From: Susan Kenney <susankenney9094@gmail.com>
Sent: Thursday, October 6, 2022 3:42 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

To Whom It May Concern:

I have live in Newport Beach all my life. I am actually third generation on both of my parents' sides. My father's parents built one of the very first homes on the water front on Balboa Island in the early 1920s. I grew up sailing and swimming in this harbor. I have seen this harbor's water quality suffer from time to time during these years. Yet, it seem that the people who deeply love this bay; who work on it, live on it, sail on it, swim in it, rise up to heal its health when needed. Now is that time once again., I wish to show my support and approval of the City of Newport Beach's Application No. 5-21-0640, hoping the Coastal Commission will move forward on approving this application for the opportunity to remove unsuitable and unhealthy materials currently layered on the bottom of floor of our harbor.

I ask the Commissioners of the California Coastal Commission to approve the above mentioned application for the Confined Aquatic Disposal Facility. The people who love our (Newport) harbor are looking forward to move this much needed project forward.

Thank you so much for your consideration, time and effort in this matter.

Yours truly,

Susan Kenney
949.294.2054
susankenney9094@gmail.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 4:27 PM
To: Revell, Mandy@Coastal
Cc: Hillard, Simone@Coastal; Hammonds, Rebecca@Coastal
Subject: FW: I Support the CAD & Dredging Project in Newport Beach - Item -17a - Application No. 5-21-0640
Attachments: NAC Executive Director CAD Letter 10-5-2022 letterhead.docx

---

From: Billy Whitford <billy@newportaquaticcenter.com>
Sent: Thursday, October 6, 2022 3:33 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I Support the CAD & Dredging Project in Newport Beach - Item -17a - Application No. 5-21-0640

Billy Whitford
Executive Director
Newport Aquatic Center (NAC)
1 Whitecliffs Drive
Newport Beach, CA. 92660
Cell (949)400-5250
FAX (949)646-8398

NEWPORT AQUATIC CENTER
CALIFORNIA, US A

TO: California Coastal Commission SouthCoast@coastal.ca.gov

SUBJECT: Newport Beach Application For Confined Aquatic Disposal Facility (CAD)
October 14, 2022

FROM: Billy Whitford - Executive Director of the Newport Aquatic Center (NAC)

DATE: October 5, 2022

As the Executive Director of the Newport Aquatic Center, I can verify that the long-awaited dredging of the harbor and the proposed CAD & Dredging Project in Newport Beach – Item 17a – Application No. 5-21-0640 project will not affect nor negatively impact any of the current NAC programs and users.

The Newport Aquatic Center is located in the Back Bay of Newport Harbor. We are a world-renowned training facility for all types of human-powered craft including Olympic-style Rowing, Olympic-style Kayaking, Outrigger and Dragon Boat paddling. Our facility also offers unique public access to the harbor for recreational users and activities. From before sunrise until after sundown, 360 days of the year, NAC members and users utilize every waterway within Newport Harbor for our varied programs.

I ask that the Commissioners approve the City of Newport Beach's application for the CAD.

PHONE 949 646 7725 FAX 949 646 8398
ONE WHITECLIFFS DRIVE NEWPORT BEACH, CA 92660

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 4:27 PM
To: Revell, Mandy@Coastal
Cc: Hillard, Simone@Coastal; Hammonds, Rebecca@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a -Application No.5-21-0640

From: Billy Whitford <billy@newportaquaticcenter.com>
Sent: Thursday, October 6, 2022 3:30 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a -Application No.5-21-0640

TO: California Coastal Commission SouthCoast@coastal.ca.gov

SUBJECT: Newport Beach Application For Confined Aquatic Disposal Facility (CAD)
October 14, 2022

FROM: Billy Whitford - Executive Director of the Newport Aquatic Center (NAC)

DATE: October 5, 2022

As the Executive Director of the Newport Aquatic Center, I can verify that the long-awaited dredging of the harbor and the proposed CAD & Dredging Project in Newport Beach – Item 17a – Application No. 5-21-0640 project will not affect nor negatively impact any of the current NAC programs and users.

The Newport Aquatic Center is located in the Back Bay of Newport Harbor. We are a world-renowned training facility for all types of human-powered craft including Olympic-style Rowing, Olympic-style Kayaking, Outrigger and Dragon Boat paddling. Our facility also offers unique public access to the harbor for recreational users and activities. From before sunrise until after sundown, 360 days of the year, NAC members and users utilize every waterway within Newport Harbor for our varied programs.

I ask that the Commissioners approve the City of Newport Beach's application for the CAD.

Billy Whitford

Executive Director
Newport Aquatic Center (NAC)
1 Whitecliffs Drive
Newport Beach, CA. 92660
Cell (949)400-5250
FAX (949)646-8398

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 4:26 PM
To: Revell, Mandy@Coastal
Cc: Hillard, Simone@Coastal; Hammonds, Rebecca@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach-Item 17a- Application No.5-21-0640
Attachments: BW CAD Letter 10-5-2022.docx

From: Billy Whitford <billy@newportaquaticcenter.com>
Sent: Thursday, October 6, 2022 3:27 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach-Item 17a- Application No.5-21-0640

TO: California Coastal Commission SouthCoast@coastal.ca.gov

SUBJECT: Newport Beach Application For Confined Aquatic Disposal Facility (CAD)
October 14, 2022

FROM: Billy Whitford

DATE: October 5, 2022

I support the CAD & Dredging Project in Newport Beach – Item 17a – Application No. 5-21-0640.

I have grown up in Newport Beach and on the harbor since 1954. As a youngster, I was lucky enough to have resided at the Sea Scout Base for the first 14 years of my life. The harbor was my playground, swimming, sailing, fishing, paddling and rowing both recreationally and competitively. I deeply cherish those memories of my past, and still today you'll find me on the harbor nearly every day.

Over the decades dredging of the harbor has been neglected. As a long-time skipper I have knowledge of where the shallow shoals are throughout the harbor. Unfortunately, nearly all of these shallow areas have made the harbor inaccessible to boaters. Should the Coastal Commission deny the City's application, the harbor will continue to silt up causing not only more navigational hazards, but the harbor won't properly flush resulting in deteriorating water quality.

By approving Application No. 5-21-0640 the Coastal Commission will allow the City to move forward the long awaited dredging of the harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.

I ask that the Commissioners approve this application for the CAD and allow this project to move forward.

Billy Whitford

Revell, Mandy@Coastal

From:	SouthCoast@Coastal
Sent:	Thursday, October 6, 2022 4:22 PM
To:	Revell, Mandy@Coastal
Cc:	Hillard, Simone@Coastal; Hammonds, Rebecca@Coastal
Subject:	FW: In regards to Item - 17a Newport Beach Dredging & CAD Project - Application No. 5-21-0640.

From: Jenieve Davenport <jenievemd@gmail.com>
Sent: Thursday, October 6, 2022 2:41 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>; Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: In regards to Item - 17a Newport Beach Dredging & CAD Project - Application No. 5-21-0640.

Coastal Commission Board and Staff,

In regards to Item- 17a Newport Beach Dredging & CAD Project - Application No. 5-21-0640.

I inadvertently sent an auto generated response not supporting Application No. 5-21-064. This email corrects the previous email and SUPPORTS the Dredging and CAD Project for Newport Beach. I am in full support of this project for these following reasons.

• By approving the City of Newport Beach Application No. 5-21-0640 the Coastal Commission has the opportunity to move forward the long awaited dredging of Newport Harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.

• The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.

• The City of Newport Beach is near the end of the road. With the California Coastal Commission's approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.

• If the Coastal Commission doesn’t approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won’t properly flush resulting in deteriorating water quality.

• This Application furthers the mission of the California Coastal Commission to protect and enhance California’s coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor’s floor.

We are also in the agreement of the Coastal Commission’s Staff’s conclusions, which are in part:

• The proposed Newport Beach disposal site for the clean sand is the least damaging feasible alternative and the proposed CAD facility is the least damaging feasible alternative for disposal of contaminated sediments (Staff Report page 3).

• The project is consistent with the allowable use, alternatives, and mitigation tests contained in Coastal Act Section 30233 (Staff Report page 3).

• The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3).

• The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).

• The City's Sediment Management Plan, which was developed to manage all of the different types of sediment within the harbor was fully vetted through the DMMT process, and it provides details on unsuitable material quantities, and therefore, Commission staff believes that it adequately supports the design of the proposed project (Staff Report page 4).

• The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5).

• The project construction would actually result in an increase of the available area for boats to pass through compared to existing conditions with an occupied anchorage in place (Staff Report page 6).

• This project is an allowable use pursuant to Section 30233(a)(2), -(4), and -(6), as components of the project achieve numerous goals for the overall functionality of Newport Harbor (Staff Report page 22).

• The Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways (Staff Report page 24).

• The proposed project includes the following characteristics which supported the Navy, USACE, and Oxnard Harbor District's consideration of CAD technology to remedy the current sediment contamination problems in Lower Newport Harbor:

o Moderate levels of contaminants in harbor sediments

o CAD design provides a low risk of failure either by fluid migration or physical exposure

o Sediments primarily contain contaminants from past practices that are not expected to re-contaminate the harbor

o CAD developers (USACE and the City of Newport Beach) are committed to a maintenance and monitoring plan that would ensure that the contaminants remain isolated in the CAD facility

o CAD location ensures that it can be adequately maintained by the CAD developers (Staff Report page 26).

• Construction of the CAD in lower Newport Harbor and deposition of beach quality sand in nearshore waters just west of the Newport Harbor mouth is not expected to cause significant adverse impacts to non-listed or sensitive bird species that nest, roost, and forage in the area (Staff Report page 34).

• Eelgrass impacts are not anticipated to occur as a result of the proposed project (Staff Report page 34).

• The project is not expected to cause a significant adverse impact to populations of these marine invertebrate species (Staff Report page 34).

• Therefore, as conditioned for revised plans limiting the locations for sand disposal to avoid contiguous sand dollar beds as shown in Exhibit 5, in addition to avoiding nighttime sand deposition to avoid potential negative impacts to grunion, Commission staff finds the project consistent with Sections 30230 and 30231 of the Coastal Act (Staff Report page 36).

• In other words, the existing water quality of Newport Bay is already negatively affected by the presence of DDx compounds and is not predicted to appreciably change as a result of the proposed placement of DDx containing sediments into the CAD. Further, by collecting, concentrating and burying contaminant laden sediments below a clean cap within the proposed CAD that are currently dispersed across Newport Bay, the proposed project may result in water quality improvements (Staff Report page 38).

• As conditioned, Commission staff has determined that the removal, placement, and permanent containment of DDT-contaminated Lower Newport Bay sediments at the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality within the Bay (Staff Report page 38).

• The Commission finds that the proposed project as conditioned would transfer sands currently isolated in Newport Harbor back into the littoral system off Newport Beach via nearshore placement, and is therefore consistent with the Section 30233(b) sand supply policy of the Coastal Act (Staff Report page 42).

• The additional sand that would be placed as part of the project is expected to contribute to efforts to minimize the hazards of flooding from high tides and waves experienced on the ocean beaches of Newport Beach (Staff Report page 44).

• The proposed project conforms with the Coastal Act policies which protect and encourage public access and recreational use of coastal areas. The proposed project would mitigate beach erosion and provide for the continuing and increased recreational use of the City beach by the public by increasing the size of the ocean beaches and would provide a larger area for recreational use. In addition, the proposed dredging components of the project would allow for continued use of coastal waters for recreational boating because the existing anchorage in the proposed CAD project area will be temporarily relocated to the Turning Basin (Staff Report pages 45-46).

• The proposed beach replenishment would maintain and improve recreational use of State Tidelands. Sand replenishment around public beaches is consistent with the City's Tidelands grant (Staff Report pages 46).

• As conditioned, the Commission finds that with these measures, the proposed project would not adversely affect visual resources of the coastal zone, and therefore, the project is consistent with the policies of the Coastal Act (Staff Report pages 47).

• The majority of communities adjacent to the proposed CAD site (except for downtown Costa Mesa), on the other hand have low overall CalEnviroScreen scores. Additionally, areas nearby with higher pollution burden scores that are above 60% in the northern part of Newport Beach would not be affected by the proposed project or any of the alternatives. Therefore, the proposed project of keeping the contaminated sediment in the harbor near the source(s) of contamination does not result in environmental justice impacts compared to the project alternatives, which would relocate contaminated sediments to communities of concern in other regions and require transport of sediments through additional communities of concern. In addition, as conditioned, the project would minimize adverse environmental impacts that may occur locally (Staff Report pages 50).

• The Commission finds that the project, as conditioned, is consistent with Coastal Act requirements and will not cause new adverse impacts to the environment. Feasible mitigation measures which will minimize all adverse environmental impacts have been required. Therefore, the Commission finds that the proposed project, as conditioned, complies with the applicable requirements of the Coastal Act to conform to CEQA (Staff Report pages 51).

I ask you the Commissioners of the California Coastal Commission to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

Thank you,

Jenieve Davenport Badajoz

Newport Beach CA 92663

Revell, Mandy@Coastal

From: Lamm, Ashley <alamm@newportbeachca.gov>
Sent: Thursday, October 6, 2022 4:10 PM
To: 'novak@jfnovaklaw.com'
Cc: 'ota.allan@epa.gov'; Revell, Mandy@Coastal; 'Gerardo.salas@usace.army.mil'; Tenorio, Claudia@Waterboards; Leung, Grace@City of Newport Beach; Webb, Dave (Public Works); Miller, Chris; Summerhill, Yolanda; Harp, Aaron
Subject: City of Newport Beach Response re: Lower Newport Bay CAD Project
Attachments: 00554725.pdf

Good Afternoon,

Please find attached hereto City's response to correspondence regarding the Lower Newport Bay CAD Project.

Thank you,
Ashley

** Attached file(s):
10.06.22 Ltr re Lower Newport Bay CAD Project (00554725.pdf)

Ashley M. Lamm
Paralegal
City Attorney's Office | City of Newport Beach
100 Civic Center Drive
Newport Beach, California 92660
949-644-3131 | 949-644-3139 Fax
alamm@newportbeachca.gov

CITY OF NEWPORT BEACH
100 Civic Center Drive
Newport Beach, California 92660
949 644-3131 | 949 644-3139 FAX
newportbeachca.gov/cityattorney

October 6, 2022

SENT VIA EMAIL: *novak@jfnovaklaw.com*

Jennifer F. Novak
Law Office of Jennifer F. Novak
Counsel for Friends of Newport Harbor, LLC
500 Silver Spur Road, Suite 206
Rancho Palos Verdes, CA 90275

RE: *City of Newport Beach's Response to Friends of Newport Harbor, LLC Correspondence re: Concerns Related to Lower Newport Bay Confined Aquatic Disposal Project, City of Newport Beach File #302021-09*

Dear Ms. Novak:

The City of Newport Beach ("City") is writing in response to your correspondence dated October 4, 2022, expressing concerns regarding the City's proposed Confined Aquatic Disposal ("CAD") and its potential for long and short-term effects on Lower Newport Bay's water quality, animal and plant species, and designated beneficial uses. Specifically, in your correspondence, you contend that the U.S. Army Corps of Engineers ("USACE") guidance was not followed for the evaluation of the proposed CAD site, contaminated material was not tested by itself, and elutriate data is needed to estimate potential effects on water quality. After a thorough review of each of these points, the City is confident that all concerns raised in your letter are adequately addressed.

Regarding your contention that the *Guidance for Subaqueous Capping of Dredged Material*[1] ("Guidance for Subaqueous Capping") developed by USACE was not followed, the Guidance for Subaqueous Capping was followed and referenced multiple times in the Basis of Design Report ("BODR"), which is included as Appendix C to Draft Environmental Impact Report ("DEIR"). Multiple scientific studies were conducted as part of the BODR to evaluate and design the proposed CAD facility in accordance with this guidance manual. Specifically, Section 5 of the BODR confirms the Guidance for Subaqueous Capping was followed and provides that:

---

[1] Palermo, M.R., J.E. Clausner, M.P. Rollings, G.L. Williams, T.E. Myers, T.J. Fredette, and R. Randall, 1998a. Guidance for Subaqueous Dredged Material Capping. Technical Report DOER-1, U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, Mississippi.

> *In particular, the USACE has published guidance on designing CAD facilities and cap layers to permanently isolate chemically impacted sediments from overlying waters and the environment (Palermo et al. 1998a, 1998b).*[2]
>
> *In soft bottom marine substrates, bioturbation is the mixing and overturning of sediments caused by organisms residing in the sediments (i.e., benthic organisms). Consistent with Palermo et al. (1998a, 1998b), cap thickness design needs to include a component of thickness that is sufficient to prevent substantial bioturbation of sediments underlying the cap. As such, a cap intending to isolate sediments unsuitable for open ocean disposal should have a thickness greater than or equivalent to the depth where the future bioturbation rate is expected to be close to zero.*

Similarly, in response to comments received during the Draft EIR public comment period pertaining to impacts to water quality or the potential to release hazardous materials during initial placement of sediment or after being capped, the City reiterated that "[c]hemical isolation modeling was conducted following U.S. Environmental Protection Agency ("USEPA") and USACE guidance to simulate the transport of mercury, DDTs, and PCBs through the final cap layer (1998a)."

Regarding the testing of material, contaminated material was tested as part of the federal channel sediment characterization program. The composite sample from the Turning Basin represents the most contaminated material proposed for placement within the CAD site, with the highest mercury and PCB concentrations compared to any other material that was unsuitable for ocean disposal. All this material is proposed for placement within the CAD site and was tested independently of any material that was determined suitable for ocean disposal. This material represents the worst-case scenario, and it was not blended with suitable material for testing. Although, chemical concentrations in this area were higher than anywhere else within the federal channels, all ecological tests passed.

Regarding the evaluation of water column impacts, standard elutriate was created and submitted for water column bioassay testing using three sensitive species, which is a better indicator of risk than chemical concentrations and is the standard practice that is required by the regulatory agencies. It should be noted that the Guidance for Subaqueous Capping <u>does not</u> provide direction on elutriate and water column bioassay procedures. Rather, the Guidance for Subaqueous Capping refers the reader to elutriate and water column bioassay procedures provided in the *Evaluation for Dredged Material Proposed for Ocean Disposal: Testing Manual* (OTM) and *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S.: Inland Testing Manual* (ITM) ("Evaluation for Dredged Material Proposed for Ocean Disposal") for conducting the evaluation of water column impacts, which is exactly what was completed as part of the testing for the federal

[2] Palermo, M.R., J. Miller, S. Maynord, and D. Reible, 1998b. Assessment and Remediation of Contaminated Sediments (ARCS) Program, Guidance for In-Situ Subaqueous Capping of Contaminated Sediments. USEPA 905/B96/004. Prepared for the Great Lakes National Program Office, U.S. Environmental Protection Agency, Chicago, Illinois. September 1998. Available at: http://www.epa.gov/glnpo/sediment/iscmain.

channel testing program. The Guidance for Subaqueous Capping and Evaluation for Dredged Material Proposed for Ocean Disposal provide a tiered approach and scientifically based decision process to assess a proposed disposal activity. For the CAD, a Tier III evaluation was conducted, which is more intensive than the evaluation of water column impacts that is conducted as part of a Tier II and includes modeling and/or elutriate chemistry. It should also be noted that in accordance with USACE and USEPA guidance, testing can begin at a later tier without conducting the evaluation at each preceding tier. Based on the results of elutriate bioassay testing conducted as part of this program, no water column impacts are expected during placement.

This testing fully complies with the USACE guidance, however, to further evaluate water column impacts during placement, a USACE developed model (i.e., STFATE) was also used to predict compliance with applicable water quality criteria. This model is discussed in the Guidance for Subaqueous Capping to evaluate water column impacts with additional details contained in Appendix D of this USACE document. As part of the CAD evaluation, USEPA and USACE requested an independent review by the U.S. Army Engineer Research and Development Center ("ERDC") of the City's STFATE model and assumptions on the approach and appropriateness of the model to assess short-term impacts to water quality. The ERDC Memorandum dated May 16, 2022, re: the City's STFATE Model, which is attached hereto as Exhibit "A," concluded that:

> *The application of the STFATE model is appropriate to evaluate the short-term losses during the placement operations at the proposed Lower Newport Bay CAD site. Applying the STFATE model for a CAD site would generate rather conservative estimates of losses until the CAD cell is nearly full. The model input, scenarios, application and assumptions are appropriate to provide a conservative picture of the potential solids losses from the placement operations.*

Therefore, STFATE modeling is applicable and was properly conducted as part of the CAD with results that are environmentally sound.

In April 2020, the City provided a draft of the BODR to the USEPA for preliminary review. Through follow up review – and as presented in the USEPA Memorandum dated May 24, 2021, which is attached hereto as Exhibit "B," the USEPA noted the following:

> *EPA comments on the BODR were appropriately addressed and incorporated into the November 29, 2020 version included as Appendix C to the project's Environmental Impact Report. The revised BODR provides a robust and appropriate technical analysis to support consideration of moving forward with permitting of the proposed CAD.*

As indicated in previous correspondence, based on the USEPA's extensive experience overseeing design and implementation of CAD facilities on the West Coast (most recently at Port Hueneme in 2009), it was the City's intent to request a focused review from the USEPA. The USEPA supported the City's BODR for the CAD noting that "the draft BODR and its appendices analyze issues associated with CAD in an appropriate manner, consistent with USEPA and USACE national technical design guidelines." (Exhibit B.)

More specifically, the letter from the USEPA was authored by Brian Ross, Dredging & Sediment Management Team USEPA, Region 9. Mr. Ross was a member of the working group that contributed to the review of Guidance for Subaqueous Capping. The working group is comprised of individuals from headquarters, field offices, and research laboratories of both agencies with scientific and/or programmatic experience related to dredged material disposal management. Mr. Ross is certainly qualified to review the BODR and confirm that the CAD complied with appropriate federal guidance documents.

The process used for designing the Newport CAD cell are identical to the procedures used by Anchor QEA for the development of the Hueneme and Long Beach CADs and by USEPA for the design of the New Bedford Harbor CAD.

We hope this response addresses all the concerns raised by Friends of Newport Harbor, LLC. If you have any additional questions, please do not hesitate to contact me.

Sincerely,

Aaron C. Harp
City Attorney

Attachments: Exhibit A - ERDC Memorandum dated May 16, 2022
Exhibit B - USEPA Memorandum dated May 24, 2021

CC: Mayor Kevin Muldoon @ kmuldoon@newportbeachca.gov
Mayor Pro Tem Noah Blom @ NBlom@newportbeachca.gov
Councilmember Brad Avery @ bavery@newportbeachca.gov
Councilmember Joy Brenner @ JBrenner@newportbeachca.gov
Councilmember Diane Dixon @ ddixon@newportbeachca.gov
Councilmember Duffy Duffield @ dduffield@newportbeachca.gov
Councilmember Will O'Neill @ woneill@newportbeachca.gov
U.S. Environmental Protection Agency, Allan Ota @ ota.allan@epa.gov
California Coastal Commission, Mandel Revell @ Mandy.Revell@coastal.ca.gov
Army Corps of Engineers, Gerry Salas @ Gerardo.salas@usace.army.mil
Santa Ana Regional Water Quality Control Board, Claudia Tenorio @ Claudia.Tenorio@Waterboards.ca.gov
City Manager Grace Leung @ gleung@newportbeachca.gov
Public Works Director Dave Webb @ DAWebb@newportbeachca.gov
Harbor Resources Manager Chris Miller @ cmiller@newportbeachca.gov

Exhibit A

ERDC Memorandum dated May 16, 2022

CEERD-EPE 16 May 2022

TECHNICAL MEMORANDUM FOR: Ms. Cori Farrar, Chief, CESPL-RGS
Mr. Gerry Salas, Senior Project Manager, CESPL- RGS-O

SUBJECT: Review of STFATE Modeling of City of Newport Beach CAD – Lower Newport Bay

1. **Background.** Anchor QEA performed an analysis of short-term water quality impacts during dredged material placement operations at the proposed confined aquatic disposal (CAD) facility within the Lower Newport Bay Federal Channels using the USACE Short-Term Fate (STFATE) model as described in Appendix G: Analysis of Short-Term Water Quality Impacts During Construction from the Basis of Design Report (Anchor QEA April 29, 2020). To support permitting of the CAD facility, I have been asked to:

(1) to review the applicability of the STFATE model for predicting sediment losses during placement of material from a bottom dump scow into the CAD cell; and

(2) to confirm that the assumptions and procedures that were applied to the Newport Bay study were accurate and appropriate for the proposed project.

2. **Applicability.** The STFATE model is an appropriate model to evaluate the short-term fate of dredged material discharged in open water from a dump scow or barge as described in both the Ocean Testing Manual: Evaluation of Dredged Material Proposed for Ocean Disposal (EPA/USACE 1991) and the Inland Testing Manual: Evaluation of Dredged Material Proposed For Discharge in Waters of the U.S. (EPA/ USACE 1998). The model predicts both water quality impacts and deposition of solids in the short term (approximately four hours after discharge). This time period is sufficient to observe impacts from the discharge and for the discharge plume to leave the disposal site and to be well dispersed. After this period, the plume would not be expected to contribute meaningfully to solids accumulation on the sediment bed.

Applying the STFATE model for a CAD cell in shallow water is likely to be rather conservative because the discharge would be confined by the wall of the CAD cell, limiting its spread. In addition, the currents within the CAD cell would be very small, which along with the greater density of the dredged material discharge would limit the vertical dispersion (vertical diffusivity) and losses. Very little of exchange of water would be anticipated at a depth 5 to 10 feet below the lip of the CAD cell. The STFATE model does not consider these effects when applied using constant water depths and uniform currents.

3. **Review of Data Input, Model Application and Assumptions.** The model requires six classes of data input: Site Description, Velocity Conditions, Execution Parameters, Dredged Material Description, Disposal Operation Description and Model Coefficients.

a. <u>Site Description</u>. The description includes water depth and salinity profile. The input in the model runs used appropriate values for the site. The input also requires a description of the modeling grid and grid resolution. The grid size and resolution were appropriate for determining deposition within the CAD cell and solids losses and water quality outside of the CAD cell.

b. <u>Velocity Conditions</u>. The velocity conditions require data on upper and lower water column velocities and directions. The site is tidally influenced and model runs were executed for both flood and ebb tides using currents for average conditions for 2 hours from slack water conditions when currents are strong. This average current was used throughout the top 12 feet of the water column which then decreased linearly to zero at the bottom of the water column (13.5 ft). The selection of the velocity data and its application is appropriate.

c. Execution Parameters. The execution parameters includes analysis desired, duration of the simulation and size of the timestep. The model was run to evaluate solids fate (transport and deposition). This is appropriate because water column toxicity was not anticipated based on the sediment chemistry. The model was run using several durations and timesteps. The duration of the model runs was appropriate to evaluate solids losses and water quality impacts. The timesteps were initially too large for the grid resolution and therefore smaller timesteps were also used to determine the sensitivity of the results on the magnitude of the timestep. The sensitivity results demonstrate that the results from using a large timestep was conservative (overpredicting losses and water quality impacts in the mid-field). As such, the selection of timesteps and durations are appropriate.

d. Dredged Material Description. The description includes the classes of solids in the dredged material, the specific gravities, their fraction in the discharge, their fall velocity, depositional void ratio and critical shear stress for deposition. The input was divided into sand, silt, clay and clumps. Model runs were executed for five scenarios with different material descriptions. The input was appropriate for the sediment properties.

e. Disposal Operation Description. The description includes barge dimension, volume, draft, discharge duration, and CAD dimensions. The input was appropriate for a 2,000-cy dump barge.

f. Model Coefficients. The model uses fourteen coefficients to model the disposal processes including entrainment, drag, friction and diffusion. Default coefficient values are provided for each of the coefficients. The model runs used the default coefficients.

4. **Conclusions.** The application of the STFATE model is appropriate to evaluate the short-term losses during the placement operations at the proposed Lower Newport Bay CAD site. Applying the STFATE model for a CAD site would generate rather conservative estimates of losses until the CAD cell is nearly full. The model input, scenarios, application and assumptions are appropriate to provide a conservative picture of the potential solids losses from the placement operations.

Paul R. Schroeder

Paul R. Schroeder, PhD, PE
Research Civil Engineer
Environmental Laboratory
U.S. Army Engineer Research and Development Center

Exhibit B

USEPA Memorandum dated May 24, 2021

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

May 24, 2021

MEMORANDUM

To: City Council, City of Newport Beach
c/o David Webb, Director of Public Works

From: Brian Ross, Dredging & Sediment Management Team
US EPA, Region 9

Subject: EPA Statement on the proposed Lower Newport Bay Dredging and CAD Project, Newport Bay, California

Dear Newport Beach City Council and Mr. Webb,

Thank you for the opportunity to provide this statement concerning the "Lower Newport Bay Dredging and CAD Project 2021", that you will be considering at your May 25, 2021 meeting. The purpose of this statement is to confirm EPA's coordination to date on technical aspects of the proposed project, and our view that a properly designed and managed Confined Aquatic Disposal (CAD) site could be a positive aspect of the larger goal to improve sediment and water quality in Lower Newport Bay.

EPA appreciates the City's ongoing work managing the Regional General Permit for dredging in Lower Newport Bay, and its commitment to beneficial use of the dredged material whenever possible. EPA has been involved in Newport Bay dredging and sediment quality issues for some time. Much of the sediment dredged from Lower Newport Bay is clean enough to be suitable for either ocean disposal at EPA's offshore "LA-3" ocean disposal site (for mud) or for beneficial use to nourish local beaches (sand). However some portions of the Federal channels, and private docks and other facilities surrounding them, contain materials that are unsuitable for ocean disposal or beach nourishment. These sediments require management that either isolates them from direct exposure to marine organisms or removes them from the aquatic environment entirely. CAD, when properly designed and maintained, can be an appropriate management option for such sediments.

While EPA has no role in approving the CAD project at this stage, EPA staff have coordinated with the City's design contractor team over the past year on technical aspects of the proposed CAD option. This coordination included EPA review of the April 29, 2020 "Draft Basis of Design Report, Sediment Dredging and Confined Aquatic Disposal" (BODR). EPA's comments on the draft BODR were provided on May 14, 2020. Overall, we found that, *"the draft BODR and its appendices analyze issues associated with CAD in an appropriate manner, consistent with EPA and US Army Corps of Engineers national technical design guidelines. In particular, it evaluates the cap design in terms of chemical isolation, biological isolation, potential cap scour, and potential water quality effects that could occur during construction of the CAD cell and disposal of dredged material into it. The BODR does a good job presenting each of these analyses and documenting an adequate basis for the proposed CAD dimensions and the proposed cap thickness."*

We also provided a number of specific comments for clarifying the analyses in the BODR. The EPA comments on the BODR were appropriately addressed and incorporated into the November 29, 2020 version included as Appendix C to the project's Environmental Impact Report. The revised BODR provides a robust and appropriate technical analysis to support consideration of moving forward with permitting of the proposed CAD.

Thank you again for the opportunity to provide this statement.

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 3:10 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Genevieve Nowicki

Date: October 6, 2022
Time: 10:09 pm
Page URL:
https://friendsofnewportharbor.org/?utm_source=social&utm_medium=paid&utm_campaign=save%20the%20bay&hsa_acc=515797409268691&hsa_cam=23851717150640773&hsa_grp=23851717150660773&hsa_ad=23851717150700773&hsa_src=ig&hsa_net=facebook&hsa_ver=3&fbclid=PAAaYx3uecwTRqsAyYI-OCrSziBciQ8_KbpDtNwGBG0qMPK4wl4EHgk3biV1E
User Agent: Mozilla/5.0 (Linux; Android 12; SM-N970U Build/SP1A.210812.016; wv) AppleWebKit/537.36 (KHTML, like Gecko) Version/4.0 Chrome/106.0.5249.79 Mobile Safari/537.36 Instagram 255.1.0.17.102 Android (31/12; 450dpi; 1080x2055; samsung; SM-N970U; d1q; qcom; en_US; 405431927)
Remote IP: 107.127.25.33
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 2:49 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Pam Conner

Date: October 6, 2022
Time: 9:48 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_6) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Safari/605.1.15
Remote IP: 70.164.212.16
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 2:47 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Augie Napolitano

Date: October 6, 2022
Time: 9:46 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 174.195.139.243
Powered by: Elementor

Revell, Mandy@Coastal

From: Jenieve Davenport <jenievemd@gmail.com>
Sent: Thursday, October 6, 2022 2:41 PM
To: SouthCoast@Coastal; Revell, Mandy@Coastal
Subject: In regards to Item - 17a Newport Beach Dredging & CAD Project - Application No. 5-21-0640.

Coastal Commission Board and Staff,

In regards to Item- 17a Newport Beach Dredging & CAD Project - Application No. 5-21-0640.

I inadvertently sent an auto generated response not supporting Application No. 5-21-064. This email corrects the previous email and SUPPORTS the Dredging and CAD Project for Newport Beach. I am in full support of this project for these following reasons.

• By approving the City of Newport Beach Application No. 5-21-0640 the Coastal Commission has the opportunity to move forward the long awaited dredging of Newport Harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.

• The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.

• The City of Newport Beach is near the end of the road. With the California Coastal Commission's approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.

• If the Coastal Commission doesn’t approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won’t properly flush resulting in deteriorating water quality.

• This Application furthers the mission of the California Coastal Commission to protect and enhance California’s coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor’s floor.

We are also in the agreement of the Coastal Commission’s Staff’s conclusions, which are in part:

• The proposed Newport Beach disposal site for the clean sand is the least damaging feasible alternative and the proposed CAD facility is the least damaging feasible alternative for disposal of contaminated sediments (Staff Report page 3).

• The project is consistent with the allowable use, alternatives, and mitigation tests contained in Coastal Act Section 30233 (Staff Report page 3).

• The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3).

• The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).

• The City's Sediment Management Plan, which was developed to manage all of the different types of sediment within the harbor was fully vetted through the DMMT process, and it provides details on unsuitable material quantities, and therefore, Commission staff believes that it adequately supports the design of the proposed project (Staff Report page 4).

• The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5).

• The project construction would actually result in an increase of the available area for boats to pass through compared to existing conditions with an occupied anchorage in place (Staff Report page 6).

• This project is an allowable use pursuant to Section 30233(a)(2), -(4), and -(6), as components of the project achieve numerous goals for the overall functionality of Newport Harbor (Staff Report page 22).

• The Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways (Staff Report page 24).

• The proposed project includes the following characteristics which supported the Navy, USACE, and Oxnard Harbor District's consideration of CAD technology to remedy the current sediment contamination problems in Lower Newport Harbor:

o Moderate levels of contaminants in harbor sediments

o CAD design provides a low risk of failure either by fluid migration or physical exposure

o Sediments primarily contain contaminants from past practices that are not expected to re-contaminate the harbor

o CAD developers (USACE and the City of Newport Beach) are committed to a maintenance and monitoring plan that would ensure that the contaminants remain isolated in the CAD facility

o CAD location ensures that it can be adequately maintained by the CAD developers (Staff Report page 26).

• Construction of the CAD in lower Newport Harbor and deposition of beach quality sand in nearshore waters just west of the Newport Harbor mouth is not expected to cause significant adverse impacts to non-listed or sensitive bird species that nest, roost, and forage in the area (Staff Report page 34).

• Eelgrass impacts are not anticipated to occur as a result of the proposed project (Staff Report page 34).

• The project is not expected to cause a significant adverse impact to populations of these marine invertebrate species (Staff Report page 34).

• Therefore, as conditioned for revised plans limiting the locations for sand disposal to avoid contiguous sand dollar beds as shown in Exhibit 5, in addition to avoiding nighttime sand deposition to avoid potential negative impacts to grunion, Commission staff finds the project consistent with Sections 30230 and 30231 of the Coastal Act (Staff Report page 36).

• In other words, the existing water quality of Newport Bay is already negatively affected by the presence of DDx compounds and is not predicted to appreciably change as a result of the proposed placement of DDx containing sediments into the CAD. Further, by collecting, concentrating and burying contaminant laden sediments below a clean cap within the proposed CAD that are currently dispersed across Newport Bay, the proposed project may result in water quality improvements (Staff Report page 38).

• As conditioned, Commission staff has determined that the removal, placement, and permanent containment of DDT-contaminated Lower Newport Bay sediments at the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality within the Bay (Staff Report page 38).

• The Commission finds that the proposed project as conditioned would transfer sands currently isolated in Newport Harbor back into the littoral system off Newport Beach via nearshore placement, and is therefore consistent with the Section 30233(b) sand supply policy of the Coastal Act (Staff Report page 42).

• The additional sand that would be placed as part of the project is expected to contribute to efforts to minimize the hazards of flooding from high tides and waves experienced on the ocean beaches of Newport Beach (Staff Report page 44).

• The proposed project conforms with the Coastal Act policies which protect and encourage public access and recreational use of coastal areas. The proposed project would mitigate beach erosion and provide for the continuing and increased recreational use of the City beach by the public by increasing the size of the ocean beaches and would provide a larger area for recreational use. In addition, the proposed dredging components of the project would allow for continued use of coastal waters for recreational boating because the existing anchorage in the proposed CAD project area will be temporarily relocated to the Turning Basin (Staff Report pages 45-46).

• The proposed beach replenishment would maintain and improve recreational use of State Tidelands. Sand replenishment around public beaches is consistent with the City's Tidelands grant (Staff Report pages 46).

• As conditioned, the Commission finds that with these measures, the proposed project would not adversely affect visual resources of the coastal zone, and therefore, the project is consistent with the policies of the Coastal Act (Staff Report pages 47).

• The majority of communities adjacent to the proposed CAD site (except for downtown Costa Mesa), on the other hand have low overall CalEnviroScreen scores. Additionally, areas nearby with higher pollution burden scores that are above 60% in the northern part of Newport Beach would not be affected by the proposed project or any of the alternatives. Therefore, the proposed project of keeping the contaminated sediment in the harbor near the source(s) of contamination does not result in environmental justice impacts compared to the project alternatives, which would relocate contaminated sediments to communities of concern in other regions and require transport of sediments through additional communities of concern. In addition, as conditioned, the project would minimize adverse environmental impacts that may occur locally (Staff Report pages 50).

• The Commission finds that the project, as conditioned, is consistent with Coastal Act requirements and will not cause new adverse impacts to the environment. Feasible mitigation measures which will minimize all adverse environmental impacts have been required. Therefore, the Commission finds that the proposed project, as conditioned, complies with the applicable requirements of the Coastal Act to conform to CEQA (Staff Report pages 51).

I ask you the Commissioners of the California Coastal Commission to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

Thank you,

Jenieve Davenport Badajoz

Newport Beach CA 92663

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:32 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Anne Worrell <annewl2@icloud.com>
Sent: Thursday, October 6, 2022 2:19 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

I am a long Newport Resident (30+yrs) avid boater; sail and electric. Dredging will allow better and cleaner water since more water will go in and out of our harbor and is of great importance to maintaining our beautiful harbor.

Anne Worrell

Anne Worrell
ANNEWL2@ICLOUD.COM
H.949.548.4615
C.949.433.2631

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:30 PM
To: Revell, Mandy@Coastal
Subject: FW: Support for the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Molly McCray <molly@mccrayco.com>
Sent: Thursday, October 6, 2022 2:00 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support for the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.
Thank you.
Sincerely,
Molly McCray
(949) 677-6312
molly@mccrayco.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:25 PM
To: Revell, Mandy@Coastal
Subject: FW: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: mhewitt lawverdict.com <mhewitt@lawverdict.com>
Sent: Thursday, October 6, 2022 11:56 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

Dear Coastal Commissioners,
I have reviewed and considered the majority of the evidence offered on both sides of the issue and the staff report, and, as confirmed by the staff report, can only conclude that the CAP is the safest and most viable solution to this issue.

The opponents proposal to use Lower Castaways as a landfill is garbage-no pun intended. Lower Castaways has a long history as a wharf and stagecoach stop dating back to the Spanish Land Grants. To consider turning this historical site into a landfill is repulsive and unnecessary.

Please adopt the staff report on this matter.
Best regards,
Mike Hewitt

Michael C. Hewitt
Attorney at Law

Law Offices of Michael C. Hewitt
2082 Michelson Drive, Suite 300
Irvine , CA 92612

(949) 825-5260 Voice
(949) 825-5261 Fax

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:20 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project - City of Newport Beach Application NO. 5-21-0640

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

From: C M <cbmccallum@gmail.com>
Sent: Thursday, October 6, 2022 9:45 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project - City of Newport Beach Application NO. 5-21-0640

I support the Dredging and CAD Project - City of Newport Beach Application NO. 5-21-0640

Carroll McCallum
2 Autumn Lane
New Canaan, CT 06840

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:20 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Jock Marlo <jockmarlo@gmail.com>
Sent: Thursday, October 6, 2022 9:12 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Please approve Coastal Development Permit application 5-21-0640 as conditioned.

As a long time homeowner, resident, boater and user of the harbor, the dredging project as proposed is reasonable and benefits the community and the coastal area.

Thank you.

John Marlo
2901 Catalpa Street
Newport Beach CA
(949)500-0080

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:18 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Norm Shepherd <normshep44@gmail.com>
Sent: Thursday, October 6, 2022 7:37 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Norm Shepherd
1946 Port Townsend Cir, Newport Beach CA 92660

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:18 PM
To: Revell, Mandy@Coastal
Subject: FW: Support CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Cunningham, Scott <SCunningham@newportbeachca.gov>
Sent: Thursday, October 6, 2022 6:33 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

As a Harbor Commissioner for the past six years, and more specifically the sub-committee leader for harbor dredging, I have intimate knowledge of the decision to construct the CAD. It is the best solution for our unsuitable sediment. We have thoroughly analyzed the alternative solutions, and are in 100% agreement with the Staff Report recommending approval of this Coastal Development Permit.

I want to highlight an added benefit to our harbor dredging that will substantially improve tidal flushing in the Transitional and Unvegetated Eelgrass Zones. These two areas have the least tidal flushing and are the specific areas we'll be removing ~800,000 Cy of built-up sediment. Each cubic yard equals 202 gallons of water, resulting in 161 million gallons of improved flushing in the upper half of our harbor. We should see substantial improvement in eelgrass growth in these two zones in the coming years.

Thank you for your support.

Scott Cunningham
Harbor Commissioner


Eelgrass Management Zones
Newport Beach
Newport Bay
Legend
Eelgrass Zones
Stable Eelgrass Zone
Transitional Eelgrass Zone
Unvegetated Eelgrass Zone
N
0 600 1,200 Feet

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:17 PM
To: Revell, Mandy@Coastal
Subject: FW: Support of Dredging Project and CAD facility– Item 17a – Application No. 5-21-0640

Krysten Tomaier | Coastal Program Analyst

CALIFORNIA COASTAL COMMISSION

South Coast District Office

301 E. Ocean Blvd, Suite 300

Long Beach, CA 90802

(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: John L. Curci <johnl@curcicompanies.com>
Sent: Thursday, October 6, 2022 1:24 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support of Dredging Project and CAD facility– Item 17a – Application No. 5-21-0640

John L. Curci
SUPPORT
Application #5-21-0640
Agenda 17a
October 14, 2022

I would like to express my **SUPPORT** of the Coastal Commission approving the City of Newport Beach Application No. 5-21-0640. Approving this application would provide the City of Newport Beach the opportunity to move forward with the long awaited and needed dredging of Newport Harbor.

As noted in the Coastal Commission's Staff Report, building a CAD facility can provide the lowest risk of environmental damage compared to other options because there is less re-handling of the material and fewer contaminant transfer pathways. And, the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality.

With your approval of this application for the CAD, the bay will return to its design depth which will significantly enhance its flushing capability and water quality by removing unsuitable materials that today are laying on the bottom of the bay. If this application is not approved, the unsuitable materials will remain on the floor of the bay and be disturbed with each passing boat, the bay will continue to silt up causing navigational challenges, and the bay will not properly flush causing further deterioration of water quality.

Sincerely,

John L. Curci

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:17 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD and Dredging Project in Newport Beach- Application No. 5-21-0640

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Devon Kelly <dkelly57@pacbell.net>
Sent: Thursday, October 6, 2022 12:17 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD and Dredging Project in Newport Beach- Application No. 5-21-0640

Dear Coastal Commissioners,

I support the CAD & Dredging Project in Newport Beach - Application No. 5-21-0640. I am a long term resident of Newport Beach (65 years), and I am also on the Board of Newport Harbor Foundation (NHF). The NHF was created for the purpose of preserving, protecting and enhancing Newport Harbor for the benefit of the City of Newport Beach, the homeowners on or near the bay, the commercial operators in the bay, and the recreational users of the bay. I have been involved in sailing and boating for most of my life. I also understand that for the health of the bay it needs the dredging so that the bay can "flush" and keep it healthy for years to come. At low tide the bay is constantly stirred up. If the bay is deeper, this will not happen. Another reason for dredging is that sailboats can easily navigate without fear of running aground.

The sediment that will be put into the CAD already exists at the bottom of the bay.

Fact: The City of Newport Beach will NOT be dumping contaminated sludge into the bay. Quite the contrary. The project will actually be removing some unsuitable material in conjunction with the dredging project. This is material that is already lying on the floor of the bay where it gets stirred up by propwash. The dredging project will provide the City with an opportunity to remove this unsuitable material from the bay floor. This material will be placed in a hole, more commonly known as a Confined Aquatic Disposal facility, "CAD", and securely covered. The unsuitable material contains up to five parts per million of mercury which, according to the EPA is not harmful to humans but is over the limit for offshore disposal. To put this into perspective, imagine a high school gymnasium filled with 999,995 green ping pong balls and 5 red ping pong balls.

The CAD has been used in many places across the U.S. with success.

Fact: CAD's are being successfully used in large commercial harbors in California, including Los Angeles, Long Beach and Port Hueneme where naval vessels and large container vessels weighing several hundred thousand tons traverse them on a daily basis without a failure. If CADs can stand up to this type of ship traffic they can stand up to recreational vessel traffic. Nationally, the New Bedford CAD – designed and implemented by EPA – is located within a small recreational harbor adjacent to residents – similar to Newport Harbor.

If we do not address this situation now, what will the results be in 10 years? A sediment laden harbor that will become unnavigable. The City of Newport Beach, The Army Corps of Engineers, the Regional Water Quality Control Board have all endorsed this system.

I strongly urge you to vote in favor of dredging and the CAD for the Newport Beach Harbor.

Respectfully,

Devon Kelly
Newport Beach

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:17 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Krysten Tomaier | Coastal Program Analyst CALIFORNIA COASTAL COMMISSION South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

-----Original Message-----
From: Ted Jones <ted@fjmercedes.com>
Sent: Thursday, October 6, 2022 12:07 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <mandy.revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

To the Coastal Commission,

As a 45-year resident and boat owner in Newport Beach as well as a 30-year business owner in the Back Bay, I am in full support of the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

The Harbor is a natural treasure that we must do anything we can to support, preserve and improve the water quality of.

A well-functioning harbor will maintain safe navigation for all vessels and continue to encourage the economic existence and life that the harbor provides to our wonderful city.

Sincerely,

Fletcher Jones Jr.

Newport Coast

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:17 PM
To: Revell, Mandy@Coastal
Subject: FW: Apply 5-21-0640

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Heidi Hall <hhatcl@outlook.com>
Sent: Thursday, October 6, 2022 11:55 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Apply 5-21-0640

Please pass this application. Newport Harbor needs a good, long- lasting clean up.
This is a godsend for the harbor.
Thank you for your help in keeping our waters clean and safe!

Heidi Hall
949-285-1146
Hhatcl@outlook.com

Get Outlook for iOS

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:16 PM
To: Revell, Mandy@Coastal
Subject: FW: I Support the CAD & Dredging Project in Newport Beach, Item 17a - Application No. 5-21-0614

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Seymour Beek <sbeek@earthlink.net>
Sent: Thursday, October 6, 2022 11:35 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I Support the CAD & Dredging Project in Newport Beach, Item 17a - Application No. 5-21-0614

Commissioners:

I am in agreement with the Commission Staff recommending that the Commission approve Coastal Development Permit Application 5-21-0640 as conditioned. I am a resident of Newport Beach, operate two harbor-dependent businesses in Newport Beach and am a frequent recreational user of the harbor.

Sincerely,

H. Seymour Beek

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:16 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: KC Carey <kcarey@viantinc.com>
Sent: Thursday, October 6, 2022 11:32 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <mandy.revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Hello,

My name is KC Carey and I am a resident of Newport Beach. I was raised in the Port Streets and my parents now live in Big Canyon. My husband and I recently bought a home across the bay and love taking our golden retriever, Woody, for walks on the trails near the Upper Bay and Interpretive Center. We are lucky to live in a city with such beautiful waters, and coastal restaurants/businesses (and their resulting economic benefits!) I have fond childhood memories of girl scout camp at the dunes, family dinners at the Ruben E. Lee, rowing camp at the Newport Aquatic Center, and Duffy rides around the bay. I'm grateful for all that you do to protect the harbor for our use now, and for future generations. In this regard, I would like to express my full support of the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

Thank you again for all you do.

KC Carey
Newport Beach, CA 92660

Disclaimer

This message and any files transmitted with it may contain confidential and/or privileged information and are intended for the named recipient(s) only. If you are not an intended recipient, you may not use, reproduce, or disclose this email, its attachments, or any part thereof. If this message has been sent to you in error, please reply to advise the sender of the error and then immediately delete this message.*

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:14 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Dave Gonzalez <Dave@fjmercedes.com>
Sent: Thursday, October 6, 2022 10:47 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

To All Concerned:

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Dave Gonzalez
3300 Jamboree Road Newport Beach, CA 92660 | Main (949) 718-3000 | www.fjmercedes.com
Office (949) 718-3010 | dave@fjmercedes.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:14 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Krysten Tomaier | Coastal Program Analyst CALIFORNIA COASTAL COMMISSION South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

-----Original Message-----
From: John Garrison <jmgarrison1@gmail.com>
Sent: Thursday, October 6, 2022 10:35 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with the Commission Staff recommending that the Commision Approve Coastal Development Permit application 5-21-0614 as conditioned.

I have been a resident of Newport Beach since 1950. My father Robert Garrison began using the bay in 1926 so I have an interest in getting this approved.

Sincerely,
John M. Garrison
10 Harbor Island
Newport Beach

Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:12 PM
To: Revell, Mandy@Coastal
Subject: FW: Support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: Bill Bloomberg <wmbloomberg@gmail.com>
Sent: Thursday, October 6, 2022 10:27 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

William Bloomberg
2323 Margaret Drive
Newport Beach, CA 92663

WmBloomberg@gmail.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:12 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Harbor dredging - please approve

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: William Brooks <billbns@aol.com>
Sent: Thursday, October 6, 2022 9:57 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Newport Harbor dredging - please approve

Commission staff recommends that the Commission **APPROVE** Coastal Development Permit application 5-21-0640 as conditioned (Staff Report page 6). The proposed Newport Beach disposal site for the clean sand is the least damaging feasible alternative and the proposed CAD facility is the least damaging feasible alternative for disposal of contaminated sediments (Staff Report page 3). The project is consistent with the allowable use, alternatives, and mitigation tests contained in Coastal Act Section 30233 (Staff Report page 3). The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3). The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3). The City's Sediment Management Plan, which was developed to manage all of the different types of sediment within the harbor was fully vetted through the DMMT process, and it provides details on unsuitable material quantities, and therefore, Commission staff believes that it adequately supports the design of the proposed project (Staff Report page 4). The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5). The project construction would actually result in an increase of the available area for boats to pass through compared to existing conditions with an occupied anchorage in place (Staff Report page 6). This project is an allowable use pursuant to Section 30233(a)(2), -(4), and -(6), as components of the project achieve numerous goals for the overall functionality of Newport Harbor (Staff Report page 22). The Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower

Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways (Staff Report page 24). The proposed project includes the following characteristics which supported the Navy, USACE, and Oxnard Harbor District's consideration of CAD technology to remedy the current sediment contamination problems in Lower Newport Harbor:

- Moderate levels of contaminants in harbor sediments
- CAD design provides a low risk of failure either by fluid migration or physical exposure
- Sediments primarily contain contaminants from past practices that are not expected to re-contaminate the harbor
- CAD developers (USACE and the City of Newport Beach) are committed to a maintenance and monitoring plan that would ensure that the contaminants remain isolated in the CAD facility
- CAD location ensures that it can be adequately maintained by the CAD developers (Staff Report page 26).

Construction of the CAD in lower Newport Harbor and deposition of beach quality sand in nearshore waters just west of the Newport Harbor mouth is not expected to cause significant adverse impacts to non-listed or sensitive bird species that nest, roost, and forage in the area (Staff Report page 34). Eelgrass impacts are not anticipated to occur as a result of the proposed project (Staff Report page 34). The project is not expected to cause a significant adverse impact to populations of these marine invertebrate species (Staff Report page 34). Therefore, as conditioned for revised plans limiting the locations for sand disposal to avoid contiguous sand dollar beds as shown in Exhibit 5, in addition to avoiding nighttime sand deposition to avoid potential negative impacts to grunion, Commission staff finds the project consistent with Sections 30230 and 30231 of the Coastal Act (Staff Report page 36). In other words, the existing water quality of Newport Bay is already negatively affected by the presence of DDx compounds and is not predicted to appreciably change as a result of the proposed placement of DDx containing sediments into the CAD. Further, by collecting, concentrating and burying contaminant laden sediments below a clean cap within the proposed CAD that are currently dispersed across Newport Bay, the proposed project may result in water quality improvements (Staff Report page 38). As conditioned, Commission staff has determined that the removal, placement, and permanent containment of DDT-contaminated Lower Newport Bay sediments at the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality within the Bay (Staff Report page 38). The Commission finds that the proposed project as conditioned would transfer sands currently isolated in Newport Harbor back into the littoral system off Newport Beach via nearshore placement, and is therefore consistent with the Section 30233(b) sand supply policy of the Coastal Act (Staff Report page 42). The additional sand that would be placed as part of the project is expected to contribute to efforts to minimize the hazards of flooding from high tides and waves experienced on the ocean beaches of Newport Beach (Staff Report page 44).The proposed project conforms with the Coastal Act policies which protect and encourage public access and recreational use of coastal areas. The proposed project would mitigate beach erosion and provide for the continuing and increased recreational use of the City beach by the public by increasing the size of the ocean beaches and would provide a larger area for recreational use. In addition, the proposed dredging components of the project would allow for continued use of coastal waters for recreational boating because the existing anchorage in the proposed CAD project area will be temporarily relocated to the Turning Basin (Staff Report pages 45-46). The proposed beach replenishment would maintain and improve recreational use of State Tidelands. Sand replenishment around public beaches is consistent with the City's Tidelands grant (Staff Report pages 46). As conditioned, the Commission finds that with these measures, the proposed project would not adversely affect visual resources of the coastal zone, and therefore, the project is consistent with the policies of the Coastal Act (Staff Report pages 47). The majority of communities adjacent to the proposed CAD site (except for downtown Costa Mesa), on the other hand have low overall CalEnviroScreen scores. Additionally, areas nearby with higher pollution burden scores that are above 60% in the northern part of Newport Beach would not be affected by the proposed project or any of the alternatives. Therefore, the proposed project of keeping the contaminated sediment in the harbor near the source(s) of contamination does not result in environmental justice impacts compared to the project alternatives, which would relocate contaminated sediments to communities of concern in other regions and require transport of sediments through additional communities of concern. In addition, as conditioned, the project would minimize adverse environmental impacts that may occur locally (Staff Report pages 50). The Commission finds that the project, as conditioned, is consistent with Coastal Act requirements and will not cause new adverse impacts to the environment. Feasible mitigation measures which will minimize all adverse environmental impacts have been required. Therefore, the Commission finds that the proposed project, as conditioned, complies with the applicable requirements of the Coastal Act to conform to CEQA (Staff Report pages 51).

Thank you
Bill Brooks
67 Beacon Bay
Newport Beach CA 92660

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:10 PM
To: Revell, Mandy@Coastal
Subject: FW: Application 5-21-0640, Agenda Item 17, South Coast District.

Krysten Tomaier | Coastal Program Analyst CALIFORNIA COASTAL COMMISSION South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

-----Original Message-----
From: D. Lawrenz <dz7law@gmail.com>
Sent: Thursday, October 6, 2022 8:59 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Application 5-21-0640, Agenda Item 17, South Coast District.

My name is Don Lawrenz and I would recommend the approval of the application from Newport Beach for the construction of CAD facility in Newport Bay.

It is unfortunate that the material is not suitable for ocean disposal. The CAD is the best choice to move other Newport Beach dredging needs forward. The material has been tested several times and found not to be bioavailable to the bentic organisms that come in contact or live in these sediments.

I have been a resident of Newport Beach for over 65 years, a former two time Newport Beach Harbor Commission Chair and a USCG Licensed Captain. I am well acquainted with the issues concerning these sediments and their natural origins in the watershed. I urge your approval of the application.
--
Don Lawrenz

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:09 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD & Dredging Project in Newport Beach

Krysten Tomaier | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

From: ronsad@earthlink.net <ronsad@earthlink.net>
Sent: Thursday, October 6, 2022 8:54 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD & Dredging Project in Newport Beach

To whom it may concern:

I am in support of the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Thank you,

Ron Sadler

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Thursday, October 6, 2022 2:09 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging Harbor

Krysten Tomaier | Coastal Program Analyst CALIFORNIA COASTAL COMMISSION South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

If you need to submit an appeal or an emergency application, please email a supervisor and copy: SouthCoast@coastal.ca.gov.

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff directly by email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov .

-----Original Message-----
From: Mary Sadler <sadler.mary@icloud.com>
Sent: Wednesday, October 5, 2022 8:19 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Dredging Harbor

Hello,

I am in support of the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640.

I have been a citizen of Newport Beach for 30 years and believe this is the best option to clean our harbor.

The dredging project and sediment relocation along our coast is very important for improving water quality in Newport Harbor. It is vital for the future of Lower Newport Harbor so that sailboats and larger vessels can navigate safely as well improving tidal flow in and out of Newport Harbor making it a cleaner harbor for all.

Thank you,

Mary Sadler
Resident of Balboa Island

Sent from my iPhone

Revell, Mandy@Coastal

From: henry buckingham <henry@meterbuilt.com>
Sent: Thursday, October 6, 2022 2:05 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

Henry, Czarina, Peter & Howard Buckingham

henry buckingham **meter**

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 1:35 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Fred Fourcher

Date: October 6, 2022
Time: 8:34 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Safari/605.1.15
Remote IP: 204.134.252.130
Powered by: Elementor

Revell, Mandy@Coastal

From: Ted Jones <ted@fjmercedes.com>
Sent: Thursday, October 6, 2022 12:07 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

To the Coastal Commission,

As a 45-year resident and boat owner in Newport Beach as well as a 30-year business owner in the Back Bay, I am in full support of the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

The Harbor is a natural treasure that we must do anything we can to support, preserve and improve the water quality of.

A well-functioning harbor will maintain safe navigation for all vessels and continue to encourage the economic existence and life that the harbor provides to our wonderful city.

Sincerely,

Fletcher Jones Jr.

Newport Coast

Revell, Mandy@Coastal

From: KC Carey <kcarey@viantinc.com>
Sent: Thursday, October 6, 2022 11:32 AM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Hello,

My name is KC Carey and I am a resident of Newport Beach. I was raised in the Port Streets and my parents now live in Big Canyon. My husband and I recently bought a home across the bay and love taking our golden retriever, Woody, for walks on the trails near the Upper Bay and Interpretive Center. We are lucky to live in a city with such beautiful waters, and coastal restaurants/businesses (and their resulting economic benefits!) I have fond childhood memories of girl scout camp at the dunes, family dinners at the Ruben E. Lee, rowing camp at the Newport Aquatic Center, and Duffy rides around the bay. I'm grateful for all that you do to protect the harbor for our use now, and for future generations. In this regard, I would like to express my full support of the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

Thank you again for all you do.

KC Carey
Newport Beach, CA 92660

Revell, Mandy@Coastal

From: Donna4design <donna4design@aol.com>
Sent: Thursday, October 6, 2022 11:05 AM
To: Revell, Mandy@Coastal
Cc: ernie@schroederinvestmentpartners.com
Subject: Application #5-21-0640 Agenda F17a

Dear Ms. Revell,

This is to notify you of my opposition to the CAD being proposed in Newport Harbor. My husband and I have been residents of Newport Beach for over 45 years, and have always enjoyed the beauty of the harbor. We have raised our family here and our children and grandchildren have spent hundreds of hours enjoying our beautiful ocean, beaches and the bay. Our family has a lovely home on Lido Isle that we built several years ago. We are also boat owners, and spend almost every weekend on the Newport Harbor Bay and in the ocean.

We have been informed about what the CAD is, and where it will be placed. We implore you and the other commissioners to deny this application, and request that the City of Newport Beach offer alternatives for disposing of the sediment that is not acceptable for release into the ocean. Our environment is so important, and we must do everything possible to preserve it for the future of generations to come. If the sediment is too toxic to release into the ocean, how can you justify it's safety to be placed near homes, businesses and within an anchorage site where the "cap" will be disturbed by anchors?

Please consider the above so that you can make a wise environmental decision for our community to preserve it's natural beauty.

Thank you,

Donna and Ernie Schroeder

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 11:00 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Jeanne lewand

Date: October 6, 2022
Time: 6:00 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 Safari/604.1
Remote IP: 172.58.23.93
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 10:57 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Suzanne Finney

Date: October 6, 2022
Time: 5:57 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 174.193.195.22
Powered by: Elementor

Revell, Mandy@Coastal

From: Dave Gonzalez <Dave@fjmercedes.com>
Sent: Thursday, October 6, 2022 10:47 AM
To: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

To All Concerned:

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Dave Gonzalez
3300 Jamboree Road Newport Beach, CA 92660 | Main (949) 718-3000 | www.fjmercedes.com
Office (949) 718-3010 | dave@fjmercedes.com

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 10:39 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Trisha Sanchez

Date: October 6, 2022
Time: 5:38 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0_2 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Mobile/15E148 Safari/604.1
Remote IP: 104.28.85.225
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 10:38 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Trisha Sanchez

Date: October 6, 2022
Time: 5:38 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0_2 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Mobile/15E148 Safari/604.1
Remote IP: 104.28.85.225
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 10:21 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Lucy Michaelian

Date: October 6, 2022
Time: 5:21 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Safari/605.1.15
Remote IP: 154.6.26.139
Powered by: Elementor

Revell, Mandy@Coastal

From: Bob Michaelian <bob.michaelian@gmail.com>
Sent: Thursday, October 6, 2022 10:09 AM
To: Revell, Mandy@Coastal
Subject: re: Application 5-21-0640 Agenda F17a, in opposition of the CAD proposed for Newport Harbor

Hello Mandy!

My name is Bob Michaelian, I am a long time resident of Newport Beach and live with my family on Lido Isle. I'm sending this email opposing the proposal to establish a CAD to dump contaminated sludge in Newport Harbor. There are at least a half dozen better options than constructing a CAD in the anchorage between Lido and Bay Island. Establishing a CAD in the anchorage will prevent future dredging efforts and there will inevitably be leakage due to the dragging of anchors across the Harbor floor.

This is an awful solution that could create long term environmental consequences and is proposed out of self interest by the City Council and a lack of understanding by the Coastal Commission. It is also in violation of the Army Corps of Engineers manual that governs the protocols that must be followed.

Please record my opposition to the CAD proposal.

Thanks so much, be well.

BobM

Revell, Mandy@Coastal

From: Stevens, Eric@Coastal
Sent: Thursday, October 6, 2022 10:07 AM
To: Revell, Mandy@Coastal
Subject: Fw: Dredging plan for newport beach

From: Libby <sweetpea4@protonmail.com>
Sent: Thursday, October 6, 2022 8:20 AM
To: Stevens, Eric@Coastal <eric.stevens@coastal.ca.gov>
Subject: Fwd: Dredging plan for newport beach

Please forward my opposition to CAD to other members of coastal commission who cover this Newport project.
Thank you.
Libby Huyck

Sent from Proton Mail for iOS

> ---------- Forwarded message ----------
> From: Libby<sweetpea4@protonmail.com>
> Date: On Thu, Oct 6, 2022 at 9:18 AM
> Subject: Fwd: Dredging plan for newport beach
> To: Eric.Stevens@coastal.ca.gov <Eric.Stevens@coastal.ca.gov>
> Cc:
> Hi Eric,
> I just reviewed the Cad plan for dredging in the Newport harbor. I feel this plan is not a good isea as it keeps the toxins in our bay. So those toxins will still be detrimental to our ecosystem, marine life and to us humans who like to swim in the bay. This plan appears to me to be a quick fix and is not a permanent plan that haopens every ten years, which weve been doing for 70 years. We need a solution where yhe people know about the plan and agree with it.
> This CAD plan works for commerical harbors like Long Beach, but Newport is a recreational harbor with lots of boats anchored in this 5 football field area they propose yo out this CAD in.
> Please oppose this plan at your meeting on oct 14.
> Thank you for considering.
> Libby Huyck
> 220 Via Mentone
> Newport Beach, CA 92663

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 9:59 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Britt Michaelian

Date: October 6, 2022
Time: 4:58 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_4) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 76.169.229.106
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 9:57 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Lowrey Douglas Tad

Date: October 6, 2022
Time: 4:57 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPad; CPU OS 15_7 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6,2 Mobile/15E148 Safari/604.1
Remote IP: 12.116.117.214
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 9:54 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Gary Storey

Date: October 6, 2022
Time: 4:54 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36 Edg/105.0.1343.53
Remote IP: 172.116.146.68
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 9:54 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Gary Storey

Date: October 6, 2022
Time: 4:53 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36 Edg/105.0.1343.53
Remote IP: 172.116.146.68
Powered by: Elementor

Revell, Mandy@Coastal

From: C M <cbmccallum@gmail.com>
Sent: Thursday, October 6, 2022 9:45 AM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project - City of Newport Beach Application NO. 5-21-0640

I support the Dredging and CAD Project - City of Newport Beach Application NO. 5-21-0640

Carroll McCallum
2 Autumn Lane
New Canaan, CT 06840

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 9:07 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Susan Lockard

Date: October 6, 2022
Time: 4:07 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/15E148 Instagram 243.1.0.14.111 (iPhone14,3; iOS 15_6_1; en_US; en-US; scale=3.00; 1284x2778; 382468104)
Remote IP: 166.196.75.122
Powered by: Elementor

Revell, Mandy@Coastal

From: Shana Conzelman <sconzelman@gmail.com>
Sent: Thursday, October 6, 2022 8:57 AM
To: Revell, Mandy@Coastal
Subject: October 14, 2022 Application 5-21-0640 Agenda F17a

Shana Conzelman

Opposed
Application 5-21-0640
Agenda F17a

Commissioners,

When I think of the Coastal Commission and our California coastal waters I feel a sense of comfort that you and I should hold common ground. I guess what I'm saying is that I should feel a sense of support when the subject matter is based on the purity of our coastal waters. I was convinced that the ludicrous idea of placing a huge CAD in Newports recreational, residential, pristine anchorage would never make it past those who are mandated to care as much as I do about preserving this bay.

I have spent the last four years going to every meeting, asking questions and trying to make sense of why anyone would consider taking toxic/unsuitable sediment from one area of the bay and placing it in this object called a CAD would even come close to the promise they made to clean up the bay. First, moving *'unsuitable for ocean disposal'* materials from one area to another is not a clean up. Taking our clean anchorage sediment and providing '*deposition of clean sandy sediments along nearshore ocean beaches'* is not beach replenishment as promised to the Newport Peninsula. And for the real kicker in the process of doing all of this digging up and dumping those contaminated sediment particles will be spread through the pluming process. The waters that you and I respect, the plant life disruption, the wildlife will all suffer and spread these contaminants even further.

The clear alternative to clean up our bay should be a CDF, Confined Disposal Facility. Properly mitigated, contaminated sediment placed on land is a permanent solution. There are viable options for this type of disposal that were never properly vetted. There is a specific alternative that has been researched and preliminary assessments made and funded by private citizens because they too desire to be prudent and do the long term, generational solution.

You, as a Coastal Commissioner and I as a very conscientious native Californian have an obligation to stand up for what is right. I respectfully ask you to consider that the supposed experts pushing this agenda are pushing from a personal gain perspective. While some may consider this human nature, we must protect 'nature' as she can not protect herself. Placing a 47' deep, 590' x 590' wide hole in the middle of the Newport Harbor anchorage and filling it with unsuitable

sediment (that **has not** gone through the Army Corp of Engineers required Elutriate testing) for travelers from all over the world to drag their anchors through is a recipe for disaster.
I hope my heartfelt desire resonates throughout this request, please do not approve the application for Coastal Permit 5-21-0640.

Respectfully submitted by: Shana Conzelman

Sent from my iPhone

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 8:50 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Katie Sullivan

Date: October 6, 2022
Time: 3:49 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0_2 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/15E148 Instagram 255.1.0.18.105 (iPhone13,4; iOS 16_0_2; en_US; en-US; scale=3.00; 1284x2778; 405816327) NW/3
Remote IP: 172.7.142.188
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 8:43 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

August Napolitano

Date: October 6, 2022
Time: 3:43 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPad; CPU OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/15E148 Instagram 255.0.0.16.105 (iPad7,2; iPadOS 15_6_1; en_US; en-US; scale=2.00; 750x1334; 404463847)
Remote IP: 68.5.35.124
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 8:30 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Ms. Jennifer Morrill Thomas

Date: October 6, 2022
Time: 3:30 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/106.0.0.0 Safari/537.36 Edg/106.0.1370.34
Remote IP: 23.124.252.64
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 8:22 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Holly Winder

Date: October 6, 2022
Time: 3:22 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 70.181.120.69
Powered by: Elementor

Revell, Mandy@Coastal

From: Morgan Chiate <mchiate@ymail.com>
Sent: Thursday, October 6, 2022 8:17 AM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640 Agenda 17a

Morgan Chiate
Opposed
Application #5-21-0640
Agenda 17a

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 7:43 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

David T "Chip" Robinson Jr

Date: October 6, 2022
Time: 2:43 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_13_6) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 70.181.84.70
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 7:43 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Libby huyck

Date: October 6, 2022
Time: 2:42 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 DuckDuckGo/7 Safari/605.1.15
Remote IP: 107.126.24.36
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 7:35 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Libby Huyck

Date: October 6, 2022
Time: 2:35 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 DuckDuckGo/7 Safari/605.1.15
Remote IP: 107.126.24.36
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Thursday, October 6, 2022 7:34 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Libby Huyck

Date: October 6, 2022
Time: 2:33 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 DuckDuckGo/7 Safari/605.1.15
Remote IP: 107.126.24.36
Powered by: Elementor

Revell, Mandy@Coastal

From: Gregory Ward <gregoryaward@aol.com>
Sent: Thursday, October 6, 2022 4:46 AM
To: Revell, Mandy@Coastal
Subject: No CAD in Newport Harbor

Gregory Ward
Opposed
Application #5-21-0640
Agenda 17a

I am strongly opposed to the CAD in Newport Harbor and support the proposal for on land remediation.

I live on Lido Isle and keep my boat in Newport Harbor. We use our boat almost every week and I am very concerned about the potential long term unintended consequences that the unproven CAD presents to human safety and the environment.

Please do not allow the CAD in Newport Harbor. I oppose application

Sincerely,

Gregory Ward
218 via Quito
Newport Beach, CA 92663

Sent from my iPad

Revell, Mandy@Coastal

From: ATX <theatreatment@yahoo.com>
Sent: Wednesday, October 5, 2022 10:05 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640 Agenda F17a

Dear Ms. Revell,
I am writing to state my opposition to the CAD being
proposed in Newport Harbor. I love & work in Newport Beach and enjoy
the beautiful harbor daily either on the water, in it or looking at it.
Having researched what the CAD is and where it will be placed I am extremely concerned. Please stop this application.
Please require the city of Newport
Beach to explore alternatives for disposing of the sediment
that is not acceptable for release into the ocean.
If the sediment is too toxic to release into the ocean, how in the world can it be safe to store near homes, businesses and most
importantly under an anchorage site, where boat anchors
will constantly be disturbing the
"cap"? Just last weekend watching the air show in HB, in open water, our anchor dragged so much we had to reposition several times.
As an active harbor and prime resort destination, routine dredging of Newport Harbor is needed. Creating
an underwater dump site, will almost certainly create
other environmental issues. There are alternatives the City of Newport Beach should be required to explore so you and your fellow commissioners can
make an informed decision.

Thank you in advance.

Warmly,
Arolyn Burns LPCC, LMFT
The A Treatment Center
www.TheATreatment.com
Located in Pasadena and Newport Beach
Call for a free 15 minute phone consultation now!
(833) 426-0303

Check out our YELP reviews:
http://www.yelp.com/biz/the-a-treatment-center-pasadena

Honored to be the recipient of the Prestigious Cornelia Funke Award for Exceptional Social Work in LA County 2014.

Revell, Mandy@Coastal

From: SHANEN FOYE <slfoye@aol.com>
Sent: Wednesday, October 5, 2022 8:30 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640 Agenda F17a

Dear Ms. Revell,

I am writing to record my opposition to the CAD being proposed in Newport Harbor. While I am a resident of Huntington Beach I work in Newport Beach and often enjoy the beautiful harbor by land and on the water.

Having researched what the CAD is and where it will be placed I implore you and your fellow commissioners to pause this application. Please require the city of Newport Beach to explore alternatives for disposing of the sediment that is not acceptable for release into the ocean.

If the sediment is too toxic to release into the ocean, how can it be safe to store near homes, businesses and most importantly under an anchorage site, where boat anchors will constantly be disturbing the "cap"?

Routine dredging of Newport Harbor is needed. Creating an underwater dump site, that will almost certainly create other environmental issues, is not. There are alternatives and the City of Newport Beach should be required to explore them so you and your fellow commissioners can make an informed decision.

Thank you for your consideration,

Shanen Foye

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 7:48 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

From: Bill Hughes <whughes@hughesinv.com>
Sent: Wednesday, October 5, 2022 7:39 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

William W. Hughes Jr
66 Linda Isle
Newport Beach, CA 92660

Revell, Mandy@Coastal

From: Bill Hughes <whughes@hughesinv.com>
Sent: Wednesday, October 5, 2022 7:46 PM
To: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

William W. Hughes Jr
66 Linda Isle
Newport Beach, CA 92660

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 6:38 PM
To: Revell, Mandy@Coastal
Subject: FW: SUPPORT: October 14th Agenda Item 17. a. Application No. 5-21-0640 City of Newport Beach

---

From: Chloe Chism <chloechism@gmail.com>
Sent: Wednesday, October 5, 2022 5:21 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: SUPPORT: October 14th Agenda Item 17. a. Application No. 5-21-0640 City of Newport Beach

Good evening,

I am reaching out to you today to express my support for the Confined Aquatic Disposal Facility Project, and to urge you to vote **yes** when this proposal comes before you.

The CAD Project gives the Coastal Commission the opportunity to create improvements that will benefit the people of this community, and protect the environment that we love and enjoy. Removal of the unsuitable materials currently sitting at the bottom of the bay is long overdue, and will result in improvement of the water quality and restoration of the Harbor to its design depth.

Please do your duty to protect this Harbor by supporting the CAD Project and voting yes on Item 17.a.

Thank you,

Chloe Chism

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 6:37 PM
To: Revell, Mandy@Coastal
Subject: FW: Support: Agenda Item 17. a. Application No. 5-21-0640 City of Newport Beach (10/14/22)

From: KATHRYN GATHERUM-LUCKER <katgat@aol.com>
Sent: Wednesday, October 5, 2022 5:23 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: Support: Agenda Item 17. a. Application No. 5-21-0640 City of Newport Beach (10/14/22)

Dear Members of the California Coastal Commission,

I would like to go on record today in support of the Confined Aquatic Disposal proposal coming before you on October 14th. The CAD proposal has been extensively studied and the EIR has been certified. It has been discussed at length, in public forums, utilizing experts and extensive research and studies. Further, CAD has been successfully implemented in other harbors throughout the country.

As a paddle boarder, boater, swimmer, and appreciative Newport Beach resident, I fully support CAD as proposed. CAD will continue the ongoing efforts to maintain a clean, safe, and beautiful Newport Harbor for all.

Thank you for your time and consideration.

Kathy Lucker
Newport Beach, CA 92660
Katgat@aol.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 6:37 PM
To: Revell, Mandy@Coastal
Subject: FW: I Support the Dredging and CAD Project - City of Newport Beach Application 17a-No.5-21-0640

-----Original Message-----
From: Gregg Kelly <gkelly57@pacbell.net>
Sent: Wednesday, October 5, 2022 5:40 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I Support the Dredging and CAD Project - City of Newport Beach Application 17a-No.5-21-0640

I am a long time resident of Newport Beach and I support the dredging and CAD project.
City of Newport Beach Application - Item 17a - NO. 5-21-0640

Gregg Kelly
Newport Beach

Gregg Kelly | (949) 310-5117 | gkelly57@pacbell.net

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 6:37 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Steven K. Fowlkes <SFowlkes@RWSELBY.com>
Sent: Wednesday, October 5, 2022 6:06 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

California Coastal Commission:

My home is on the bay in Newport Harbor and I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Thank you for your consideration,

Steven K. Fowlkes

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 6:36 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Jenieve Davenport <jenievemd@gmail.com>
Sent: Wednesday, October 5, 2022 6:21 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Thank you

Jenieve Badajoz
Newport Beach, 92663

Revell, Mandy@Coastal

From: Gregg Kelly <gkelly57@pacbell.net>
Sent: Wednesday, October 5, 2022 5:40 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I Support the Dredging and CAD Project - City of Newport Beach Application 17a-No.5-21-0640

I am a long time resident of Newport Beach and I support the dredging and CAD project.
City of Newport Beach Application - Item 17a - NO. 5-21-0640

Gregg Kelly
Newport Beach

Gregg Kelly | (949) 310-5117 | gkelly57@pacbell.net

Revell, Mandy@Coastal

From: KATHRYN GATHERUM-LUCKER <katgat@aol.com>
Sent: Wednesday, October 5, 2022 5:23 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: Support: Agenda Item 17. a. Application No. 5-21-0640 City of Newport Beach (10/14/22)

Dear Members of the California Coastal Commission,

I would like to go on record today in support of the Confined Aquatic Disposal proposal coming before you on October 14th. The CAD proposal has been extensively studied and the EIR has been certified. It has been discussed at length, in public forums, utilizing experts and extensive research and studies. Further, CAD has been successfully implemented in other harbors throughout the country.

As a paddle boarder, boater, swimmer, and appreciative Newport Beach resident, I fully support CAD as proposed. CAD will continue the ongoing efforts to maintain a clean, safe, and beautiful Newport Harbor for all.

Thank you for your time and consideration.

Kathy Lucker
Newport Beach, CA 92660
Katgat@aol.com

Revell, Mandy@Coastal

From:	Chloe Chism <chloechism@gmail.com>
Sent:	Wednesday, October 5, 2022 5:21 PM
To:	SouthCoast@Coastal
Cc:	Revell, Mandy@Coastal
Subject:	SUPPORT: October 14th Agenda Item 17. a. Application No. 5-21-0640 City of Newport Beach

Good evening,

I am reaching out to you today to express my support for the Confined Aquatic Disposal Facility Project, and to urge you to vote **yes** when this proposal comes before you.

The CAD Project gives the Coastal Commission the opportunity to create improvements that will benefit the people of this community, and protect the environment that we love and enjoy. Removal of the unsuitable materials currently sitting at the bottom of the bay is long overdue, and will result in improvement of the water quality and restoration of the Harbor to its design depth.

Please do your duty to protect this Harbor by supporting the CAD Project and voting yes on Item 17.a.

Thank you,

Chloe Chism

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 5:07 PM
To: Revell, Mandy@Coastal
Subject: FW: Cad & Dredging Project

From: craig.reese@me.com <craig.reese@me.com>
Sent: Wednesday, October 5, 2022 3:52 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Cad & Dredging Project

I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640.

Craig **Reese**
949.**584.**4499
craig.reese@me.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 5:05 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging in Newport Harbor

From: greentechlandscapinginc@gmail.com <capnernie1@aol.com>
Sent: Wednesday, October 5, 2022 3:39 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Dredging in Newport Harbor

Sir or Madam

Please know that as a long time resident and licensed captain for over 40 years operating large sailing vessels out of Newport Harbor that I am totally IN FAVOR of keeping our harbor properly dredged. I'm aware that many dredging projects
have taken place over that past ten years and that I personally watched the dredging of our harbor entrance only a couple of years ago. I thank you for the work you have allowed the marine contractors to do in Newport Harbor and it is comforting to know our mariners will have your continued support. Sincerely. Capt. G.E. Minney II.
A resident of Newport Beach since 1948...

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 5:05 PM
To: Revell, Mandy@Coastal
Subject: FW:

From: tom boyer <tboyer@boyerco.com>
Sent: Wednesday, October 5, 2022 3:40 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject:

: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:54 PM
To: Revell, Mandy@Coastal
Subject: FW: Support

-----Original Message-----
From: Mickey LaBarthe <mickey@mickeylabarthe.com>
Sent: Wednesday, October 5, 2022 4:23 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support

I support the CAD& Dredging Project in Newport Beach- Item 17a-Application No. 5-21-0640.

Thank you,
MickeyLaBarthe Dick

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:51 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: David Kray <dkray@cjkinvestments.com>
Sent: Wednesday, October 5, 2022 4:36 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission Staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Thank you,

David Kray

David Kray | Principal
4100 MacArthur Blvd, Suite 200 | Newport Beach, CA 92660
Direct: +1.949.224.4176
Mobile: +1.949.433.8008
Fax: +1.949.468.5521
dkray@cjkinvestments.com
www.cjkinvestments.com

CJK CRAIG JARECKI KRAY INVESTMENTS

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:51 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

From: David Lamb <DLamb@StrathamHomes.com>
Sent: Wednesday, October 5, 2022 4:36 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

I support the above referenced dredging project in the city of Newport Beach. I live near the CAD site on Lido Isle.

David Lamb
801 Via Lido Soud
Newport Beach, Ca 92663
Cell: 949-315-1113

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:50 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

-----Original Message-----
From: Rick Barrett <r.barrett@verizon.net>
Sent: Wednesday, October 5, 2022 4:41 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

I support the dredging and CAD Project

Thank you,

Rick Barrett
930 ViaLido Nord
Newport Beach, CA 92663

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:50 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD & Dredging Project - Newport Beach

From: Elise Sadler <eliseinezsadler@gmail.com>
Sent: Wednesday, October 5, 2022 4:42 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD & Dredging Project - Newport Beach

Hello,

I am in support of the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640.

I have been a citizen of Newport Beach for 28 years and believe this is the best option to clean our harbor.

The dredging project and sediment relocation along our coast is very important for improving water quality in Newport Harbor. It is vital for the future of Lower Newport Harbor so that sailboats and larger vessels can navigate safely as well improving tidal flow in and out of Newport Harbor making it a cleaner harbor for all.

Thank you,

Elise

Elise Sadler
eliseinezsadler@gmail.com
(949) 375-2618

Revell, Mandy@Coastal

From: Rick Barrett <r.barrett@verizon.net>
Sent: Wednesday, October 5, 2022 4:41 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

I support the dredging and CAD Project

Thank you,

Rick Barrett
930 ViaLido Nord
Newport Beach, CA 92663

Revell, Mandy@Coastal

From: David Lamb <DLamb@StrathamHomes.com>
Sent: Wednesday, October 5, 2022 4:36 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

I support the above referenced dredging project in the city of Newport Beach. I live near the CAD site on Lido Isle.

David Lamb
801 Via Lido Soud
Newport Beach, Ca 92663
Cell: 949-315-1113

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:31 PM
To: Revell, Mandy@Coastal
Subject: FW: Support of CAD & Dredging Project – Item 17a – Application No. 5-21-0640

From: tom purcell <thpurcell@gmail.com>
Sent: Wednesday, October 5, 2022 2:58 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support of CAD & Dredging Project – Item 17a – Application No. 5-21-0640

Thomas H. Purcell
SUPPORT
Application #5-21-0640
Agenda 17a
October 14, 2022

Dear Commissioners,

I would like to express my **FULL SUPPORT** for the Coastal Commission to approve the City of Newport Beach Application No. 5-21-0640. Approving this application would provide the City of Newport Beach the opportunity to move forward with the long awaited and needed dredging of Newport Harbor.

As noted in the Coastal Commission's Staff Report, building a Confined Aquatic Disposal (CAD) facility can provide the lowest risk of environmental damage compared to other options because there is less re-handling of the material and fewer contaminant transfer pathways. And, the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality.

With your approval of this application for the CAD, the City will move forward with the dredging of the bay to its design depth which will significantly enhance its flushing capability and water quality and removing unsuitable materials that today are laying on the bottom of the bay. If this application is not approved, the unsuitable materials will remain on the floor of the bay and be disturbed with each passing boat, the bay will continue to silt up causing navigational challenges, and the bay will not properly flush causing further deterioration of water quality.

Respectfully submitted,

Thomas H. Purcell

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:30 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging & CAD Project

-----Original Message-----
From: charlene murphy <murphy.charlene@gmail.com>
Sent: Wednesday, October 5, 2022 2:23 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: Dredging & CAD Project

We support the dredging and CAD project - City of Newport Beach Application - item 17a - No 5-21-0640

Richard & Charlene Murphy
Newport Beach, CA 92663

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:29 PM
To: Revell, Mandy@Coastal
Subject: FW: In support of Newport Beach Dredging & CAD Project – Item 17a - Application No. 5-21-0640

From: David Badajoz <d.badajoz@gmail.com>
Sent: Wednesday, October 5, 2022 2:10 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: In support of Newport Beach Dredging & CAD Project – Item 17a - Application No. 5-21-0640

Coastal Commission Board and Staff,

In regards to Item- 17a Newport Beach Dredging & CAD Project - Application No. 5-21-0640.

My family and I are in full support of this project of this project. For the following reasons.

• By approving the City of Newport Beach Application No. 5-21-0640 the Coastal Commission has the opportunity to move forward the long awaited dredging of Newport Harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.

• The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.

• The City of Newport Beach is near the end of the road. With the California Coastal Commissions approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.

• If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.

• This Application furthers the mission of the California Coastal Commission to protect and enhance California's coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor's floor.

We are also in the agreement of the Coastal Commission's Staff's conclusions, which are in part:

• The proposed Newport Beach disposal site for the clean sand is the least damaging feasible alternative and the proposed CAD facility is the least damaging feasible alternative for disposal of contaminated sediments (Staff Report page 3).

• The project is consistent with the allowable use, alternatives, and mitigation tests contained in Coastal Act Section 30233 (Staff Report page 3).

• The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3).

• The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).

• The City's Sediment Management Plan, which was developed to manage all of the different types of sediment within the harbor was fully vetted through the DMMT process, and it provides details on unsuitable material quantities, and therefore, Commission staff believes that it adequately supports the design of the proposed project (Staff Report page 4).

• The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5).

• The project construction would actually result in an increase of the available area for boats to pass through compared to existing conditions with an occupied anchorage in place (Staff Report page 6).

• This project is an allowable use pursuant to Section 30233(a)(2), -(4), and -(6), as components of the project achieve numerous goals for the overall functionality of Newport Harbor (Staff Report page 22).

• The Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways (Staff Report page 24).

• The proposed project includes the following characteristics which supported the Navy, USACE, and Oxnard Harbor District's consideration of CAD technology to remedy the current sediment contamination problems in Lower Newport Harbor:

o Moderate levels of contaminants in harbor sediments

o CAD design provides a low risk of failure either by fluid migration or physical exposure

o Sediments primarily contain contaminants from past practices that are not expected to re-contaminate the harbor

o CAD developers (USACE and the City of Newport Beach) are committed to a maintenance and monitoring plan that would ensure that the contaminants remain isolated in the CAD facility

o CAD location ensures that it can be adequately maintained by the CAD developers (Staff Report page 26).

• Construction of the CAD in lower Newport Harbor and deposition of beach quality sand in nearshore waters just west of the Newport Harbor mouth is not expected to cause significant adverse impacts to non-listed or sensitive bird species that nest, roost, and forage in the area (Staff Report page 34).

• Eelgrass impacts are not anticipated to occur as a result of the proposed project (Staff Report page 34).

• The project is not expected to cause a significant adverse impact to populations of these marine invertebrate species (Staff Report page 34).

• Therefore, as conditioned for revised plans limiting the locations for sand disposal to avoid contiguous sand dollar beds as shown in Exhibit 5, in addition to avoiding nighttime sand deposition to avoid potential negative impacts to grunion, Commission staff finds the project consistent with Sections 30230 and 30231 of the Coastal Act (Staff Report page 36).

• In other words, the existing water quality of Newport Bay is already negatively affected by the presence of DDx compounds and is not predicted to appreciably change as a result of the proposed placement of DDx containing sediments into the CAD. Further, by collecting, concentrating and burying contaminant laden sediments below a clean cap within the proposed CAD that are currently dispersed across Newport Bay, the proposed project may result in water quality improvements (Staff Report page 38).

• As conditioned, Commission staff has determined that the removal, placement, and permanent containment of DDT-contaminated Lower Newport Bay sediments at the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality within the Bay (Staff Report page 38).

• The Commission finds that the proposed project as conditioned would transfer sands currently isolated in Newport Harbor back into the littoral system off Newport Beach via nearshore placement, and is therefore consistent with the Section 30233(b) sand supply policy of the Coastal Act (Staff Report page 42).

• The additional sand that would be placed as part of the project is expected to contribute to efforts to minimize the hazards of flooding from high tides and waves experienced on the ocean beaches of Newport Beach (Staff Report page 44).

• The proposed project conforms with the Coastal Act policies which protect and encourage public access and recreational use of coastal areas. The proposed project would mitigate beach erosion and provide for the continuing and increased recreational use of the City beach by the public by increasing the size of the ocean beaches and would provide a larger area for recreational use. In addition, the proposed dredging components of the project would allow for continued use of coastal waters for recreational boating because the existing anchorage in the proposed CAD project area will be temporarily relocated to the Turning Basin (Staff Report pages 45-46).

• The proposed beach replenishment would maintain and improve recreational use of State Tidelands. Sand replenishment around public beaches is consistent with the City's Tidelands grant (Staff Report pages 46).

• As conditioned, the Commission finds that with these measures, the proposed project would not adversely affect visual resources of the coastal zone, and therefore, the project is consistent with the policies of the Coastal Act (Staff Report pages 47).

• The majority of communities adjacent to the proposed CAD site (except for downtown Costa Mesa), on the other hand have low overall CalEnviroScreen scores. Additionally, areas nearby with higher pollution burden scores that are above 60% in the northern part of Newport Beach would not be affected by the proposed project or any of the alternatives. Therefore, the proposed project of keeping the contaminated sediment in the harbor near the source(s) of contamination does not result in environmental justice impacts compared to the project alternatives, which would relocate contaminated sediments to communities of concern in other regions and require transport of sediments through additional communities of concern. In addition, as conditioned, the project would minimize adverse environmental impacts that may occur locally (Staff Report pages 50).

• The Commission finds that the project, as conditioned, is consistent with Coastal Act requirements and will not cause new adverse impacts to the environment. Feasible mitigation measures which will minimize all adverse environmental impacts have been required. Therefore, the Commission finds that the proposed project, as conditioned, complies with the applicable requirements of the Coastal Act to conform to CEQA (Staff Report pages 51).

My family ask you the Commissioners of the California Coastal Commission to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

Thank you for your time.

The Badajoz family

Newport Beach CA 92663

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 4:28 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Stacie Gaut <stacie@ocoffice.net>
Sent: Wednesday, October 5, 2022 1:18 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

To whom it may concern:

Please approve the harbor dredging in Newport Harbor.

The Harbor Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways.

Revell, Mandy@Coastal

From: Rick Barrett <r.barrett@verizon.net>
Sent: Wednesday, October 5, 2022 2:52 PM
To: SouthCoast@coastalca.gov
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project - City of Newport Beach Application - Item 17a - No. 5-21-0640

I support the Dredging and CAD Project in Newport Beach.

Richard Barrett
930 Via Lido Nord
Newport Beach, CA 92663

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 2:38 PM
To: Revell, Mandy@Coastal
Subject: FW: In support of Newport Beach Dredging & CAD Project – Item 17a - Application No. 5-21-0640

From: David Badajoz <d.badajoz@gmail.com>
Sent: Wednesday, October 5, 2022 2:10 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: In support of Newport Beach Dredging & CAD Project – Item 17a - Application No. 5-21-0640

Coastal Commission Board and Staff,

In regards to Item- 17a Newport Beach Dredging & CAD Project - Application No. 5-21-0640.

My family and I are in full support of this project of this project. For the following reasons.

• By approving the City of Newport Beach Application No. 5-21-0640 the Coastal Commission has the opportunity to move forward the long awaited dredging of Newport Harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.

• The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.

• The City of Newport Beach is near the end of the road. With the California Coastal Commissions approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.

• If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.

• This Application furthers the mission of the California Coastal Commission to protect and enhance California's coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor's floor.

We are also in the agreement of the Coastal Commission's Staff's conclusions, which are in part:

• The proposed Newport Beach disposal site for the clean sand is the least damaging feasible alternative and the proposed CAD facility is the least damaging feasible alternative for disposal of contaminated sediments (Staff Report page 3).

• The project is consistent with the allowable use, alternatives, and mitigation tests contained in Coastal Act Section 30233 (Staff Report page 3).

• The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3).

• The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).

• The City's Sediment Management Plan, which was developed to manage all of the different types of sediment within the harbor was fully vetted through the DMMT process, and it provides details on unsuitable material quantities, and therefore, Commission staff believes that it adequately supports the design of the proposed project (Staff Report page 4).

• The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5).

• The project construction would actually result in an increase of the available area for boats to pass through compared to existing conditions with an occupied anchorage in place (Staff Report page 6).

• This project is an allowable use pursuant to Section 30233(a)(2), -(4), and -(6), as components of the project achieve numerous goals for the overall functionality of Newport Harbor (Staff Report page 22).

• The Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways (Staff Report page 24).

• The proposed project includes the following characteristics which supported the Navy, USACE, and Oxnard Harbor District's consideration of CAD technology to remedy the current sediment contamination problems in Lower Newport Harbor:

o Moderate levels of contaminants in harbor sediments

o CAD design provides a low risk of failure either by fluid migration or physical exposure

o Sediments primarily contain contaminants from past practices that are not expected to re-contaminate the harbor

o CAD developers (USACE and the City of Newport Beach) are committed to a maintenance and monitoring plan that would ensure that the contaminants remain isolated in the CAD facility

o CAD location ensures that it can be adequately maintained by the CAD developers (Staff Report page 26).

• Construction of the CAD in lower Newport Harbor and deposition of beach quality sand in nearshore waters just west of the Newport Harbor mouth is not expected to cause significant adverse impacts to non-listed or sensitive bird species that nest, roost, and forage in the area (Staff Report page 34).

• Eelgrass impacts are not anticipated to occur as a result of the proposed project (Staff Report page 34).

• The project is not expected to cause a significant adverse impact to populations of these marine invertebrate species (Staff Report page 34).

• Therefore, as conditioned for revised plans limiting the locations for sand disposal to avoid contiguous sand dollar beds as shown in Exhibit 5, in addition to avoiding nighttime sand deposition to avoid potential negative impacts to grunion, Commission staff finds the project consistent with Sections 30230 and 30231 of the Coastal Act (Staff Report page 36).

• In other words, the existing water quality of Newport Bay is already negatively affected by the presence of DDx compounds and is not predicted to appreciably change as a result of the proposed placement of DDx containing sediments into the CAD. Further, by collecting, concentrating and burying contaminant laden sediments below a clean cap within the proposed CAD that are currently dispersed across Newport Bay, the proposed project may result in water quality improvements (Staff Report page 38).

• As conditioned, Commission staff has determined that the removal, placement, and permanent containment of DDT-contaminated Lower Newport Bay sediments at the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality within the Bay (Staff Report page 38).

• The Commission finds that the proposed project as conditioned would transfer sands currently isolated in Newport Harbor back into the littoral system off Newport Beach via nearshore placement, and is therefore consistent with the Section 30233(b) sand supply policy of the Coastal Act (Staff Report page 42).

• The additional sand that would be placed as part of the project is expected to contribute to efforts to minimize the hazards of flooding from high tides and waves experienced on the ocean beaches of Newport Beach (Staff Report page 44).

• The proposed project conforms with the Coastal Act policies which protect and encourage public access and recreational use of coastal areas. The proposed project would mitigate beach erosion and provide for the continuing and increased recreational use of the City beach by the public by increasing the size of the ocean beaches and would provide a larger area for recreational use. In addition, the proposed dredging components of the project would allow for continued use of coastal waters for recreational boating because the existing anchorage in the proposed CAD project area will be temporarily relocated to the Turning Basin (Staff Report pages 45-46).

• The proposed beach replenishment would maintain and improve recreational use of State Tidelands. Sand replenishment around public beaches is consistent with the City's Tidelands grant (Staff Report pages 46).

• As conditioned, the Commission finds that with these measures, the proposed project would not adversely affect visual resources of the coastal zone, and therefore, the project is consistent with the policies of the Coastal Act (Staff Report pages 47).

• The majority of communities adjacent to the proposed CAD site (except for downtown Costa Mesa), on the other hand have low overall CalEnviroScreen scores. Additionally, areas nearby with higher pollution burden scores that are above 60% in the northern part of Newport Beach would not be affected by the proposed project or any of the alternatives. Therefore, the proposed project of keeping the contaminated sediment in the harbor near the source(s) of contamination does not result in environmental justice impacts compared to the project alternatives, which would relocate contaminated sediments to communities of concern in other regions and require transport of sediments through additional communities of concern. In addition, as conditioned, the project would minimize adverse environmental impacts that may occur locally (Staff Report pages 50).

• The Commission finds that the project, as conditioned, is consistent with Coastal Act requirements and will not cause new adverse impacts to the environment. Feasible mitigation measures which will minimize all adverse environmental impacts have been required. Therefore, the Commission finds that the proposed project, as conditioned, complies with the applicable requirements of the Coastal Act to conform to CEQA (Staff Report pages 51).

My family ask you the Commissioners of the California Coastal Commission to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

Thank you for your time.

The Badajoz family

Newport Beach CA 92663

Revell, Mandy@Coastal

From: charlene murphy <murphy.charlene@gmail.com>
Sent: Wednesday, October 5, 2022 2:23 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: Dredging & CAD Project

We support the dredging and CAD project - City of Newport Beach Application - item 17a - No 5-21-0640

Richard & Charlene Murphy
Newport Beach, CA 92663

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 2:12 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Lee Hancock

Date: October 5, 2022
Time: 9:11 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/106.0.0.0 Safari/537.36
Remote IP: 216.238.28.5
Powered by: Elementor

Revell, Mandy@Coastal

From: David Badajoz <d.badajoz@gmail.com>
Sent: Wednesday, October 5, 2022 2:10 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: In support of Newport Beach Dredging & CAD Project – Item 17a - Application No. 5-21-0640

Coastal Commission Board and Staff,

In regards to Item- 17a Newport Beach Dredging & CAD Project - Application No. 5-21-0640.

My family and I are in full support of this project of this project. For the following reasons.

• By approving the City of Newport Beach Application No. 5-21-0640 the Coastal Commission has the opportunity to move forward the long awaited dredging of Newport Harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.

• The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.

• The City of Newport Beach is near the end of the road. With the California Coastal Commissions approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.

• If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.

• This Application furthers the mission of the California Coastal Commission to protect and enhance California's coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor's floor.

We are also in the agreement of the Coastal Commission's Staff's conclusions, which are in part:

• The proposed Newport Beach disposal site for the clean sand is the least damaging feasible alternative and the proposed CAD facility is the least damaging feasible alternative for disposal of contaminated sediments (Staff Report page 3).

• The project is consistent with the allowable use, alternatives, and mitigation tests contained in Coastal Act Section 30233 (Staff Report page 3).

• The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3).

• The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).

• The City's Sediment Management Plan, which was developed to manage all of the different types of sediment within the harbor was fully vetted through the DMMT process, and it provides details on unsuitable material quantities, and therefore, Commission staff believes that it adequately supports the design of the proposed project (Staff Report page 4).

• The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5).

• The project construction would actually result in an increase of the available area for boats to pass through compared to existing conditions with an occupied anchorage in place (Staff Report page 6).

• This project is an allowable use pursuant to Section 30233(a)(2), -(4), and -(6), as components of the project achieve numerous goals for the overall functionality of Newport Harbor (Staff Report page 22).

• The Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways (Staff Report page 24).

• The proposed project includes the following characteristics which supported the Navy, USACE, and Oxnard Harbor District's consideration of CAD technology to remedy the current sediment contamination problems in Lower Newport Harbor:

o Moderate levels of contaminants in harbor sediments

o CAD design provides a low risk of failure either by fluid migration or physical exposure

o Sediments primarily contain contaminants from past practices that are not expected to re-contaminate the harbor

o CAD developers (USACE and the City of Newport Beach) are committed to a maintenance and monitoring plan that would ensure that the contaminants remain isolated in the CAD facility

o CAD location ensures that it can be adequately maintained by the CAD developers (Staff Report page 26).

• Construction of the CAD in lower Newport Harbor and deposition of beach quality sand in nearshore waters just west of the Newport Harbor mouth is not expected to cause significant adverse impacts to non-listed or sensitive bird species that nest, roost, and forage in the area (Staff Report page 34).

• Eelgrass impacts are not anticipated to occur as a result of the proposed project (Staff Report page 34).

• The project is not expected to cause a significant adverse impact to populations of these marine invertebrate species (Staff Report page 34).

• Therefore, as conditioned for revised plans limiting the locations for sand disposal to avoid contiguous sand dollar beds as shown in Exhibit 5, in addition to avoiding nighttime sand deposition to avoid potential negative impacts to grunion, Commission staff finds the project consistent with Sections 30230 and 30231 of the Coastal Act (Staff Report page 36).

• In other words, the existing water quality of Newport Bay is already negatively affected by the presence of DDx compounds and is not predicted to appreciably change as a result of the proposed placement of DDx containing sediments into the CAD. Further, by collecting, concentrating and burying contaminant laden sediments below a clean cap within the proposed CAD that are currently dispersed across Newport Bay, the proposed project may result in water quality improvements (Staff Report page 38).

• As conditioned, Commission staff has determined that the removal, placement, and permanent containment of DDT-contaminated Lower Newport Bay sediments at the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality within the Bay (Staff Report page 38).

• The Commission finds that the proposed project as conditioned would transfer sands currently isolated in Newport Harbor back into the littoral system off Newport Beach via nearshore placement, and is therefore consistent with the Section 30233(b) sand supply policy of the Coastal Act (Staff Report page 42).

• The additional sand that would be placed as part of the project is expected to contribute to efforts to minimize the hazards of flooding from high tides and waves experienced on the ocean beaches of Newport Beach (Staff Report page 44).

• The proposed project conforms with the Coastal Act policies which protect and encourage public access and recreational use of coastal areas. The proposed project would mitigate beach erosion and provide for the continuing and increased recreational use of the City beach by the public by increasing the size of the ocean beaches and would provide a larger area for recreational use. In addition, the proposed dredging components of the project would allow for continued use of coastal waters for recreational boating because the existing anchorage in the proposed CAD project area will be temporarily relocated to the Turning Basin (Staff Report pages 45-46).

• The proposed beach replenishment would maintain and improve recreational use of State Tidelands. Sand replenishment around public beaches is consistent with the City's Tidelands grant (Staff Report pages 46).

• As conditioned, the Commission finds that with these measures, the proposed project would not adversely affect visual resources of the coastal zone, and therefore, the project is consistent with the policies of the Coastal Act (Staff Report pages 47).

• The majority of communities adjacent to the proposed CAD site (except for downtown Costa Mesa), on the other hand have low overall CalEnviroScreen scores. Additionally, areas nearby with higher pollution burden scores that are above 60% in the northern part of Newport Beach would not be affected by the proposed project or any of the alternatives. Therefore, the proposed project of keeping the contaminated sediment in the harbor near the source(s) of contamination does not result in environmental justice impacts compared to the project alternatives, which would relocate contaminated sediments to communities of concern in other regions and require transport of sediments through additional communities of concern. In addition, as conditioned, the project would minimize adverse environmental impacts that may occur locally (Staff Report pages 50).

• The Commission finds that the project, as conditioned, is consistent with Coastal Act requirements and will not cause new adverse impacts to the environment. Feasible mitigation measures which will minimize all adverse environmental impacts have been required. Therefore, the Commission finds that the proposed project, as conditioned, complies with the applicable requirements of the Coastal Act to conform to CEQA (Staff Report pages 51).

My family ask you the Commissioners of the California Coastal Commission to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

Thank you for your time.

The Badajoz family

Newport Beach CA 92663

Revell, Mandy@Coastal

From: George Posey <george@newportaero.com>
Sent: Wednesday, October 5, 2022 2:09 PM
To: Revell, Mandy@Coastal
Cc: Shanen
Subject: Application #5-21-0640 Agenda F17a

Dear Mandy :

As a fifty year resident of Newport Beach I recently became aware of this toxic dumping proposal, and to say the least …I'm shocked and dismayed.

I thought it was the Coastal Commission's mission to protect the harbors and coastline from unnecessary toxic dumping .

The more I research this proposal the more I become increasingly disturbed by the lack of alternatives to this dumping ..

More and more of California's citizens are becoming aware of this toxic dumpling proposal, and no one is for this option. NO ONE.

At lease more study needs to be made for "alternatives" to what you commission has in front of you ..

Thank you for this opportunity to relate my opposition to this dumping..

Respectfully,

George Posey

george@newportaero.com

949-574-4100

885 Production Place

Newport Beach, CA 92663

NEWPORT AERONAUTICAL
The Aerospace Technical Library
www.newportaero.com

within the United States, or otherwise disposed of in any other country outside of its intended destination, either in original form or after being incorporated through an intermediate process into other data without the prior written approval of the US Department of State.

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 2:05 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Lee Hancock

Date: October 5, 2022
Time: 9:05 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/106.0.0.0 Safari/537.36
Remote IP: 216.238.28.5
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 1:05 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Amy Peters

Date: October 5, 2022
Time: 8:05 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_6) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 172.116.157.249
Powered by: Elementor

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:53 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a ~ Application No. 5-21-0614

From: fostersgardens@aol.com <fostersgardens@aol.com>
Sent: Wednesday, October 5, 2022 6:53 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a ~ Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Regards,
Steven F. Foster

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:52 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a ~ Application No. 5-21-0614

From: fostersgardens@aol.com <fostersgardens@aol.com>
Sent: Wednesday, October 5, 2022 6:58 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a ~ Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Regards,
Steven W. Foster

Regards,
Michelle Scharmann
Administrative Assistant
Fosters' Gardens, Inc.
949-631-6340

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:52 PM
To: Revell, Mandy@Coastal
Subject: FW: NEWPORT HARBOR

From: Denis LaBonge <denislabonge@gmail.com>
Sent: Wednesday, October 5, 2022 7:11 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: NEWPORT HARBOR

SIMPLY STATED I SUPPORT THE EFFORT FOR DREDGING NEWPORT HARBOR.

PLS APPROVE WITHOUT RESTRAINTS .
DENIS LABONGE
CITY OF NB RESIDENT
92657

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:52 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging and CAD project

From: John Bibb <jbibb@sbcglobal.net>
Sent: Wednesday, October 5, 2022 12:51 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: Dredging and CAD project

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640
Email Body: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640
John and Kim Bibb

421 M Street
Newport Beach, Ca. 92661
Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:51 PM
To: Revell, Mandy@Coastal
Subject: FW: Cad

-----Original Message-----
From: bill menninger <bmenninger1@gmail.com>
Sent: Wednesday, October 5, 2022 8:32 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Cad

I'm not supportive of this project and a lot of users of the bay can't figure out how this is a good thing or a clean thing for kids and families that use the bay. Get the spoils 100 miles offshore and skip the giant hole that's likely to create problems we do not understand. Get rid of the dredge spoils the way it's been done for 100 years

Long time newport resident

Sent from my iPhone

Revell, Mandy@Coastal

From: John Bibb <jbibb@sbcglobal.net>
Sent: Wednesday, October 5, 2022 12:51 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: Dredging and CAD project

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640
Email Body: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640
John and Kim Bibb

421 M Street
Newport Beach, Ca. 92661
Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:51 PM
To: Revell, Mandy@Coastal
Subject: FW: LTR TO COASTAL

From: SanDiegoCoast@Coastal <SanDiegoCoast@coastal.ca.gov>
Sent: Wednesday, October 5, 2022 9:05 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: RE: LTR TO COASTAL

Hi,

I'm not sure if you meant to send this to us because it's in reference to CDP# 5-21-0640.

Thank you,

Adriana Palato
Management Services Technician
California Coastal Commission
7575 Metropolitan Drive #103
San Diego, CA 92108#

From: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Sent: Tuesday, October 4, 2022 3:12 PM
To: SanDiegoCoast@Coastal <SanDiegoCoast@coastal.ca.gov>
Subject: FW: LTR TO COASTAL

I believe this belong to you guys.
Best,
Becky

From: dave1@basinmarine.com <dave1@basinmarine.com>
Sent: Tuesday, October 4, 2022 9:18 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: LTR TO COASTAL

Please see attached
Thank you
Dave New

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:51 PM
To: Revell, Mandy@Coastal
Subject: FW: Application #5-21-0640, Agenda F17a, October 14, 2022

From: Don Kazanjian <dkazanjian@lee-assoc.com>
Sent: Wednesday, October 5, 2022 9:35 AM
To: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Cc: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Application #5-21-0640, Agenda F17a, October 14, 2022

Dumping contaminated sludge into the center of Newport Harbor would create a potential environmental hazard for residents and visitors for years to come. When toxic or unsuitable materials are left in water **they remain toxic**. When those same materials are **placed on land and mitigated they are no longer harmful**. Which is why the EPA and the local regulators prefer out of the water locations to store contaminated material. The proposed CAD area could never be dredged again. I support responsible sustainable dredging. **I strongly urge a no vote on the proposed CAD**.

Thank you,

Donald E. Kazanjian
President & Principal
Lee & Associates | Ontario

D 909.373.2929
O 909.989.7771
M 714.273.1283
F 909.373.2992

dkazanjian@lee-assoc.com

LEE & ASSOCIATES
COMMERCIAL REAL ESTATE SERVICES

Corporate ID 00976995 / License ID 00860886
3535 Inland Empire Boulevard
Ontario, California 91764

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:50 PM
To: Revell, Mandy@Coastal
Subject: FW: Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

-----Original Message-----
From: Jeff Cyr <cyr6@cox.net>
Sent: Wednesday, October 5, 2022 12:49 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Thank you

Jeff Cyr, 25 year Newport Beach resident

Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:50 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project - City of Newport Beach Application - Item 17a -No. 5-21-0640

From: Bill Hendricksen <bill@hendricksens.com>
Sent: Wednesday, October 5, 2022 9:40 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project - City of Newport Beach Application - Item 17a -No. 5-21-0640

Hello California Coastal Commission,

My name is Bill Hendricksen and I am a Newport Beach resident. As a home owner within the harbpr we have been concerned for years about the quality of the harbor water and how it has been managed. For years now we have been made aware of the reports showing unsuitable materials currently lying on the floor of the harbor. We now understand that the Santa Ana Regional Water Quality Control Board issued a permit allowing the City of Newport to proceed with it's project to dredge the bay to federally mandated depths and to create a Confined Aquatic Disposal site to safely mitigate unsuitable material now existing in the harbor, but that the final approval rests with the Coastal Commission.

The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project. If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be distributed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.

We are asking you the commissioners of the California Coastal Commission to approve this application for the Confined Aquatic Disposal Facility today and move this project forward because it is the right thing to do.

Thank you.

Bill Hendricksen

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:50 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Meserve, Scott <meserves@koll.com>
Sent: Wednesday, October 5, 2022 9:44 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

To Whom It May Concern,
I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned. We look forward to your approval.

Thanks,

Scott M. Meserve
Resident of Newport Beach

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:49 PM
To: Revell, Mandy@Coastal
Subject: FW: SUPPORT CAD & Dredging Project in NB
Attachments: Approval Letter.pdf

-----Original Message-----
From: Kenneth Crume <socalinv@gmail.com>
Sent: Wednesday, October 5, 2022 9:57 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Ken Crume <socalinv@gmail.com>
Subject: SUPPORT CAD & Dredging Project in NB

To Whom it May Concern,

Please see attached letters of SUPPORT for:

CAD & Dredging Project in Newport Beach, Item: 17a - Application No. 5-21-0614

Thanks,

Ken Crume

Kenneth H. Crume
48 Beacon Bay
Newport Beach, CA 92660

October 4, 2022

CALIFORNIA COASTAL COMMISSION via Email

Re: CAD & Dredging Project in Newport Beach
Item: 17a – Application No. 5-21-0614

To Whom It May Concern:

We live on the Bay in Newport Beach. We boat, kayak, paddle board and swim in the Bay.

We SUPPORT the above referenced Project and ask for your APPROVAL.

Thank you,

Crume

Kenneth H. Crume

Gail A. Crume
48 Beacon Bay
Newport Beach, CA 92660

October 4, 2022

CALIFORNIA COASTAL COMMISSION via Email

Re: CAD & Dredging Project in Newport Beach
Item: 17a – Application No. 5-21-0614

To Whom It May Concern:

We live on the Bay in Newport Beach. We boat, kayak, paddle board and swim in the Bay.

We SUPPORT the above referenced Project and ask for your APPROVAL.

Thank you,

Gail A. Crume

Gail A. Crume

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:49 PM
To: Revell, Mandy@Coastal
Subject: FW: Coastal Dredging
Attachments: Talking Points - Coastal Commission CAD Communications 2022-09-30.docx

-----Original Message-----
From: Lois Madison <loismadison@yahoo.com>
Sent: Wednesday, October 5, 2022 10:07 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Coastal Dredging

I support the CAD and Coastal Dredging project for Newport Beach.

Sincerely,
Lois Madison
22 Beacon Bay
Newport Beach 92660

CALIFORNIA COASTAL COMMISSION HEARING
NEWPORT BEACH APPLICATION FOR CONFINED AQUATIC DISPOSAL FACILITY
OCTOBER 14, 2022

TALKING POINTS FOR COASTAL COMMISSION COMMUNICATIONS

- By approving the City of Newport Beach Application No. 5-21-0640 the Coastal Commission has the opportunity to move forward the long awaited dredging of Newport Harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.

- Coastal Commission staff has reviewed this application and is recommending approval of the same.

- The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.

- The City of Newport Beach is near the end of the road. With the California Coastal Commissions approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.

- If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.

- This Application furthers the mission of the California Coastal Commission to protect and enhance California's coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor's floor.

- (I, we, my family, my organization) ask you the Commissioners of the California Coastal Commission to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:49 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Jerry Conrad <jconrad@ocoffice.net>
Sent: Wednesday, October 5, 2022 12:49 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

I'm writing this email in hopes that the City of Newport Beach will approve the CAD & Dredging Project in Newport Beach. I live on the water on Lido Isle and see the evidence of toxicity and debris floating in and on top of the water. Based on what I've heard, I believe enough research and studies have been conducted to make this safe for everyone.

I think it would in everyone's best interest to clean up the sediments and toxic elements in the water because the water is our back yard. I am proud to live in a clean city, and it only makes sense to have the cleanest water in the bay that we can possibly achieve.

I hope that based on the research and studies the City of Newport have done is sufficient to approve this project!

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:48 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

From: Robert Brunner <brunnerr@pacbell.net>
Sent: Wednesday, October 5, 2022 10:12 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: mandy.Ravell@coastal.ca.gov
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Robert Brunner
607 36th St
Newport Beach, CA 92663
+1-213.840.7555

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:48 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging Project in Newport Beach; item17a- Application No. 5-21-0640

From: rad@rdycc.com <rad@rdycc.com>
Sent: Wednesday, October 5, 2022 10:14 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Dredging Project in Newport Beach; item17a- Application No. 5-21-0640

Dear Coastal Commission,

I am in agreement with the Commission staff recommending that the Commission approve Coastal Development Permit application 5-21-0640 as conditioned.

I have lived in Newport Beach for over 40 years.

Thank you,

Roger De Young

Roger DeYoung
DE YOUNG INVESTMENTS, LLC
2415 Campus Drive, Ste 130
Irvine, CA 92612
949-296-2810

Revell, Mandy@Coastal

From:	SouthCoast@Coastal
Sent:	Wednesday, October 5, 2022 12:48 PM
To:	Revell, Mandy@Coastal
Subject:	FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

From: Tim Marshall <timcmarshall@LIVE.COM>
Sent: Wednesday, October 5, 2022 10:21 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Coastal Commission,

As a Newport beach home owner and boat owner, it is important that we maintain safe navigation in the harbor. More importantly, this dredging project is important to sustain a clean harbor due to the improved (or reduced degradation) of tidal flushing associated with a shallower harbor.

I'd appreciate you approving this project.

Tim Marshall

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:47 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the dredging and cad project-City of Newport Beach Application -Item 17a-No. 5-21-0640

From: kmfinnbic@att.net <kmfinnbic@att.net>
Sent: Wednesday, October 5, 2022 10:38 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the dredging and cad project-City of Newport Beach Application -Item 17a-No. 5-21-0640

Dear Sirs,

I am in strong support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

Kevin Finn
Newport Beach

Revell, Mandy@Coastal

From:	SouthCoast@Coastal
Sent:	Wednesday, October 5, 2022 12:47 PM
To:	Revell, Mandy@Coastal
Subject:	FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

From: Donnie Crevier <donnie@crevierclassiccars.com>
Sent: Wednesday, October 5, 2022 11:09 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

City of Newport Beach and
California Coastal Commission

I am writing you to inform you that I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Donnie Crevier
Resident of Laguna Beach, CA

Donnie Crevier

Crevier Classic Cars

Office: 714 – 426 – 0238

Mobile: 714 – 318 – 1773

Fax: 714 – 426 – 0311

donnie@crevierclassiccars.com

www.crevierclassiccars.com

2995 Airway Ave Suite B, Costa Mesa, CA 92626

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:46 PM
To: Revell, Mandy@Coastal
Subject: FW: Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Taylor Anderson <taylor@aetherapparel.com>
Sent: Wednesday, October 5, 2022 11:31 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Sincerely,
Taylor Anderson

AETHER Apparel
6100 Melrose Ave | Los Angeles, CA 90038
P 323.785.0701 ext. 203
www.aetherapparel.com
@aetherapparel

F17a Briefing Book

Anne Blemker <ablemker@mccabeandcompany.net>

Tue 10/4/2022 1:13 PM

To: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>

Cc: Miller, Chris <CMiller@newportbeachca.gov>

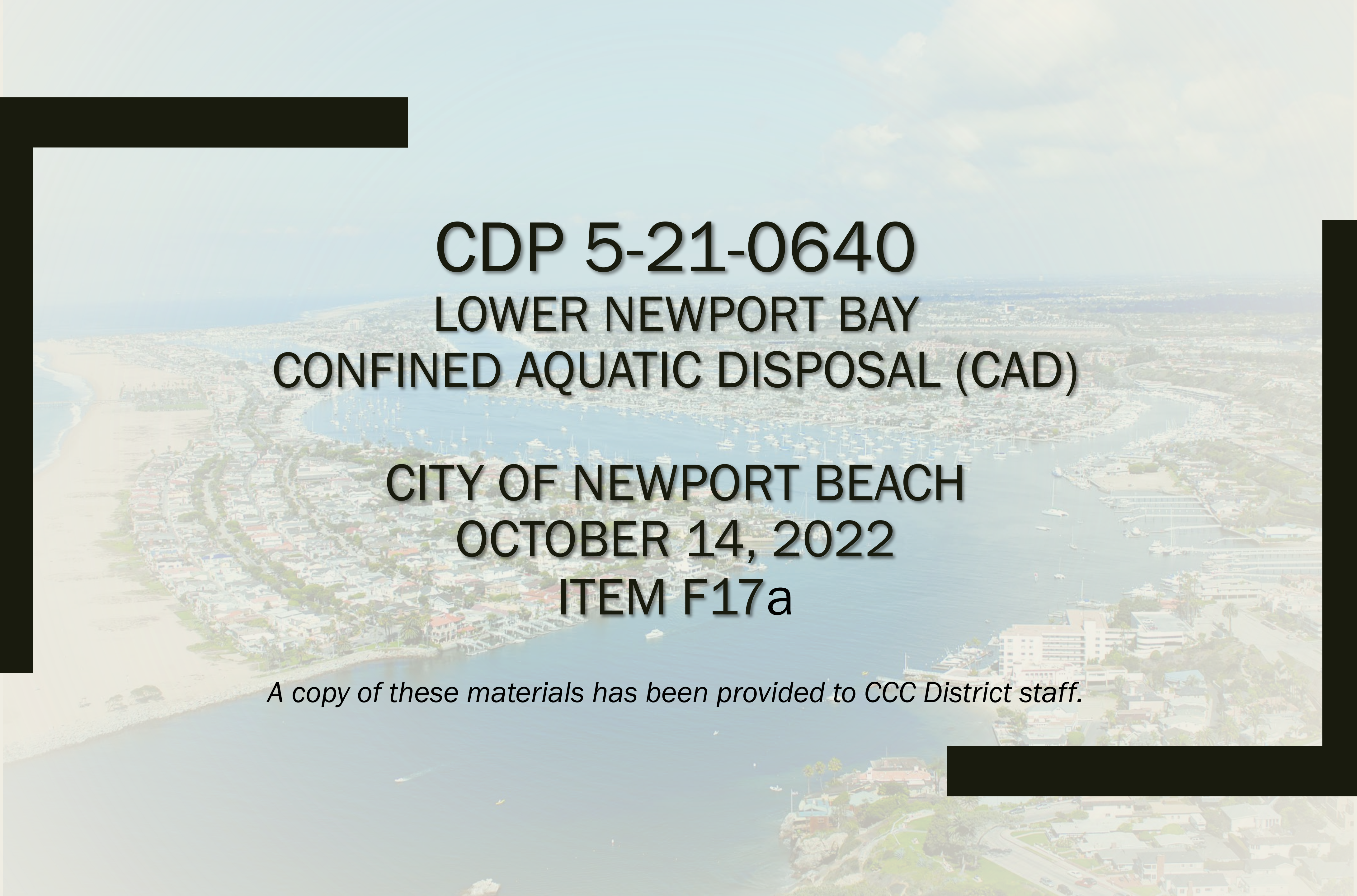
1 attachments (4 MB)

F17a Newport Beach CAD Briefing Book.pdf;

Hi Mandy,

Hope you're doing well. Attached please find a briefing book that we intend to share with Commissioners. Please confirm receipt.

Thanks,
Anne
--
Anne Blemker
McCabe & Company
310-463-9888



CDP 5-21-0640

LOWER NEWPORT BAY
CONFINED AQUATIC DISPOSAL (CAD)

CITY OF NEWPORT BEACH
OCTOBER 14, 2022
ITEM F17a

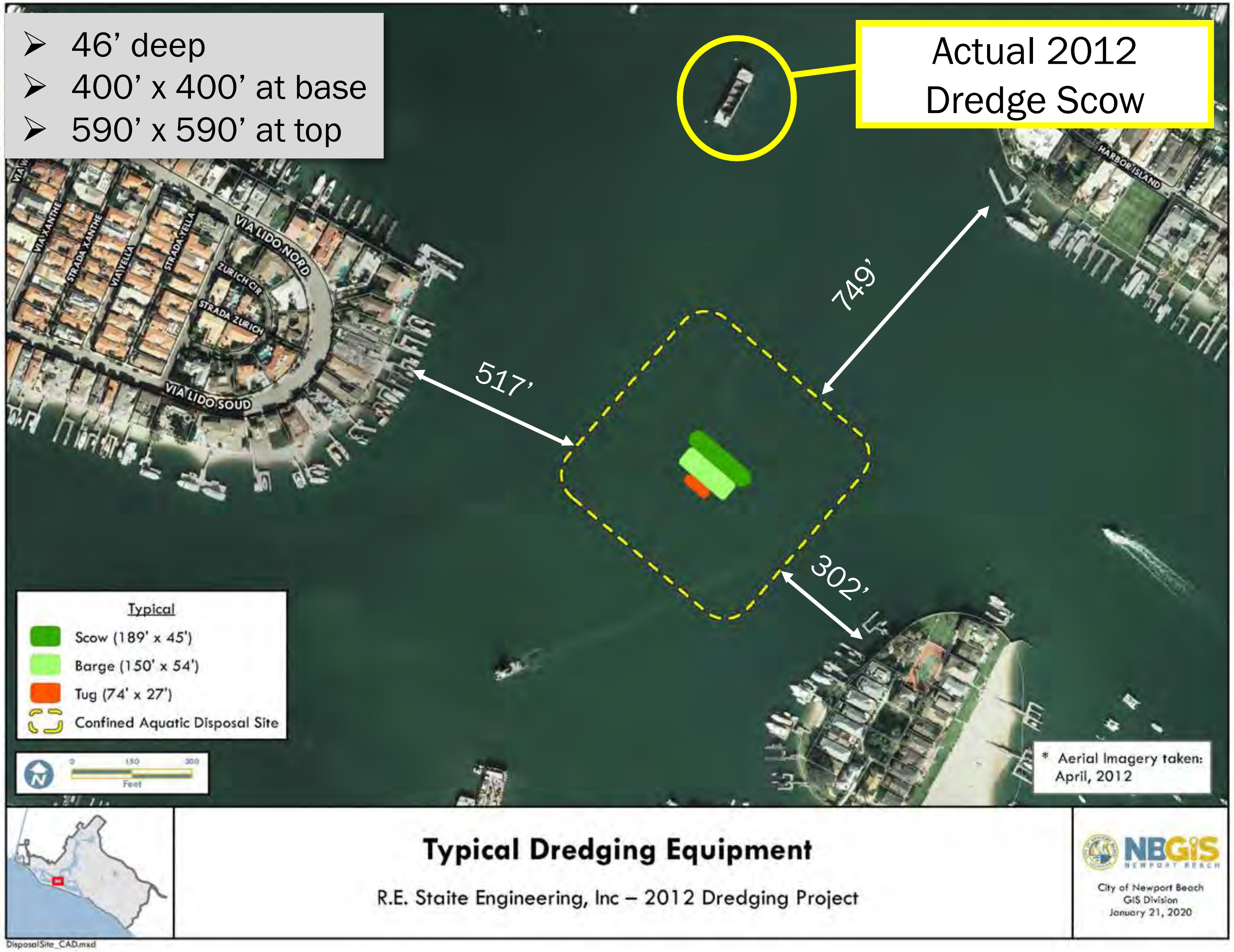
A copy of these materials has been provided to CCC District staff.

Background and Project Need

- Lower Newport Harbor requires periodic maintenance dredging to remove accumulated sediment that impedes navigation and full use of harbor
- Army Corps (USACE) proposes “Federal Channels maintenance dredging program” in 2022-23
- Most of dredged sediment (90%) determined <u>suitable</u> for open ocean disposal
- Approx. 112,500 cy determined <u>unsuitable</u> for open ocean disposal and requires alternative disposal options
- City (local sponsor) responsible for identifying disposal options for unsuitable material:
  - *Proposed confined aquatic disposal (CAD) facility in central portion of Lower Newport Harbor*

Project Location
Lower Newport Harbor
Proposed Confined Aquatic Disposal Facility (CAD)
Dredged Material Suitable for Open Ocean or Nearshore Disposal
Dredged Material Not Suitable for Open Ocean or Nearshore Disposal
N
W
E
S
0
500
1,000
Feet
NBGIS
NEWPORT BEACH
City of Newport Beach
GIS Division
August 30, 2022
Turning Basin -19
WEST LIDO CHANNEL
LIDO CHANNEL
LIDO ISLE
Lido Isle Reach -20
Newport Channel -15
CAD
Yacht Anchorage -15
Harbor Island Reach -20
BALBOA ISLAND
Balboa Reach -20
Nearshore Placement Area
Nearshore Placement Area
DESERT
CALIFORNIA
Los Padres National Forest
Los Angeles
Newport Beach
San Diego

CAD Description and Location



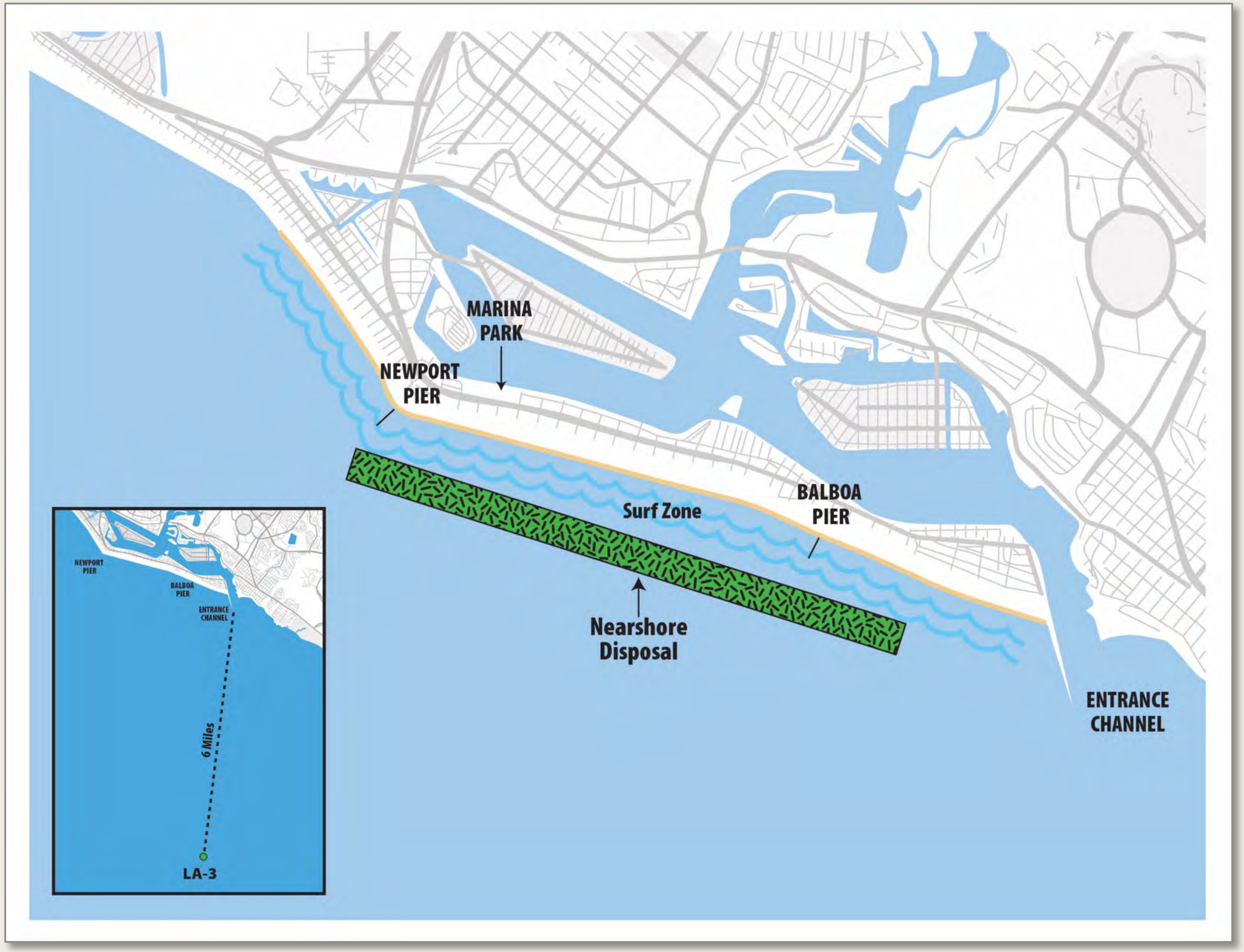
Confined Aquatic Disposal (CAD) facility is a depression in an aquatic seafloor used to contain and store sediment.

- CAD will accommodate unsuitable dredge material from Federal Channels dredging program.
- Proposed CAD site is centrally located within Newport Harbor.

Material Unsuitable for Ocean Disposal

- NOT toxic
- NOT hazardous

- Currently on the harbor bottom – Allowed to leave in place (***not required to be removed by City***)
- City is funding 50% of overall project (up to $10M) – allows USACE to dredge Federal Channels to full authorized depths.
- Plan supported by agencies including EPA, Dredged Material Management Team, etc.
  - *Regional Water Board 401 Certification issued September 30, 2022*



Disposal of Suitable Material

- Clean material excavated during construction of CAD facility will be ***beneficially reused/placed in the nearshore zone along the ocean beaches (natural replenishment).***

- Dredge material deemed suitable for open-ocean disposal will be deposited at EPA managed site (“LA-3”), 6 miles from Newport Harbor.

Permitting and Project Responsibility

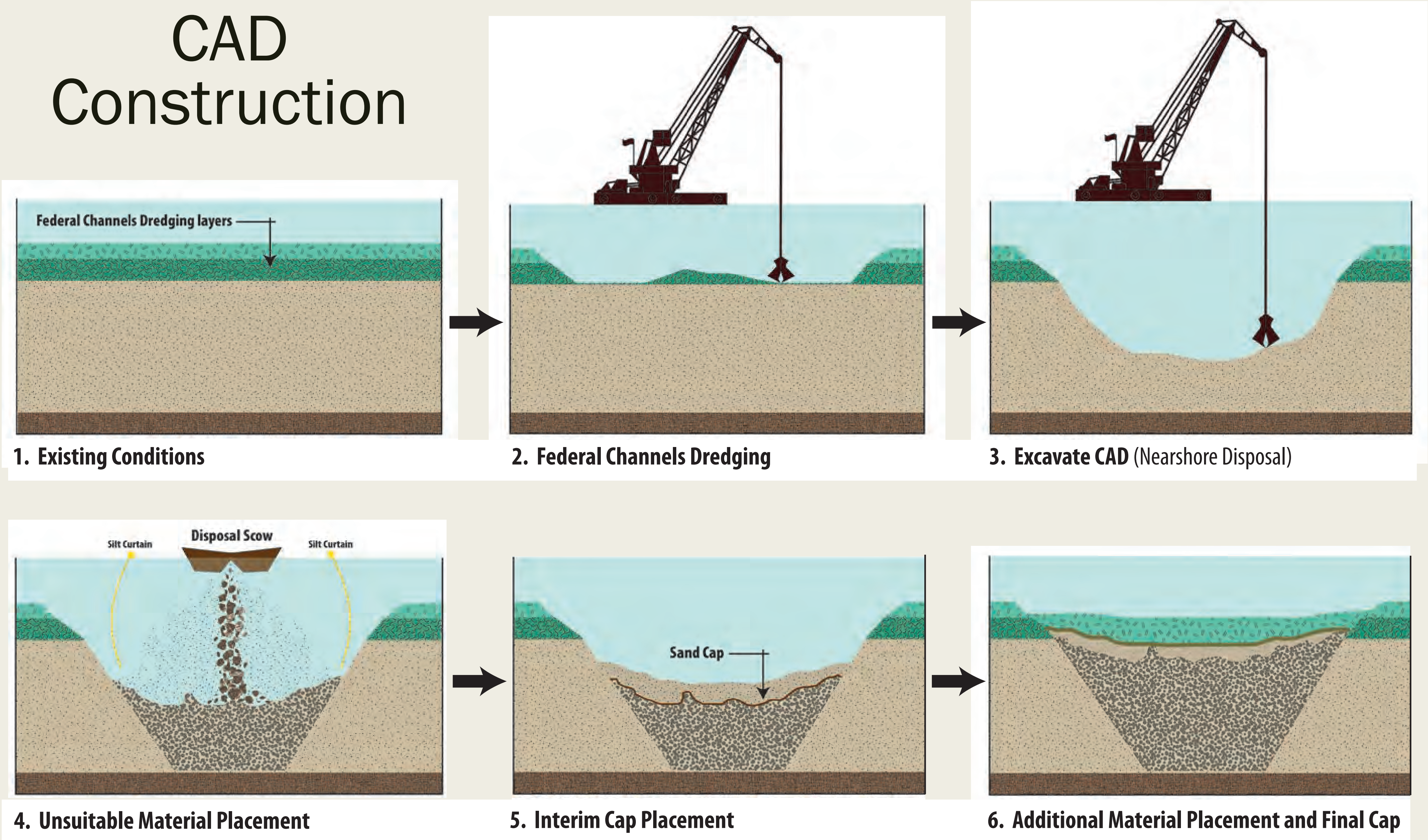
USACE dredging within <u>Federal Channels</u> to maintain navigation and authorized depths.

- USACE obtained CCC concurrence for maintenance dredging on May 27, 2022 (Negative Determination No. ND-0020-22)
- Likely last major federal dredging effort due to improved watershed sediment management

City construction of CAD facility for unsuitable dredge material and placement of a final cap layer.

- Current application (CDP No. 5-21-0640) <u>limited to City's CAD portion of overall project</u>

CAD Construction



Additional Benefit for Harbor

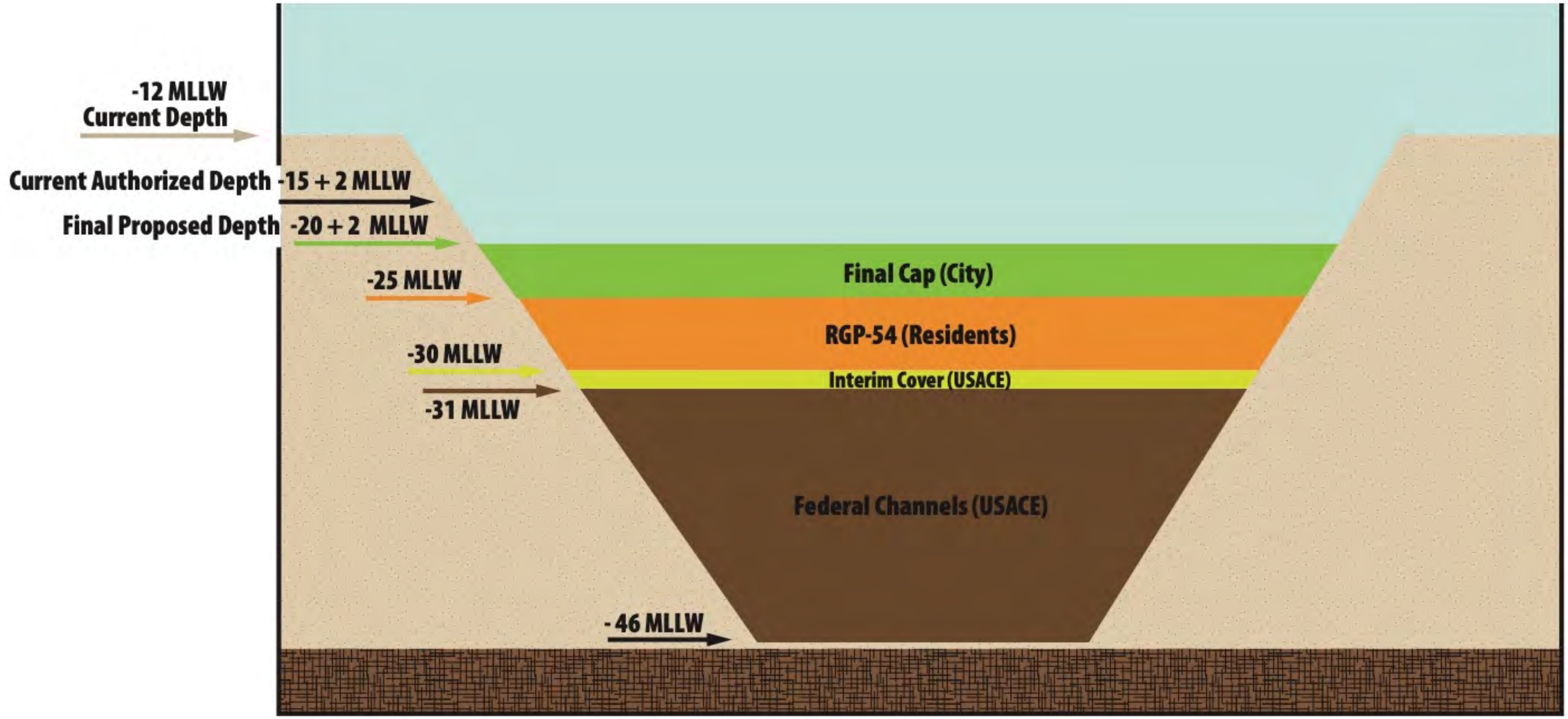
- US EPA requested development of a <u>Sediment Management Plan</u> to address other non-federal unsuitable sediment.
  - *Creates an inventory of all sediment in Newport Harbor requiring dredging both within and outside the Federal Channels*
  - *Identifies sediment management options based on sediment characteristics, disposal location, and permitting requirements*

- City designed CAD to accommodate <u>*additional* 50,000 cy</u> to assist other harbor residents/marinas – holistic harborwide approach.
  - *Available during a 6-month window two years after USACE places unsuitable Federal Channels material*
  - *Cost-effective and convenient disposal opportunity for waterfront homeowners with impacted sediment*

Timeline - Capping of CAD

- Interim cap placed after Federal Channels material for 2 years.
- 50,000 cy of other harbor material placed for 6 months.
- Final cap layer placed within CAD to isolate the underlying sediments from burrowing organisms and biota residing in the overlying water column.
  - *Clean material sourced by the City and designed/modeled to a thickness of 3-feet (33,600 cy).*
  - *Clean material likely consisting of material dredged under the City's RGP 54 dredging program, maintenance dredging at the Santa Ana River as a contingency, or other sources available at the time. (Plan required per CCC Special Condition No. 2)*

CAD Facility Design Layers



Fill Responsibilities

Long Term Monitoring

- An Operations, Management, and Monitoring Plan (OMMP) for the CAD facility will be implemented. This includes:
  - *Management and monitoring objectives for the CAD*
  - *Communications plan for the entire CAD construction and sediment disposal process*
  - *Construction monitoring and post-disposal monitoring plans*
  - *Contingency plans*
  - *Annual monitoring plans*
  - *Long-term management plans after final cap*
  - *Other plans as required by CCC and Water Board*

Response to Public Comments

- *Comment: Stakeholder and Public Input*

  Response:

  - More than 65 public outreach efforts (meetings, media, announcements)

- *Comment: Lower Castaways Disposal Alternative (Presented by Friends of Newport Harbor)*

  Response:

  - Environmental Impact Report (EIR) considered landside disposal – more impactful than CAD (rehandling material, over 9,000 truck trips, dewatering, treating etc.)
  - Conflicts with City's Local Coastal Program with significant impacts to public access, ESHA, coastal bluffs, visual quality, and public views
  - Site would not accommodate all material (independent 3rd party review)
  - City Council has not decided appropriate long-term use of this City public park

Response to Public Comments (cont.)

- *Comment: Newport Dunes Resort Disposal Alternative*

  Response:

  - County owned property (Not City) – Assumes County would accept material. Site currently designated for hotel.

- *Comment: Short Term Water Quality Impacts*

  Response:

  - "The [City's} application of the STFATE model is appropriate to evaluate the short-term losses during the placement operations at the proposed Lower Newport Bay CAD site. Applying the STFATE model for a CAD site would generate rather conservative estimates of losses until the CAD cell is nearly full. ***The model input, scenarios, application and assumptions are appropriate to provide a conservative picture of the potential solids losses from the placement operations."***

(Paul R. Schroeder, PhD, PE, USACE Engineering and Research Development Center, May 16, 2022)

Response to Public Comments (cont.)

- *Comment: CAD Can Never Be Dredged Again*

  Response:

  - Final CAD elevation will be deeper than authorized depth (15-feet vs 20-feet)
  - Equal to deepest Federal Channels (20-feet) – planning for the future.

- *Comment: CAD Construction Is Not Putting Sand Directly On Beach*

  Response:

  - Sand will be placed in nearshore zone as close to shore as possible
  - Proven/accepted sand management technique along coastal communities. Adding valuable sand back into littoral cell.

Response to Public Comments (cont.)

- *Comment: Anchorage with Large Vessels Traversing, Propellers, Thrust Engines and Anchors*

  Response:

  - CAD final elevation will be at least 5-feet deeper than existing depth therefore providing more clearance from propellers and bow-thrusters.
  - Cap design included engineered modeling for larger propellers and anchors

- *Comment: Stability of CAD Adjacent to Federal Channel – Thin Wall of Sediment*

  Response:

  - CAD immediately adjacent to Federal Channel. Final elevation at same or deeper depth than Federal Channel.
  - No thin wall of sediment

Response to Public Comments (cont.)

- *Comment: CAD Will Not Benefit Newport Homeowners*

  Response:

  - Sediment Management Plan allows for ***any*** sediment in Newport Harbor to take advantage of CAD ***including*** residential docks.
  - The City's residential dredging program (CDP 5-19-1296, Special Condition 5.E.1) states that "…dredge material may be disposed of at a Commission approved Confined Aquatic Disposal site (CAD)."

- *Comment: Material Remains Toxic In CAD*

  Response:

  - Material is NOT toxic as scientifically defined by regulatory agencies.
  - CAD is an accepted method for unsuitable material as permitted elsewhere in California and other east coast locations (e.g. New Bedford, MA – residential)

Response to Public Comments (cont.)

- *Comment: Sediment with Contaminants Cannot Be Disposed Offshore*

  Response:

  - DDT material is below threshold – acceptable to dispose offshore.
  - Mercury level is 1 ppm (negotiated to 1.5 ppm). Material passed toxicity tests and does not pose a risk to human health.

- *Comment: The City's Testing Is Incomplete*

  Response:

  - All sediment material is thoroughly vetted and approved by regulatory and resource agencies (Dredged Material Management Team).
  - EPA scrutinized sampling plan and final report. Evaluated against all past harbor sampling events.

Response to Public Comments (cont.)

- *Comment: Post Dredge Monitoring Plan Inadequate*

  Response:

  - Regulatory agencies (CCC, RWQCB and USACE) issue permits with conditions including required monitoring plans.

- *Comment: The CAD Will Have a Thin Interim Cap Layer*

  Response:

  - The interim cap is engineered for the 2-year term after the federal project and while the residents secure their permits for disposal.
  - The interim cap elevation will be at 30-feet (deep within the side-slope walls and 8-feet deeper than final elevation).
  - The anchorage area will not be in use during this period.

Project Benefits

Improved navigation and recreation

Beneficial reuse of suitable beach material

Proper management of unsuitable material

Conclusion

The City of Newport Beach appreciates and agrees with the staff recommendation and all special conditions and respectfully requests approval by the Commission.

Thank You

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:46 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Horace Benjamin <ben@hbbenjamin.com>
Sent: Wednesday, October 5, 2022 11:33 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Ladies and Gnetlemen,

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Horace B. Benjamin

ben@hbbenjamin.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:45 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Beach Dredging and CAD Project Application – Item 17a - No. 5-21-0640

From: Randy Black <randyoc949@gmail.com>
Sent: Wednesday, October 5, 2022 11:33 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: Newport Beach Dredging and CAD Project Application – Item 17a - No. 5-21-0640

My family has been in Newport Harbor since 1926 and we strongly support the City of Newport Beach's application. As noted by Commission staff in their recommendation for approval, this project shall "significantly improve public access and recreational opportunities" and would "result in an increase of the available area for boats to pass through" while "the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the Coastal Zone".

We respectfully request that the Commission approve this Application.

Randy Black
Newport Beach

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:44 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Kelly M Cunningham <kellyalexismcelroy@gmail.com>
Sent: Wednesday, October 5, 2022 11:43 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Hi CA Coastal Commission,

Reaching out to confirm my support of the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640 for the following reasons:

- The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).
- The City's Sediment Management Plan, which was developed to manage all of the different types of sediment within the harbor was fully vetted through the DMMT process, and it provides details on unsuitable material quantities, and therefore, Commission staff believes that it adequately supports the design of the proposed project (Staff Report page 4).
- The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5).

Thank you,
Kelly

--
Kelly McElroy Cunningham
M. 949.244.3824

Revell, Mandy@Coastal

From:	teresa lewis <maxine05@sbcglobal.net>
Sent:	Wednesday, October 5, 2022 12:44 PM
To:	Revell, Mandy@Coastal
Subject:	CAD OPPOSITION

TERESA D. LEWIS

OPPOSED

APPLICATION #5-21-0640

AGENDA F17a

October 14, 2022

Mandy.Revell@Coastal.ca.gov

CALIFORNIA COASTAL COMMISSION

SOUTH COAST AREA OFFICE

301 E OCEAN BLVD SUITE 300

LONG BEACH CA 90802-4302

I oppose the CAD project. I believe dumping contaminated sludge into Newport Harbor would create a potential environmental hazard for residents and visitors. More environmental testing is needed before this project should move forward. I do not believe that better alternative solutions have been researched enough to follow through with CAD.

Please stop the CAD Project until further environmental testing and alternative storage solutions have been thoroughly researched. Thank you for your consideration.

Teresa Lewis

Maxine05@sbcglobal.net

(949)702-3551

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:43 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

-----Original Message-----
From: Doug Welsh <DougWelsh@msn.com>
Sent: Wednesday, October 5, 2022 11:59 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

This is something long over due and is needed

Terence Douglas Welsh
375 Newport Glen Ct.
Newport Beach CA 92660

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:43 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging newport harbor

-----Original Message-----
From: George Gallian <ggallian@me.com>
Sent: Wednesday, October 5, 2022 12:00 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Dredging newport harbor

We need the harbor dredged, its been many decades from the last dredging.

I am a Newport resident
George Gallian

Thank you

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:43 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging NH

-----Original Message-----
From: Tom Iovenitti <tom@benutech.com>
Sent: Wednesday, October 5, 2022 12:02 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Dredging NH

We need our harbor dredged and maintained. Please insure the residents and boat owners of the community are heard reading this very important issue that we support fully. Thank you. Tom iovenitti 1425 W Bay, NB 92661.

Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:42 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614
Attachments: Document_20221005_0002.pdf

From: Steve Jarecki <sjarecki@cjkinvestments.com>
Sent: Wednesday, October 5, 2022 12:20 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Steve Jarecki <sjarecki@cjkinvestments.com>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

October 5, 2022

To: SouthCoast@coastal.ca.gov

Subject: I support the CAD & Dredging Project in Newport Beach; Item 1
Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-064(
conditioned.

Steve Jarecki

Steve Jarecki

Steve Jarecki | Principal
4100 MacArthur Blvd, Suite 200 | Newport Beach, CA 92660
Direct: (949) 224-4175 |
sjarecki@cjkinvestments.com
www.cjkinvestments.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:42 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Andrew Cunningham <andrew6183@gmail.com>
Sent: Wednesday, October 5, 2022 12:21 PM
To: Kelly M Cunningham <kellyalexismcelroy@gmail.com>; SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Hi CA Coastal Commission,

Reaching out to confirm my support of the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640 for the following reasons:

- The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).
- The City's Sediment Management Plan, which was developed to manage all of the different types of sediment within the harbor was fully vetted through the DMMT process, and it provides details on unsuitable material quantities, and therefore, Commission staff believes that it adequately supports the design of the proposed project (Staff Report page 4).
- The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5).

Thank you,
Andrew

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:40 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614
Attachments: Document_20221005_0003.pdf

From: Debbie Jarecki <dmjarecki6@gmail.com>
Sent: Wednesday, October 5, 2022 12:24 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Steve Jarecki <sjarecki@cjkinvestments.com>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:40 PM
To: Revell, Mandy@Coastal
Subject: FW: Application No. 5-21-0640

From: Jay Blackstock <jayblackstock@hotmail.com>
Sent: Wednesday, October 5, 2022 12:27 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Application No. 5-21-0640

Coastal Commission,

I am long-term resident and boater in Newport Beach, CA and wanted to register my support for continuing the successful dredging on Newport Harbor per the current application No. 5-21-0640 incorporating the CAD facility as reviewed and supported by the Coastal Commission staff.

The perception of harm by a very small and affluent number of residents is understandable, but no projection of harm has been determined and the benefit to the remaining residents is immense.

Please consider the efforts and conclusions of both the Coastal Commission and Newport Harbor staffs and their recommendation for approval.

Regards,
Jay Blackstock
32 Canyon Island Drive
Newport Beach, CA 92660

October 5, 2022

To: SouthCoast@coastal.ca.gov

Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Debbie McLain

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:40 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD and Dredging project in Newport Beach application no. 5-21-0640

From: Dougall Johnson <yankmec@earthlink.net>
Sent: Wednesday, October 5, 2022 12:31 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD and Dredging project in Newport Beach application no. 5-21-0640

I am in favor of this dredging project. All of the materials are already in the bay so this seems like a good solution to keep the bay navigable.
I have been in and on the waters of Newport Harbor since 1963 and still have a small boat in the bay.
Thank you for your service to the Coastal community.
Best regards,
Dougall Johnson

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:39 PM
To: Revell, Mandy@Coastal
Subject: FW: Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Yvonne Sherie <yvonne@ocoffice.net>
Sent: Wednesday, October 5, 2022 12:37 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: FW: Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

I write this email in support of the CAD & Dredging Project in Newport Beach. As a resident on the water, I can visibly see the undesireable elements in the water. I believe that it is in the best interest of everyone to clean up the sediments and toxic elements in the water, for boaters, swimmers and our pets. Newport is a beautiful and clean city, and it only makes sense to have the cleanest water in the bay that we can possibly achieve.

I hope that based on the research and studies the City of Newport have done is sufficient to approve this project!

Yvonne Conrad
949-878-1787

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Wednesday, October 5, 2022 12:39 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

It's a new day, with more to come! Sorry!!!

From: Steve Jarecki <sjarecki@cjkinvestments.com>
Sent: Wednesday, October 5, 2022 12:38 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

October 5, 2022

To: SouthCoast@coastal.ca.gov

Subject: I support the CAD & Dredging Project in Newport Beach; Item
Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-06
conditioned.

Josephine Jarecki

Josephine Jarecki

Revell, Mandy@Coastal

From: Randy Black <randyoc949@gmail.com>
Sent: Wednesday, October 5, 2022 11:33 AM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: Newport Beach Dredging and CAD Project Application – Item 17a - No. 5-21-0640

My family has been in Newport Harbor since 1926 and we strongly support the City of Newport Beach's application. As noted by Commission staff in their recommendation for approval, this project shall "significantly improve public access and recreational opportunities" and would "result in an increase of the available area for boats to pass through" while "the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the Coastal Zone".

We respectfully request that the Commission approve this Application.

Randy Black
Newport Beach

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 11:26 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Marko C Barker

Date: October 5, 2022
Time: 6:26 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Safari/605.1.15
Remote IP: 104.28.85.225
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 11:20 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Tori Bush

Date: October 5, 2022
Time: 6:19 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.2 Safari/605.1.15
Remote IP: 98.152.194.10
Powered by: Elementor

Revell, Mandy@Coastal

From: Chace Warmington <chace.warmington@gmail.com>
Sent: Wednesday, October 5, 2022 11:13 AM
To: Revell, Mandy@Coastal
Subject: Opposition to CAD in Newport Harbor Application #5-21-0640, Agenda F17a on October 14

$
Q w2$Vizipp0$
$
M${erx$xs$vikmwxiv$q}$sttswmxmsr$xs$Ettpmgexmsr$'916514:840eGEH$w}wxiq$mr$Ri{tsvx$Levfsv2$$Vigirx$wgmirxmjmg$uyiwxmsrw$lezi$
ipizexih$q}$gsrgivr$xlex$eGEHw}wxiq$qmklx$rsxfixli$fiwx$jmxjsvsyv$viwmhirxmep$fiegl$gsqqyrmx}2$$Mewojsver$i|xirwmsr$xs$
izepyexixliuyiwxmsrw$tswih$f}xlirsrtvsjmx0XliJvmirhwsjRi{tsvx$Levfsv2$
$
M$ettvigmexi$}sy$vikmwxivmrk$q}$sttswmxmsr${mxlxliGsewxep$Gsqqmwwmsr0${lmgl${mpp$ehhviww$xlmw$mwwyisrSgxsfiv$58xl2$
$
[mxl$ettvigmexmsr0$
$
Glegi$[evqmrkxsr$
$

Revell, Mandy@Coastal

From: Donnie Crevier <donnie@crevierclassiccars.com>
Sent: Wednesday, October 5, 2022 11:09 AM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

City of Newport Beach and
California Coastal Commission

I am writing you to inform you that I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Donnie Crevier
Resident of Laguna Beach, CA

Donnie Crevier

Crevier Classic Cars

Office: 714 – 426 – 0238

Mobile: 714 – 318 – 1773

Fax: 714 – 426 – 0311

donnie@crevierclassiccars.com

www.crevierclassiccars.com

2995 Airway Ave Suite B, Costa Mesa, CA 92626

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 11:05 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Tom Duffy

Date: October 5, 2022
Time: 6:04 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.127 Safari/537.36
Remote IP: 76.95.75.161
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 11:04 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Linda K Duffy

Date: October 5, 2022
Time: 6:04 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/100.0.4896.127 Safari/537.36
Remote IP: 76.95.75.161
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 10:51 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Shari Wilkins

Date: October 5, 2022
Time: 5:51 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/106.0.0.0 Safari/537.36
Remote IP: 76.95.73.120
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 10:43 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Midori Uyeda

Date: October 5, 2022
Time: 5:42 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Linux; Android 13) AppleWebKit/537.36 (KHTML, like Gecko) Version/4.0 Chrome/105.0.5195.136 Mobile DuckDuckGo/5 Safari/537.36
Remote IP: 172.89.36.90
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 10:42 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Midori Uyeda

Date: October 5, 2022
Time: 5:42 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Linux; Android 13) AppleWebKit/537.36 (KHTML, like Gecko) Version/4.0 Chrome/105.0.5195.136 Mobile DuckDuckGo/5 Safari/537.36
Remote IP: 172.89.36.90
Powered by: Elementor

Revell, Mandy@Coastal

From: kmfinnbic@att.net
Sent: Wednesday, October 5, 2022 10:38 AM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the dredging and cad project-City of Newport Beach Application -Item 17a-No. 5-21-0640

Dear Sirs,

I am in strong support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640.

Kevin Finn
Newport Beach

Revell, Mandy@Coastal

From: Tim Marshall <timcmarshall@LIVE.COM>
Sent: Wednesday, October 5, 2022 10:21 AM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Coastal Commission,

As a Newport beach home owner and boat owner, it is important that we maintain safe navigation in the harbor. More importantly, this dredging project is important to sustain a clean harbor due to the improved (or reduced degradation) of tidal flushing associated with a shallower harbor.

I'd appreciate you approving this project.

Tim Marshall

Revell, Mandy@Coastal

From: Robert Brunner <brunnerr@pacbell.net>
Sent: Wednesday, October 5, 2022 10:14 AM
To: Revell, Mandy@Coastal
Subject: Fw: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Sorry Mandy, I had a typo in your e-mail address.

See below for my support for the dredging project.

Robert Brunner
607 36th St
Newport Beach, CA 92663
+1-213.840.7555

----- Forwarded Message -----
From: Robert Brunner <brunnerr@pacbell.net>
To: SouthCoast@coastal.ca.gov <southcoast@coastal.ca.gov>
Cc: mandy.Ravell@coastal.ca.gov <mandy.ravell@coastal.ca.gov>
Sent: Wednesday, October 5, 2022 at 10:11:51 AM PDT
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Robert Brunner
607 36th St
Newport Beach, CA 92663
+1-213.840.7555

Revell, Mandy@Coastal

From: Bill Hendricksen <bill@hendricksens.com>
Sent: Wednesday, October 5, 2022 9:40 AM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project - City of Newport Beach Application - Item 17a -No. 5-21-0640

Hello California Coastal Commission,

My name is Bill Hendricksen and I am a Newport Beach resident. As a home owner within the harbpr we have been concerned for years about the quality of the harbor water and how it has been managed. For years now we have been made aware of the reports showing unsuitable materials currently lying on the floor of the harbor. We now understand that the Santa Ana Regional Water Quality Control Board issued a permit allowing the City of Newport to proceed with it's project to dredge the bay to federally mandated depths and to create a Confined Aquatic Disposal site to safely mitigate unsuitable material now existing in the harbor, but that the final approval rests with the Coastal Commission.

The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project. If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be distributed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.

We are asking you the commissioners of the California Coastal Commission to approve this application for the Confined Aquatic Disposal Facility today and move this project forward because it is the right thing to do.

Thank you.

Bill Hendricksen

Revell, Mandy@Coastal

From: kris mungo <krismungo@gmail.com>
Sent: Wednesday, October 5, 2022 8:40 AM
To: Revell, Mandy@Coastal
Subject: Opposed

Hv2$Vmglevh$erh$Ovmxr$Qyrks$

Sttswih$

Ettpmgexmsr$'916514:84$

Ekirhe$J5;e$

Sgxsfiv$580$6466$

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 8:38 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Cara Mungo

Date: October 5, 2022
Time: 3:38 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 104.0.81.201
Powered by: Elementor

Revell, Mandy@Coastal

From: Mason(0426-TFG), Scott <smason@advbenesys.com>
Sent: Wednesday, October 5, 2022 7:15 AM
To: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application – Item 17a - No. 5-21-0640

Dear Ms. Revell,

I support the aforementioned dredging project that has received approval from the Santa Ana Regional Quality Water Board, which was one of the conditions for Coastal Commission to consider approval. The dredging project is critical to the water health of Newport Bay and benefits residents and visitors alike. I respectfully ask that you and the Commission approve the project at your next meeting, and thank you in advance for your consideration.

Respectfully,

Scott Mason
Corona del Mar resident
2019 Commodore, Newport Harbor Yacht Club

Scott Mason, CLU®, ChFC®
Financial Advisor of Securian Financial Services, Inc, Securities Dealer,
Member FINRA/SIPC & A Registered Investment Advisor
4695 MacArthur CT., #360
Newport Beach, CA 92660
949-325-0224
800-453-3437
Fax: 949-325-0225
smason@advbenesys.com

Revell, Mandy@Coastal

From: Denis LaBonge <denislabonge@gmail.com>
Sent: Wednesday, October 5, 2022 7:13 AM
To: Revell, Mandy@Coastal
Subject: NEWPORT HARBOR DREDGING

Mandy
Pls approve the effort for dredging Newport Harbor .
I am a 50 yr resident of Orange County, now living in Newport for the last 22 years .
Let's move forward - now.
Denis LaBonge
92657

Revell, Mandy@Coastal

From: sandra Weiner <sandyweiner@yahoo.com>
Sent: Wednesday, October 5, 2022 6:58 AM
To: Revell, Mandy@Coastal
Subject: Dumping contaminated sludge into the center of Newport Harbor

$

Werhve$[imriv$

Sttswih$

Ettpgexmsr$' 916514:84$

Ekirhe$J5;e$

Sgxsfiv$580$6466$

Hyq tmrk$gsrxeq mrexih$wpyhki$mrxs$xli$girxiv$sj$Ri{ tsvx$Levfsv$ { syph$gviexi$e$tsxirxmep$irzmvsrq irxep$le~evh$jsv$viwmhirxw$erh$ zmwmxsvw2

-Sandy-
Sandra Weiner
949 289-6871

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Wednesday, October 5, 2022 12:25 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Brooke R. Coldren

Date: October 5, 2022
Time: 7:25 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 108.184.67.30
Powered by: Elementor

Revell, Mandy@Coastal

From: Russ <rhbutcher@roadrunner.com>
Sent: Tuesday, October 4, 2022 9:55 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640

Russell Butcher

Opposed

Application #5-21-0640

Agenda F17a

October 14,2022Mandy Revell

Mandy Revell

California Coastal Commission

South Coast Area Office

301 East Ocean Blvd. Suite 300

Long Beach , CA 90802-4302

Dear Mandy,

I have just recently become aware of the intentions of the Newport Beach City Council to proceed with dredging our harbor and disposing of the most toxic material in the main turning basin, stored in what is referred to as a CAD.

As far as I can tell, this is a hole dug in the floor of the harbor with the material being dumped into it and then topped with one or two feet of "good material".

Although I understand the need for dredging the harbor, I can't, for the life of me, understand how anyone would think this idea for the storage of toxic material is a good idea. As the material is being dumped into the hole it will, of course, dissipate into the water and spread throughout the bay. After the project is completed and this area is again used by boaters, the dragging of anchors across the bottom will shirly re-release the toxins. This area is used daily by hundreds of boats and the chances of the toxins remaining contained are slim and none.

I am also concerned that the project has been in the planning for years and I and everyone I know are just recently finding out about it with little chance to respond. Is there a reason for this?

Please consider other options for the storage of these toxic materials. The health of our bay and the people who use it are at risk.

Sincerely,

Russ Butcher

Vice Commodore

Lido Isle Yacht Club

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Tuesday, October 4, 2022 8:25 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Russ Butcher

Date: October 5, 2022
Time: 3:25 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Safari/605.1.15
Remote IP: 108.184.77.179
Powered by: Elementor

Revell, Mandy@Coastal

From: William Johnson <johnsonlido@sbcglobal.net>
Sent: Tuesday, October 4, 2022 8:46 PM
To: Revell, Mandy@Coastal
Subject: Opposition to Application #5-21-0640 Agenda 17a
Attachments: Application #5-21-0640 - Opposed.pdf

Ms. Revell,

Please find attached my letter of opposition to the Newport Harbor dredging/CAD plan, under consideration by the Coastal Commission.

Best,

William S. Johnson
johnsonlido@sbcglobal.net
949-981-4595 (mobile)

William S. Johnson

Opposed

Application #5-21-0640

Agenda 17a

October 4, 2022

California Coastal Commission

South Coast Area Office

Long Beach, CA 90802

Dear Ms. Revell:

I am a Lido Isle resident and am strongly opposed to the proposed Newport Harbor dredging and sediment disposal project as currently proposed.

This plan has major long-term risks for the harbor, and I implore the Coastal Commission to conduct more studies and consider alternative engineering solutions before making its final approval.

Sincerely,

William S. Johnson

744 Via Lido Soud

Newport Beach, CA 92663

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Tuesday, October 4, 2022 8:24 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Derek DuBois

Date: October 5, 2022
Time: 3:24 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 108.85.197.47
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Tuesday, October 4, 2022 8:24 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Russ Butcher

Date: October 5, 2022
Time: 3:23 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Safari/605.1.15
Remote IP: 108.184.77.179
Powered by: Elementor

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 6:59 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD and dredging project in Newport Beach. Item 17a. Application No. 5-21-6640

-----Original Message-----
From: Teresa Duffield <terryduff@me.com>
Sent: Tuesday, October 4, 2022 4:39 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD and dredging project in Newport Beach. Item 17a. Application No. 5-21-6640

I support the CAD and dredging project in Newport Beach. I am an avid sailor and power boater and fully support this project.

Thank you

Terry Duffield

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 6:56 PM
To: Revell, Mandy@Coastal
Subject: FW: Item 17a - Application No. 5-21-0614

From: Peter Kissam <peterkissam@gmail.com>
Sent: Tuesday, October 4, 2022 5:42 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Item 17a - Application No. 5-21-0614

> Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614
>
> I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.
>
> Peter Kissam
> Local Marine Electrician
> peterkissam@gmail.com

October 4, 2022

Revell, Mandy@Coastal

From: Carla Anderson <tocanderson@yahoo.com>
Sent: Tuesday, October 4, 2022 5:32 PM
To: Revell, Mandy@Coastal
Subject: Proposed CAD in Newport Harbor

- **Carla Anderson writing to OPPOSE the application noted below which would provide for the construction of a dump site in Newport Harbor.**

Opposed

Application #5-21-0640

Agenda 17a

I am a homeowner on Lido Isle in Newport Harbor and strongly oppose the application to build the CAD in the bay's eastern turning AND RECREATION area. The project is ludicrous and without merit. Why would anyone propose to accumulate thousands of pounds (tons?) of toxic waste in a harbor used by residents instead of finding an alternative solution on land or somewhere in the Pacific Ocean where it would not be subject to leakage caused by anchors and use of the area by residents during the construction period and after the project is completed?

This idea is insane and should be stopped immediately! Please do not allow this project to move forward! A land-based solution that can be controlled makes much more sense.

VOTE AGAINST THIS --- PLEASE

Carla Anderson

Revell, Mandy@Coastal

From: Brent Anderson <banderson_pire@yahoo.com>
Sent: Tuesday, October 4, 2022 5:27 PM
To: Revell, Mandy@Coastal
Subject: Proposed CAD dumpsite in Newport Harbor, CA

Brent Anderson writing to OPPOSE the application noted below which would provide for the construction of a dump site in Newport Harbor.

Opposed
Application #5-21-0640
Agenda 17a

I am a homeowner on Lido Isle in Newport Harbor and strongly oppose the application to build the CAD in the bay's eastern turning AND RECREATION area. The project is ludicrous and without merit. Why would anyone propose to accumulate thousands of pounds (tons?) of toxic waste in a harbor used by residents instead of finding an alternative solution on land or somewhere in the Pacific Ocean where it would not be subject to leakage caused by anchors and use of the area by residents during the construction period and after the project is completed?

This idea is insane and should be stopped immediately! Please do not allow this project to move forward! A land-based solution that can be controlled makes much more sense.

VOTE IN OPPOSITION --- PLEASE

Brent Anderson

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:26 PM
To: Revell, Mandy@Coastal
Subject: FW: City of Newport Beach Dredging

From: Allen Cashion <allencashion@gmail.com>
Sent: Tuesday, October 4, 2022 4:23 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: City of Newport Beach Dredging

Dear California Coastal Commission and voting commissioners:

I am a 60-year resident of Newport Beach who has been active in various aspects of my hometowns growth, development and improvement throughout my life. I am fortunate to live near the harbor and spend most every day in/on/around it and have most my life.

As such, I have been following the lengthy process involving the long overdue dredging of our harbor and know we are nearing the end of a very lengthy process that has involved local and state governments. From what I have seen, it has been a cooperative and thorough process with input from the public, multiple studies and environmental reports from proper experts and the resulting conclusion of completing the work as certified is the best result for the health of the bay, harbor, my fellow city residents and all stakeholders. And, from what I understand, funding has been secured in the amount of $20mm.

Thus, I fully support the City of Newport Beach's application (5-21-0640) which I also understand is supported by you, The Coastal Commission.

I am also well aware that there are some opponents to the plan who currently have a loud voice in the public square of which, from those I have heard/read, are uninformed at best, spreading misinformation at worst.

I encourage you all to ignore those voices, vote to approve the application and allow our great city with its magnificent harbor to be properly and safely dredged and cleaned.

Thank you,
Allen Cashion
52 Beacon Bay, Newport Beach, CA 92660

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:24 PM
To: Revell, Mandy@Coastal
Subject: FW: Support CAD and Dredging project in Newport Beach - Application 5-21-0640
Attachments: Newport Beach CAD and Dredging 5-21-0640.pdf

From: David Clark <David.Clark@warmingtongroup.com>
Sent: Tuesday, October 4, 2022 3:35 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support CAD and Dredging project in Newport Beach - Application 5-21-0640

Please see attached.

Thank you.

David

David H. Clark | President
Warmington Properties

3090 Pullman St. | Costa Mesa, CA 92626
t: 714.434.4411 | f: 714.437.9300
WarmingtonPropertiesInc.com

David H. Clark

October 4, 2022

California Coastal Commission
southcoast@coastal.ca.gov

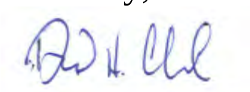
RE: I support the CAD and Dredging project in Newport Beach
Application no. 5-21-0640

Dear Commissioners:

I am writing to express my support for the CAD and Dredging project in Newport Beach, application 5-21-0640.

I have been a resident of Newport Beach for over sixty years, am a lifelong boater that frequently enjoys the harbor and I am eager to see the dredging project approved.

Sincerely,



David H. Clark

705 W. Bay Avenue, Newport Beach, CA 92661

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 6:55 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging in Newport Beach; Item 17a - Application No. 5-21-0614

From: Terry Sheward <terrys@shewards.net>
Sent: Tuesday, October 4, 2022 5:47 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with the Commission Staff recommending that the Commission Approve Coastal Development application 5-21-0640 as conditioned.

Thank you,

\Terry Sheward

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:24 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD and Dredging project in Newport Beach application no. 5-21-0640.

From: Chase Rief <chase.rief@gmail.com>
Sent: Tuesday, October 4, 2022 3:34 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD and Dredging project in Newport Beach application no. 5-21-0640.

I have lived in Newport Beach for 20 years and support the dredging project (application no. 5-21-0640). I am active on the bay in both sail and power boating and have taken the time to study and understand this project.

Please support this,

Chase Rief

Rief Media, Inc
t. (949) 287-4163

Want to chat? Here's a direct link to my calendar where you can pencil in a time that works for both of us:
https://go.oncehub.com/ChaseRief

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:23 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a-Application No. 5-21-0614

-----Original Message-----
From: Jamie Shepherdson <jamie@crcapitalgroup.com>
Sent: Tuesday, October 4, 2022 10:59 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a-Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

James Shepherdson
949-533-0800
2710 Bayshore Drive
Newport Beach, Ca 92663

Sent from my iPad

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:22 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: John Cotton <qtipnb@aol.com>
Sent: Tuesday, October 4, 2022 11:10 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

To Whom It May Concern:

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Best Regards,

John Cotton
714.336.5396

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:22 PM
To: Revell, Mandy@Coastal
Subject: FW: Application No. 5-21-0640 (City of Newport Beach)

From: Stephen Scully <stephenscully.mail@gmail.com>
Sent: Tuesday, October 4, 2022 11:13 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Application No. 5-21-0640 (City of Newport Beach)

Date of Comment: October 4, 2022
Date of Hearing: October 7, 2022
Agenda Items: Application No. 5-21-0640 (City of Newport Beach)
Position: **Approve**

To the Honorable members of the California Coastal Commission:

My name is Steve Scully, and I am a resident of Newport Beach California, a long-term user of Newport Harbor and I am the current Chairman of the Newport Beach Harbor Commission.

I am writing you today to support the City of Newport Beach's effort to construct a "Confined Aquatic Device" (CAD) in the center of our harbor. As a member of the Newport Beach Harbor Commission and boat owner, it is critical that we dredge Newport Harbor to its required depths. Over the years we have worked diligently to mitigate the amount of sediment and pollution that terminates within our Harbor from various cities along the San Diego Creek. We have locations within the harbor that are too shallow and must be addressed.

The Newport Beach Harbor Commission has worked closely with the Public Works department on this topic, and we have evaluated hundreds of pages of material. We debated the work that has been done to investigate all viable options to address just over 100,000 cubic yards of unsuitable dredged material. We have seen all options and without question the CAD is the only permittable and economical option. This sediment is currently located within our harbor, and we cannot transport it to another permittable location, nor can this be barged out into the ocean and deposited in an approved site. With that said we own this sediment and to address this in the correct manner we must build a CAD and store this soil properly.

It is important to recognize that the Newport Beach Harbor Commission spent a significant amount of time on this topic and had multiple public meetings. The direction to build the CAD was supported by the public and the Newport Beach Harbor Commission voted to approve the CAD unanimously 7 to 0.

Thank you for this opportunity to express my view and I respectfully request that the Commission approve this project so that the City of Newport Beach can move forward with this critical need.

Respectfully submitted,

--
Stephen Scully
stephenscully.mail@gmail.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:21 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Bill Messenger <bill@messengerco.com>
Sent: Tuesday, October 4, 2022 11:23 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0614 as conditioned.

Respectfully,

Bill

William S. Messenger, Jr.
MESSENGER INVESTMENT COMPANY
270 newport center dr., suite 100 | newport beach, ca 92660
C. 714.313.9867
bill@messengerco.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:20 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Don Nikols <dnikols@nikolsco.com>
Sent: Tuesday, October 4, 2022 11:30 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

To: SouthCoast@coastal.ca.gov

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

I both reside, have my boat and my company in the city of Newport Beach.

Don Nikols
Chairman of the Board/Founder

NIKOLS MORTGAGE FUND, LLC

The Nikols Company
Manager of Nikols Mortgage Fund, LLC
4041 MacArthur Blvd, Suite 140
Newport Beach CA 92660
O: 949.474.8488
C: 949.678.9140
www.nikolsco.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:18 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Joan Beer Damask <jbdamask@sbcglobal.net>
Sent: Tuesday, October 4, 2022 12:02 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

att: California Coastal Commission:

Nothing is more important to the long-term health of our harbor then keeping it dredged.

- The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3).

- The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).

I urge you to support this project.

Joan Damask
108C via Antibes
Newport Beach, CA 92663
C: 314-283-8541

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:15 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD and Dredging Project in Newport Beach - Item 17a - Application no. 5-21-0640
Attachments: California Coastal Commision Hearing.pdf

From: Rick Godber <rickgodber@gmail.com>
Sent: Tuesday, October 4, 2022 12:20 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Fwd: I support the CAD and Dredging Project in Newport Beach - Item 17a - Application no. 5-21-0640

I support the CAD and Dredging Project in Newport Beach - Item 17a - Application

To Whom It May Concern:

I am responding to the above project as it relates to the California Coastal Commission hearing,Newport Beach application for confined aquatic disposal facility, October 14, 222.

Please reference the attachment below.

I ask you the Commissioners of the California Coastal Commission to approve the Application for the Confined Aquatic Disposal Facility today and move the project forward.

Thank you,

Richard Godber
20 Beacon Bay
Newport Beach, Ca 92660

- Coastal Commission staff has reviewed this application and is recommending approval of the same.

- The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.

- The City of Newport Beach is near the end of the road. With the California Coastal Commissions approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.

- If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.

- This Application furthers the mission of the California Coastal Commission to protect and enhance California's coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor's floor.

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:10 PM
To: Revell, Mandy@Coastal
Subject: FW: Support for Dredging & CAD Project--City of Newport Beach Application no. 5-21-0640

From: val-lyon@sbcglobal.net <val-lyon@sbcglobal.net>
Sent: Tuesday, October 4, 2022 12:26 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: RE: Support for Dredging & CAD Project--City of Newport Beach Application no. 5-21-0640

Staff and members of the California Coastal Commission:

My wife and I would like to express our unqualified **support** for the dredging and confined aquatic disposal project for Newport Harbor contained in the City of Newport Beach Application no. 5-21-0640.

Sincerely,

Edward and Barbara Lyon
427 San Bernardino Avenue
Newport Beach, California 92663

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:09 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Harbor Dredging & CAD

From: Doug Wetton <doug@dwinvestments.com>
Sent: Tuesday, October 4, 2022 12:33 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Newport Harbor Dredging & CAD

Dear California Coastal Commision,

• By approving the City of Newport Beach Application No. 5-21-0640 the Coastal Commission has the opportunity to move forward the long awaited dredging of Newport Harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.
• Coastal Commission staff has reviewed this application and is recommending approval of the same.
• The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.
• The City of Newport Beach is near the end of the road. With the California Coastal Commissions approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.
• If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.
• This Application furthers the mission of the California Coastal Commission to protect and enhance California's coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor's floor.

• We ask you the Commissioners of the California Coastal Commission to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

All the best,

Doug Wetton

Doug Wetton Properties
PO Box 5647 | Balboa Island, CA 92662
o 949.759.0220 ex 102 | f 949.759.0240 | c 949.500.4760

DRE: 01009432

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:07 PM
To: Revell, Mandy@Coastal
Subject: FW: Dredging & Dumping In Newport Harbor

From: Debi Marshall <debiamarshall@gmail.com>
Sent: Tuesday, October 4, 2022 1:14 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Dredging & Dumping In Newport Harbor

Coastal Commission Members:
This is the first time We are hearing of the plan to dump Mercury and DDT into Newport Harbor.

The CA Coastal Commission needs more time to evaluate your proposal to dump material that is unsuitable for open ocean disposal into a giant hole in the middle of Newport Harbor.

Please ask the CA Coastal Commission for a 90 day extension to fully evaluate this plan.

Thank you,
Mr. & Mrs. Robert Marshall

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:06 PM
To: Revell, Mandy@Coastal
Subject: FW: Application 5-21-0640 dredging project

From: DOUGLAS RASTELLO <drastello@me.com>
Sent: Tuesday, October 4, 2022 1:14 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Application 5-21-0640 dredging project

I support the CAD and Dredging project in Newport Beach application no. 5-21-0640. I own a house on the water and have been involved with Newport Beach for over 40 years and understand the benefits of the proposed project.

I overwhelmingly support the dredging project.

Best Regards

Douglas Rastello

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 4:06 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Harbor CAD and Dredging Project No. 5-21-0640

From: d b <NHYC@msn.com>
Sent: Tuesday, October 4, 2022 1:16 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Newport Harbor CAD and Dredging Project No. 5-21-0640

As a 55 year resident of Newport Beach, I use the harbor regularly, meaning several times a week, all year long, and have for decades

I have thoroughly read the EIR and Permit and feel very comfortable with the CAD program and dredging process;

therefore I support the CAD and Dredging project in Newport Beach application No. 5-21-0640.

Dwight Belden
148 Via Trieste
Newport Beach, CA 92663
949-500-1110
nhyc@msn.com

Revell, Mandy@Coastal

From: Roman, Liliana@Coastal
Sent: Tuesday, October 4, 2022 3:59 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Dredging Project

-----Original Message-----
From: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Sent: Tuesday, October 4, 2022 3:08 PM
To: Roman, Liliana@Coastal <Liliana.Roman@coastal.ca.gov>
Subject: FW: Newport Dredging Project

Could this be your project he is referring to?

-----Original Message-----
From: Randy Hause <randyhausejr@gmail.com>
Sent: Tuesday, October 4, 2022 8:57 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Newport Dredging Project

I am opposed to dredging Newport Harbor and relocating this contamination merely one or two miles away into the middle of the widely used turning basin.

Another political grab. Follow the money before time runs out!

Shame on this reckless approach.

Randy Hause
Newport Beach

Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:53 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: David LaMontagne <david.lamontagne@cox.net>
Sent: Tuesday, October 4, 2022 1:25 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am a stakeholder and life-long user of Newport Harbor. As both, please let this e-mail serve to inform you that I am in agreement with The Commission's staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Kind regards,

David LaMontagne
Founder – Vessel Assist Assn. of America, Inc.
Owner – Pacific Towing, LLC
Vessel Assist / TowBoatUS Newport Beach
949/433-9190

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:47 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD Dredging Project

From: Michele Miller <mfmiller122@gmail.com>
Sent: Tuesday, October 4, 2022 1:52 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD Dredging Project

As a forty five year resident of Newport Beach whose residence is steps from the bay I support the CAD Dredging Project! Please vote to protect our beautiful bay.
Item 17A, App no. 5-21-064
Best, Michele Miller, 122 Harbor Island Road, 92660

Thank you for your consideration.

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Tuesday, October 4, 2022 3:40 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Brittany Thomas

Date: October 4, 2022
Time: 10:40 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 107.127.56.59
Powered by: Elementor

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:34 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Harbor Dredging Project- Application #5-21-0640

From: Tim Collins <tim@tccollins.com>
Sent: Tuesday, October 4, 2022 2:20 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Newport Harbor Dredging Project- Application #5-21-0640

Coastal Commissioners, I am a 54 year resident of Newport Beach, a boater, and frequent user of our harbor.
I served as a Harbor Commissioner for 8 years and am well versed in the technical details of our dredging needs, history, and the current proposed CAD and dredging project.
Having reviewed the staff report and read the materials provided in the late challenge by a few bayfront owners, I remain convinced that the project, as proposed, will properly secure the contaminated sediments in the most feasible and least environmentally impactful manner.
The City of Newport Beach has been a good steward of the Harbor and the design of this project is consistent with the City's Sediment Management Plan and goals for protection of water quality and marine resources.
I support the project.
Thank you for your consideration and placing this resident communication on the hearing record.

Timothy C. Collins
T.C. Collins & Associates, Inc
201 Shipyard Way
Suite 1
Newport Beach, CA 92663
Fax: 949-863-9010
Cell: 714-343-4485

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:33 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Beach - Item 17a - Application No. 5-21-0640

-----Original Message-----
From: Carson Hill <carsonphill@gmail.com>
Sent: Tuesday, October 4, 2022 2:23 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Newport Beach - Item 17a - Application No. 5-21-0640

To whom it may concern:

I am in support of the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

I am writing to you as a citizen for 34 years and business owner in Newport Beach, CA. I am in FAVOR of the CAD(Confined Aquatic Disposal
Facility) for it is the only option to clean up our Harbor. I also think the overall dredging project and sediment relocation along our coast is very important for improving water quality in Newport Harbor.
It is vital for the future of Lower Newport Harbor so that sailboats and larger vessels can navigate safely as well improving tidal flow in and out of Newport Harbor making it a cleaner harbor for all Marine Life.

The sediment that is unsuitable for the open ocean is already sitting on the surface of our bay and is not toxic. That being said there is no reason why it couldn't be put into a CAD and be disposed of properly for good.

I would love to see this project move forward so that this beautiful body of water and our wonderful beaches are protected for years to come and future generations are able to enjoy it as much as I have. I truly believe that our public oceanfront beaches need this drastically due to the amount of beach erosion that has gone on at "W" Street(The Wedge) in Newport. So many residents of Orange County and visitors get to enjoy Newport Harbor cruising on a boat or building sandcastles on the beach so this project is for more than just the citizens of Newport Beach. Please consider the future of Newport Harbor; with a cleaner bay and marine habitat as well as helping with beach erosion along our coast. Thank you for your service and dedication to protecting our coastline.

Thank You,

Carson P. Hill
C: 949-244-9879
W: 949-675-0740

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:28 PM
To: Revell, Mandy@Coastal
Subject: FW: Support for Newport Harbor Dredging and CAD project

-----Original Message-----
From: Karen Prioleau <karen@prioleau.com>
Sent: Tuesday, October 4, 2022 2:38 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support for Newport Harbor Dredging and CAD project

To Whom it may concern,

I have reviewed the plan and find it an acceptable means of dealing with dredging materials.

Sincerely,
Karen Prioleau

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:22 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD and Dredging project in Newport Beach

-----Original Message-----
From: Steve Morton <stevelmorton@earthlink.net>
Sent: Tuesday, October 4, 2022 3:20 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD and Dredging project in Newport Beach

I am in agreement with the Coastal Commission staff recommending that the Commission approve Coastal Development Permit application No. 5-21-0614

Thank you,
Steve Morton
Newport Beach, Ca

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:22 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD and Dredging Project in Newport Beach

From: phillyons@pinecreek.net <phillyons@pinecreek.net>
Sent: Tuesday, October 4, 2022 3:13 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD and Dredging Project in Newport Beach

Ladies and Gentlemen,

We fully support the CAD & Dredging Project in Newport Beach, CA; Item 17a - Application No. 5-21-0614.

We are in complete agreement with the Commission staff recommendation that the Commission approve Coastal Development permit application 5 -21-0640 as conditioned.

Sincerely,

Phillip N. Lyons and Mary A. Lyons
36 Harbor Island
Newport Beach, CA 92660

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:21 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a-Application No.5-21-0614

From: Carrie Nikols <cnikols@nikolsco.com>
Sent: Tuesday, October 4, 2022 3:12 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a-Application No.5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Thank you,

Carrie Nikols
Chief Executive Officer

NIKOLS MORTGAGE FUND, LLC

The Nikols Company
Manager of Nikols Mortgage Fund, LLC
4041 MacArthur Blvd, Suite 140, Newport Beach CA 92660
O: 949.474.8666
C: 949.922.9852
www.nikolsco.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:21 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD and Newport Dredging Item 17A, Application 5-21-0641

Information wrong, but I think it's your.

-----Original Message-----
From: Tim Quinn <tquinn5000@sbcglobal.net>
Sent: Tuesday, October 4, 2022 3:11 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD and Newport Dredging Item 17A, Application 5-21-0641

I am writing to urge the Commission to approve the CAD/Newport Dredging Application 5-21-0641.

Thank You,

Tim Quinn
Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:18 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach. Item 17 a-Application No. 5-21-0640

From: Tom Corkett <Tom.Corkett@NorthropandJohnson.com>
Sent: Tuesday, October 4, 2022 10:53 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach. Item 17 a-Application No. 5-21-0640

I am in agreement with the Commission staff recommending that the Commission Approve Coastal Development Permit Application 5-21-0640 as conditioned.
Regards,
Thomas Corkett
1032 W. Oceanfront
Newport Beach, Ca. 92661
Resident of Newport Beach for over 65 years.

Tom Corkett
Yacht Broker
-
Mobile +1 714 322 1667
Office +1 949 642 5735

2801 West Coast Hwy, Suite 260
Newport Beach, CA 92663 United States
northropandjohnson.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:18 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD & Dredging Project in Newport Beach

From: Morgan Hill <morgan@stospartners.com>
Sent: Tuesday, October 4, 2022 10:55 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD & Dredging Project in Newport Beach

Dear Commissioners,

My name is Morgan Paul Hill, I have lived in the Newport Beach and Costa Mesa area for over thirty-eight years. I have been boating and swimming in the Newport Harbor for my entire life. I now enjoy it with my family of four and really appreciate the beauty and all that Newport Harbor has to offer. With that said, I feel the CAD & Dredging project is essential for the functionality of the harbor moving forward.

I very much support the CAD & Dredging Project in Newport Beach
Application No. 5-21-0640

Sincerely,

Morgan Hill
V.P. Acquisitions
Direct: (949) 275-4146
Email: morgan@stospartners.com
www.stospartners.com

STOS PARTNERS

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:17 PM
To: Revell, Mandy@Coastal
Subject: FW: Item 17. a. Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

From: Brett Swartzbaugh/USA <Brett.Swartzbaugh@cushwake.com>
Sent: Tuesday, October 4, 2022 10:48 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Item 17. a. Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

I hereby request that the Coastal Commission **approve** the subject Application.   Thank you

Best regards,

Brett Swartzbaugh
Director
Brokerage
CA License #01742530

Mobile (949) 648-0350
brett.swartzbaugh@cushwake.com

18111 Von Karman Avenue
Suite 1000
Irvine, CA 92612 | USA

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:17 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Beach CAD & Dredging

From: ppallette@aol.com <ppallette@aol.com>
Sent: Tuesday, October 4, 2022 10:41 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Newport Beach CAD & Dredging

Ladies & Gentlemen:

I support the CAD and Dredging Project in Newport Beach, Item 17a - Application #5-21-0614.
I am in agreement with The Commission staff recommendation that the Commission approve Coastal Development Permit Application 5-21-0640 as conditioned.

Cordially, Peter C. Pallette, 1210 East Balboa, Blvd. Balboa, CA 92661

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:16 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: William Bissell <wbissell@wgb-law.com>
Sent: Tuesday, October 4, 2022 10:23 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

William G. Bissell
23 Corporate Plaza Drive, Suite 150
Newport Beach, CA 92660
(949) 287-4503
wbissell@wgb-law.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:16 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

-----Original Message-----
From: Larry Somers <losomers@gmail.com>
Sent: Tuesday, October 4, 2022 10:21 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Lawrence Somers

--
Larry Somers
314 L Street
Newport Beach, CA 92661

Home: (949) 675-7097
Cell: (949) 422-0570

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:13 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Jeff Stone <jstonenb@aol.com>
Sent: Tuesday, October 4, 2022 9:27 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Jeff Stone

Revell, Mandy@Coastal

From: Seifert, Chloe@Coastal
Sent: Tuesday, October 4, 2022 3:10 PM
To: Revell, Mandy@Coastal
Cc: SouthCoast@Coastal; Sy, Fernie@Coastal
Subject: RE: Cad in newport

This is Mandy's. (Sorry Mandy ☹)

Chloe Seifert | Coastal Program Analyst
CALIFORNIA COASTAL COMMISSION
South Coast District Office
301 E. Ocean Blvd, Suite 300
Long Beach, CA 90802
(562) 590-5071

Please note that public counter hours for all Commission offices are currently suspended indefinitely in light of the coronavirus. However, in order to provide the public with continuity of service while protecting both you and our employees, the Commission remains open for business, and you can contact staff by phone, email, and regular mail. Phone messages left in the Long Beach office will be returned sporadically. If your matter is urgent, please send an email. In addition, more information on the Commission's response to the COVID-19 virus can be found on our website at www.coastal.ca.gov.

-----Original Message-----
From: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Sent: Tuesday, October 4, 2022 3:02 PM
To: Seifert, Chloe@Coastal <chloe.seifert@coastal.ca.gov>; Sy, Fernie@Coastal <Fernie.Sy@coastal.ca.gov>
Subject: FW: Cad in newport

Not sure what this is for, but it's Newport Beach

-----Original Message-----
From: bill menninger <bmenninger1@gmail.com>
Sent: Tuesday, October 4, 2022 8:10 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Cad in newport

Whats a mess. Rather than place spoils our 20 miles to sea we are going to treat all the residents and users of our bay to contamination.
Dredge and dry and ship off to a place that needs land fill.
Newport resden for 45 years.
Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:09 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

From: Robert Kinney <robert@alcommarine.com>
Sent: Tuesday, October 4, 2022 9:12 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

Robert Kinney
Balboa CA.

Robert Kinney
Alcom Marine Electronics
711 West 17th Street
Unit C12
Costa Mesa, California 92627
949 515 1727 office
949 279 5048 mobile

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 3:00 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Mark Callin <mark.callin@gmail.com>
Sent: Tuesday, October 4, 2022 8:02 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640

Mark Callin
Water front resident
1112 W Bay Ave
Newport Beach

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 1:52 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Paul Prioleau <pprioleau@gmail.com>
Sent: Tuesday, October 4, 2022 6:43 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

Dear Coastal Commission Members,
I am writing to express my agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

I am an active user of Newport Harbor, and strongly support this dredging operation.

Thank you,
Paul Prioleau

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 1:52 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project - City of Newport Beach Application NO. 5-21-0640

From: Peter Kinney <peterakinney@gmail.com>
Sent: Tuesday, October 4, 2022 12:08 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project - City of Newport Beach Application NO. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

Thank you,
Peter Kinney
Newport Beach, CA

Peter Kinney
(949)735-9582 - Cell
peterakinney@gmail.com
peter@alcommarine.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 1:51 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: lou Grasso <lou.grasso@gmail.com>
Sent: Monday, October 3, 2022 10:43 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

> I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

lou

Revell, Mandy@Coastal

From:	Kim Lewand-Martin <kim@jfnovaklaw.com>
Sent:	Tuesday, October 4, 2022 12:50 PM
To:	Revell, Mandy@Coastal
Cc:	Jennifer Novak
Subject:	Fwd: Concerns related to Lower Newport Bay Confined Aquatic Disposal Project, City of Newport Beach File #302021-09
Attachments:	2022.10.04_FNH Let NB City Attorney.pdf; ADA348723 (1).pdf; D2287B7E-DC25-4104-96AD-E2D4956F733F.pdf

Mandy,

We also wanted to forward you correspondence we sent to the City of Newport Beach this morning for your review and the include in the Administrative Record on this matter.

Please let us know if you have any questions.

Best,

Kim

Kim Lewand Martin
Of Counsel
Law Office of Jennifer F. Novak
500 Silver Spur Road, Suite 206
Rancho Palos Verdes, California 90275
(310) 693-0775 office
(310) 291-4476 mobile
(310) 627 0172 fax
www.jfnovaklaw.com

The Law Office of
Jennifer F. Novak
Environmental Law

Begin forwarded message:

From: Yolande Venter <yolande@jfnovaklaw.com>
Subject: Concerns related to Lower Newport Bay Confined Aquatic Disposal Project, City of Newport Beach File #302021-09
Date: October 4, 2022 at 10:34:09 AM PDT
To: "aharp@newportbeachca.gov" <aharp@newportbeachca.gov>
Cc: "kevinmmuldoon@yahoo.com" <kevinmmuldoon@yahoo.com>, "dianebdixon@gmail.com" <dianebdixon@gmail.com>, "oneill4newport@gmail.com" <oneill4newport@gmail.com>, "joy@newportbeachca.gov" <joy@newportbeachca.gov>, Kim Lewand-Martin <kim@jfnovaklaw.com>, Jennifer Novak <novak@jfnovaklaw.com>

Good morning, Mr. Harp

Please see attached correspondence from Friends of Newport Harbor regarding the Lower Newport confined aquatic disposal project.

Regards,
Yolandé Venter
Virtual Assistant
Law Office of Jennifer F. Novak
500 Silver Spur Road, Suite 206
Rancho Palos Verdes, California 90275
(310) 693-0775 office
(310) 627 0172 fax
www.jfnovaklaw.com

The Law Office of
Jennifer F. Novak
Environmental Law

The Law Office of
Jennifer F. Novak
Environmental Law

500 Silver Spur Road, Suite 206
Rancho Palos Verdes, California 90275
T: (310) 693-0775
novak@jfnovaklaw.com

October 4, 2022

Aaron C. Harp
City Attorney
City of Newport Beach
100 Civic Center Drive
Newport Beach, CA, 92660
Phone: (949) 644-3131

Sent by electronic mail: aharp@newportbeachca.gov

Copies via email to:
Kevin Muldoon kevinmmuldoon@yahoo.com
Diane Dixon dianebdixon@gmail.com
Will O'Neill oneill4newport@gmail.com
Joy joy@newportbeachca.gov

RE: Concerns related to Lower Newport Bay Confined Aquatic Disposal Project, City of Newport Beach File #302021-09

Dear Mr. Harp:

We represent Friends of Newport Harbor, LLC (Friends), an organization comprised of a significant number of local citizens and directly affected residents who are gravely concerned about the City of Newport Beach's proposed Confined Aquatic Disposal (CAD) Project and its potential for long and short-term effects on Lower Newport Bay's (Bay) water quality, animal and plant species, and designated beneficial uses.

Primarily for the reason explained below, **we ask the City to seek a 90-day extension for the Coastal Commission to consider the City's application for its Coastal Development Permit.** It is our understanding the Coastal Commission is empowered to grant a 90-day extension of its review of the requested Permit if the City makes the request.

The reason for the extension is simply this: despite the City's continued claims that it has conducted a full environmental review and performed all required sampling and analysis for its project, **that is not true.** As we prepare for the upcoming California Coastal Commission (Coastal Commission) hearing on the City's Coastal Development Permit application, we have determined the City failed to perform an entire suite of sampling that must be performed before a CAD may be considered and constructed to accept contaminated material. We have searched through all of the City's offered evidence and documentation for this project. We see no evidence to fill this void in the process.

According to Friends' research, there are 3 ways to dispose of dredged material, and each of the 3 ways have their own unique corresponding guidance documents that must be followed: 1) nearshore disposal (with its related *USACE Upland Testing Manual*; 2) open ocean disposal (with its related *USACE Evaluation for Open Ocean Disposal of Dredge Material)*; and 3) disposal into a CAD (with its related *USACE Subaqueous Capping Technical Guidance)*. Because the City proposes to place the material into a CAD, neither the *USACE Upland Testing Manual*, nor the *USACE Evaluation for Open Ocean Disposal of Dredge Material* were the appropriate guidance documents to govern the evaluation of unsuitable materials to be placed into the CAD. Rather, the required document to follow was the *USACE Subaqueous Capping Technical Guidance*. We have attached a flow chart prepared by Friends' scientific expert to better illustrate the above. For your convenience, we are also attaching the relevant *USACE Subaqueous Capping Technical Guidance.*

The ACOE, which constructs CADs, is bound by this manual, which required testing of the unsuitable material from dredging before permitting a CAD. By the relevant government agency admissions, **the *USACE Subaqueous Capping Technical Guidance* manual was not followed by any government agency, including the City, and thus the required testing pursuant to the manual was never done.** When the City conducted its sampling, it did so as a composite: it blended unsuitable material with suitable material. <u>It was also supposed to test the unsuitable material alone to determine its chemistry</u>. Under the required process to select, design, and construct CADs, chemical testing is a critical component, as it helps to determine whether material is suitable for a CAD, and the types of engineering construction necessary to contain that material. The sampling data inform the project.

The project cannot be selected and designed, then justified ad hoc, after-the-fact. Thus, neither the City nor the Coastal Commission may look to the Water Board Clean Water Act Section 401 Water Quality Certification and Order for the Lower Newport Bay Confined Aquatic Disposal Construction Project (SARWQCB WDID #302021-09) (401 Order) to remedy this fatal flaw. **This is not simply a procedural defect; as Friends has consistently maintained, this required testing of unsuitable material is critically needed to protect human health and the health of the marine environment of Newport Bay.** In sum, the environmental review needed for the City's proposed CAD is incomplete. Friends believe this omission and lack of information creates a fatal impact and prevents the relevant agencies from being able to rely upon the environmental review that has previously been done.

We believe that a 90-day extension benefits the City so it has time to assess this omission and take any necessary actions to remedy it, thereby showing the relevant government agency stakeholders the City is committed to rigorous and robust testing in order to preserve beneficial uses in the Newport Bay.

As the Friends has oft repeated, its concerns stem from the fact that the **CAD is being proposed in an area extremely and unusually close to residents and protected marine habitat.** The Friends has previously shared its concerns that it is not appropriate to leave so much to chance through a future iterative approach, whereby the City is entrusted to propose plans, and then simply react after-the-fact to water quality exceedances, diminution in beneficial uses, or irreparable harm. We now know that concern is supported by the requirement to test for unsuitable material pursuant to the *USACE Subaqueous Capping Technical Guidance* manual. We ask the City to request a 90-day extension from the Coastal Commission to allow the City to assess this requirement needed to protect the people and aquatic life within the Newport Bay.

Regards,

Jennifer F. Novak
Law Office of Jennifer F. Novak
Counsel for Friends of Newport Beach

Technical Report DOER-1
June 1998

US Army Corps
of Engineers
Waterways Experiment
Station

Dredging Operations and Environmental Research Program

Guidance for Subaqueous Dredged Material Capping

by *Michael R. Palermo, James E. Clausner, Marian P. Rollings*
Gregory L. Williams, Tommy E. Myers, WES
Thomas J. Fredette, New England District
Robert E. Randall, Texas A&M University

Approved For Public Release; Distribution Is Unlimited

Prepared for Headquarters, U.S. Army Corps of Engineers

Dredging Operations and Environmental Research Program

Technical Report DOER-1
June 1998

Guidance for Subaqueous Dredged Material Capping

by Michael R. Palermo, James E. Clausner, Marian P. Rollings
Gregory L. Williams, Tommy E. Myers

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Thomas J. Fredette

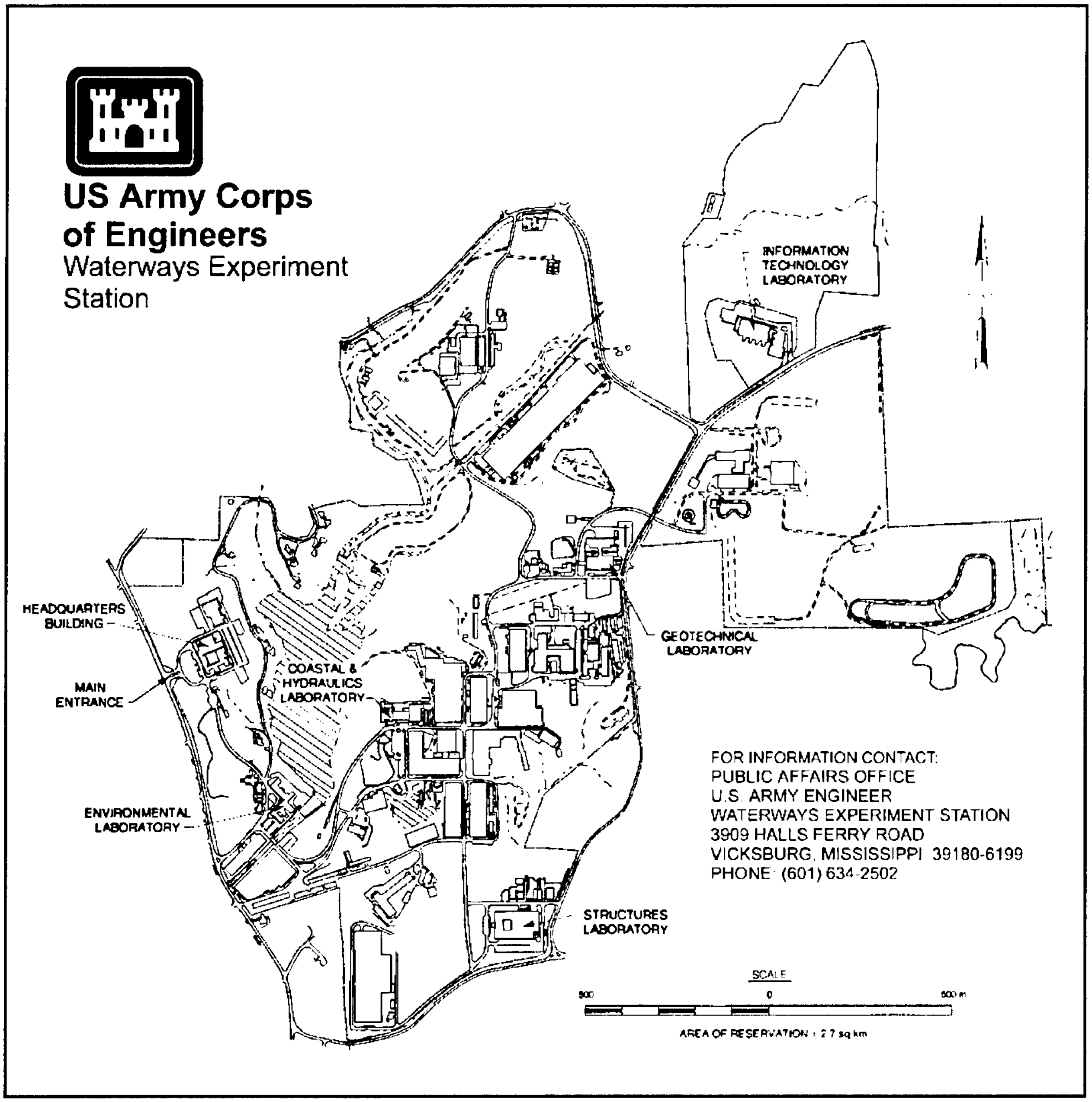
U.S. Army Engineer District, New England
696 Virginia Road
Concord, MA 01742-2751

Robert E. Randall

Texas A&M University
College Station, TX 77843

Final report

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000



Waterways Experiment Station Cataloging-in-Publication Data

Guidance for subaqueous dredged material capping / by Michael R. Palermo ... [et al.] ; prepared for U.S. Army Corps of Engineers.
302 p. : ill. ; 28 cm. -- (Technical report ; DOER-1)
Includes bibliographic references.
1. Sediment capping -- Guidebooks. 2. Hazardous waste site remediation -- Guidebooks. 3. In situ remediation -- Guidebooks. 4. Contaminated sediments -- Guidebooks. I. Palermo, Michael R. II. United States. Army. Corps of Engineers. III. U.S. Army Engineer Waterways Experiment Station. IV. Dredging Operations and Environmental Research Program (U.S.) V. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; DOER-1.
TA7 W34 no.DOER-1

U.S. Army Corps of Engineers Research Report Summary, June 1998
Dredging Operations and Environmental Research Program

Dredging: Contaminated Sediments

Guidance for Subaqueous Dredged Material Capping (TR DOER-1)

ISSUE: Potential for water column and benthic effects related to sediment contamination must be evaluated when considering open-water placement. Management options aimed at reducing the release of contaminants to the water column during placement and/or subsequent isolation of the material from benthic organisms may control potential contaminant effects. Subaqueous capping is the controlled, accurate placement of contaminated dredged material at an appropriately selected open-water placement site, followed by a covering (cap) of suitable isolating material. Although conventional placement equipment and techniques may be used for a capping project, these practices must be more precisely controlled in this application.

RESEARCH: The objective was to develop a comprehensive approach for evaluation of subaqueous capping projects, including these goals:

- Refine and adapt numerical models, laboratory testing procedures, and engineering design approaches for capping evaluations.
- Develop design requirements and a design sequence for capping.
- Document equipment and placement techniques for contaminated material and capping material placement.
- Define capping project site selection considerations.
- Develop guidelines for cap monitoring.

SUMMARY: The research resulted in technical guidance for evaluation of subaqueous dredged material capping. Guidance includes level-bottom capping, contained aquatic disposal, design requirements, a design sequence, site selection, equipment and placement techniques, geotechnical considerations, mixing and dispersion during placement, required capping sediment thickness, material spread and mounding during placement, cap stability, and monitoring plans. This guidance is applicable to dredged material capping projects in ocean waters as well as inland and near-coastal waters.

AVAILABILITY OF REPORT: The report is available in .pdf format on the World Wide Web at *http://www.wes.army.mil/el/dots* and through Interlibrary Loan Service from the U.S. Army Engineer Waterways Experiment Station (WES) Library, telephone (601) 634-2355. To purchase a copy of the report, call NTIS at (703) 487-4780.

About the Authors: Dr. Michael R. Palermo, Messrs. Tommy E. Myers, James E. Clausner, Gregory L. Williams, and Dr. Marian E. Rollings perform research at WES; contract support was provided by Dr. Robert E. Randall, Civil Engineering Department, Texas A&M University; and Dr. Thomas J. Fredette, the U.S. Army Engineer District, New England. **Point of Contact**: Dr. Palermo, Principal Investigator, telephone (601) 634-3753 or e-mail *palermm@ex1.wes.army.mil.*

Contents

List of Figures

List of Tables

Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), and initiated as part of the "Management of Dredging Projects" Technical Area 5 of the Dredging Research Program (DRP). The work was performed under Work Unit 32489 for which Mr. James E. Clausner was Technical Manager. Mr. John G. Housley was the DRP Technical Monitor for the work. Mr. Robert H. Campbell, HQUSACE, was the Chief DRP Technical Monitor.

The work was completed as part of the Dredging Operations and Environmental Research (DOER) program "Contaminated Sediment Characterization and Management" Focus Area, managed by Dr. Michael R. Palermo. DOER Program Monitors are Messrs. Barry Holliday, Joseph Wilson, John Bianco, and Charles Chestnutt, HQUSACE.

The work was performed by Dr. Palermo, Principal Investigator and Mr. Tommy E. Myers, U.S. Army Engineer Waterways Experiment Station (WES) Environmental Laboratory (EL); Dr. Marian P. Rollings, WES Geotechnical Laboratory (GL); Messrs. Clausner and Gregory L. Williams, WES Coastal and Hydraulics Laboratory (CHL); Dr. Thomas J. Fredette, U.S. Army Engineer District, New England; and Dr. Robert E. Randall, Texas A&M University. The contributions of Drs. Paul R. Schroeder, Doug Clarke, and Joe Gailani, WES, and Danny D. Reible, Louisiana State Universsity, who authored Appendix B, are gratefully acknowledged.

The study was conducted by or under the following WES supervision:

EL—Dr. Palermo, Special Projects Group, Environmental Engineering Division (EED); and Mr. Myers, Environmental Restoration Branch (ERB), EED. Additional supervision was provided by Mr. Daniel E. Averett, Chief, ERB; Mr. Norman R. Francingues, Jr., Chief, EED; Dr. Raymond L. Montgomery (retired), former Chief, EED; Dr. John W. Keeley, Assistant Director, EL; and Dr. John Harrison, Director, EL.

CHL—Messrs. Clausner and Williams, Coastal Evaluation and Design Branch (CEDB), Coastal Sediments and Engineering Division (CSED). Additional supervision was provided by Ms. Joan Pope, Chief, CEDB; Mr. Thomas W. Richardson, Chief, CSED; Messrs. Charles C. Calhoun, Jr., and Richard A. Sager, Assistant Directors, CHL; and Dr. James R. Houston, Director, CHL.

GL—Dr. Rollings, Materials Analysis Branch (MAB), Airfields and Pavements Division (APD). Additional supervision was provided by Mr. Timothy W. Vollor, Chief, MAB; Dr. David Pittman, Chief, APD; and Dr. William F. Marcuson III, Director, GL.

Mr. E. Clark McNair, Jr., CHL, was the DRP Program Manager, and is the DOER Operational Program Manager. Dr. Robert M. Engler, EL, is the DOER Executive Program Manager.

Technical review of this report was provided by a joint U.S. Army Corps of Engineers (USACE)/U.S. Environmental Protection Agency (EPA) workgroup comprised of individuals from Headquarters, field offices, and research laboratories of both agencies with scientific and/or programmatic experience related to dredged material disposal management.

Members of the workgroup are as follows:

Joe Wilson	USACE Headquarters	John Lishman	EPA Headquarters
Dave Mathis	USACE Headquarters	Bev Baker	EPA Headquarters
Jan Miller	USACE North Central District	Dave Redford	EPA Headquarters
Tom Fredette	USACE New England District	Tom Chase	EPA Headquarters
John Tavolaro	USACE New York District	Kimberlee Keckler	EPA Region I
Alex Sumeri	USACE Seattle District	Dan Forger	EPA Region II
Douglas Pirie	USACE South Pacific Division	Andrey Massa	EPA Region II
Mike Palermo	USACE WES	Bill Muir	EPA Region III
Jim Clausner	USACE WES	Robert Howard	EPA Region IV
Tom Myers	USACE WES	Phil Murphy	EPA Region IV
Clark McNair	USACE WES	Steve Johnson	EPA Region V
Robert Engler	USACE WES	Suzie McKinney	EPA Region VI
		Norm Sears	EPA Region VI
		Brian Ross	EPA Region IX
		Justine Barton	EPA Region X

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

This report should be cited as follows:

Palermo, M. R., Clausner, J. E., Rollings, M. P., Williams, G. L., Myers, T. E., Fredette, T. J., and Randall, R. E. (1998). "Guidance for subaqueous dredged material capping," Technical Report DOER-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Conversion Factors, Non-SI to SI Units of Measurement

Non-Si units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
acres	4,046.873	square meters
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
inches	25.4	millimeters
miles (U.S. statute)	1.609347	kilometers

1 Introduction

Background

The U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA) have statutory responsibilities with regard to the management of dredged material placement in both ocean and inland and nearshore waters. When dredged materials proposed for open-water placement are found to require isolation from the benthic environment, capping may be appropriate for consideration as a management action. The report herein is intended to provide technical guidance for evaluation of capping projects.

This is one of a series of guidance reports pertaining to dredged material management. This series includes a document entitled "Evaluating Environmental Effects of Dredged Material Management Alternatives - A Technical Framework" (Framework Document - USACE/EPA 1992). The Framework Document articulates those factors to be considered in identifying the environmental effects of dredged material management alternatives on a continuum of discharge sites from uplands to the oceans (management alternatives include open-water, confined, and beneficial-use situations) that meet the substantive and procedural requirements of the National Environmental Policy Act (NEPA), The Federal Water Pollution Control Act of 1972, Public Law 92-500, as amended by the Clean Water Act of 1977 (CWA), and the Marine Protection, Research, and Sanctuaries Act (MPRSA). Application of the technical guidance in this report will allow for consistency in decision making with respect to capping within the Technical Framework.

Potential for water column and benthic effects related to sediment contamination must be evaluated when considering open-water placement of dredged material. Management options aimed at reducing the release of contaminants to the water column during placement and/or subsequent isolation of the material from benthic organisms may be considered to control potential contaminant effects. Such options include operational modifications, use of subaqueous discharge points, diffusers, subaqueous lateral confinement of material, or capping of contaminated material with suitable material (Francingues et al. 1985; USACE/EPA 1992).

Subaqueous dredged material capping is the controlled, accurate placement of contaminated dredged material at an appropriately selected open-water placement site, followed by a covering or cap of suitable isolating material (a glossary of terms used in this report is found in Appendix A). Capping of contaminated dredged material in open-water sites began in the late 1970s, and a number of capping operations under a variety of placement conditions have been accomplished. Conventional placement equipment and techniques are frequently used for a capping project, but these practices must be controlled more precisely than for conventional placement.

Purpose and Scope

This report provides guidance for evaluation of subaqueous dredged material capping projects. Design requirements, a design sequence, site selection, equipment and placement techniques, geotechnical considerations, mixing and dispersion during placement, required capping sediment thickness, material spread and mounding during placement, cap stability, and monitoring are included. From a technical perspective, this guidance is applicable to dredged material capping projects in ocean waters as well as inland and near-coastal waters.

The technical guidance in this report is intended for use by USACE and EPA personnel, State regulatory personnel, as well as dredging permit applicants and others (e.g., scientists, engineers, managers, and other involved or concerned individuals).

Regulatory Setting

Capping involves placement of dredged material in either ocean waters or inland and near-coastal waters (waters of the United States). The primary Federal environmental statute governing transportation of dredged material to the ocean for purpose of placement is the MPRSA, also called the Ocean Dumping Act. The primary Federal environmental statute governing the discharge of dredged and/or fill material into waters of the United States (inland of the baseline to the territorial sea) is the Federal Water Pollution Control Act Amendments of 1972, also called the CWA. All proposed dredged material placement activities regulated by the MPRSA and CWA must also comply with the applicable requirements of the NEPA and its implementing regulations. In addition to MPRSA, CWA, and NEPA, there are a number of other Federal laws, Executive Orders, etc., that must be considered in the evaluation of dredging projects.

The London Convention (Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter, December 29, 1972 (26 UST 2403:TIAS 8165)), to which the United States is a signatory, is an international treaty that deals with marine-waste placement, with jurisdiction that includes all waters seaward of the baseline of the territorial sea. The ocean-dumping criteria developed under MPRSA are required to "apply the standards and criteria binding upon the United States under the

Convention, including its Annexes," to the extent this would not result in relaxation of MPRSA requirements.

In evaluating proposed ocean placement activities, the USACE is required to apply criteria developed by the EPA relating to the effects of the proposed placement activity. The MPRSA criteria are given in 40 CFR 220-227. In evaluating proposed placement activities in inland or coastal waters, the USACE is required to apply guidelines given by Section 404 of the CWA to ensure that such proposed discharge will not result in unacceptable adverse environmental impacts to waters of the United States. The guidelines are given in 40 CFR 230. A tiered approach to sediment testing and assessments is described in detail in the dredged material testing manuals for MPRSA and CWA (EPA/USACE 1991; EPA/USACE 1998).

This report addresses technical and scientific issues associated with capping and does not address the various regulatory requirements of the CWA and MPRSA. Whether or not a particular project involving capping satisfies the relevant regulatory criteria can only be determined by applying the relevant requirements of the regulation and consulting, as necessary, with legal counsel.

Overview and Description of the Capping Process

Capping defined

For purposes of this report, the term "contaminated" refers to material for which isolation from the benthic environment is appropriate because of potential contaminant effects, while the term "clean" refers to material found to be acceptable for open-water placement. Capping is the controlled accurate placement of contaminated material at an open-water placement site, followed by a covering or cap of clean isolating material. For most navigation dredging projects, capping alternatives involving armor stone layers or other nonsediment materials for capping would not normally be considered.

Level-bottom capping (LBC) is defined as the placement of a contaminated material in a mounded configuration and the subsequent covering of the mound with clean sediment. Contained aquatic disposal (CAD) is similar to LBC but with the additional provision of some form of lateral confinement (e.g., placement in natural-bottom depressions, constructed subaqueous pits, or behind subaqueous berms) to minimize spread of the materials on the bottom. An illustration of LBC and CAD is shown in Figure 1.

The objective of LBC is to place a discrete mound of contaminated material on an existing flat or gently sloping natural bottom. A cap is then applied over the mound by one of several techniques, but usually in a series of placement sequences to ensure adequate coverage. CAD is generally used

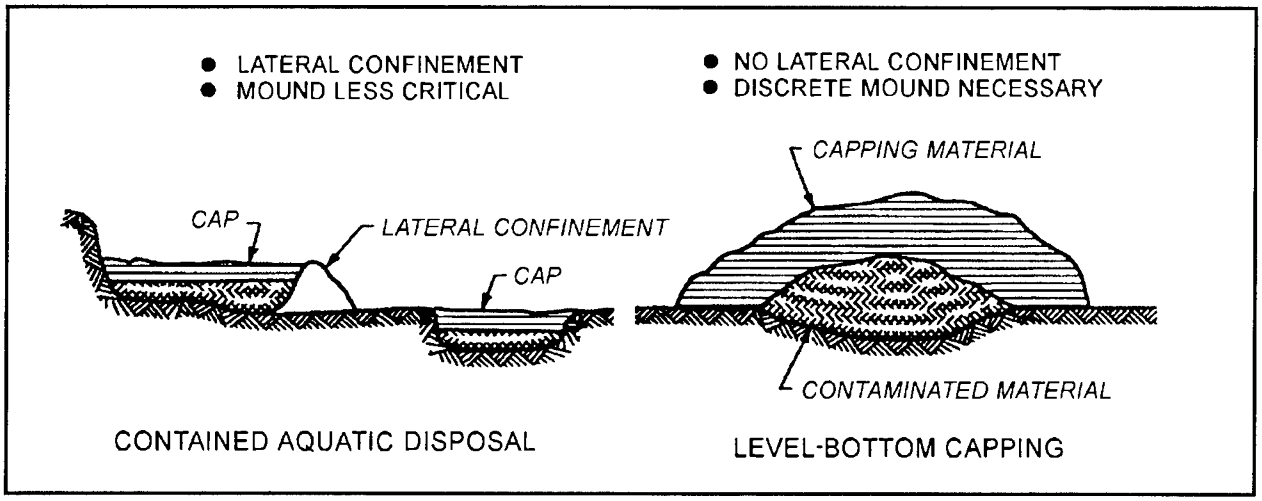


Figure 1. Schematic illustrating LBC and CAD

where the mechanical properties of the contaminated material and/or bottom conditions (e.g., slopes) require positive lateral control measures during placement. Use of CAD can also reduce the required quantity of cap material and thus the costs. Options might include the use of an existing natural or excavated depression, preexcavation of a placement pit, or construction of one or more submerged dikes for confinement (Truitt 1987a).

Dredged material capping versus in situ capping for remediation

Capping is also a potential alternative for remediation of contaminated sediments in place or in situ. However, a clear distinction should be made between navigation dredged material capping and capping in the remediation context. For dredged material capping associated with navigation projects, the sediment of concern would typically require capping because it may exhibit potential for toxicity or significant bioaccumulation in benthic organisms. Often these sediments are only marginally contaminated in comparison with other sediments in the area. The objective of capping in this context is to effectively eliminate direct exposure of benthic organisms to the contaminated sediments and thus virtually eliminate potential benthic toxicity or bioaccumulation.

For in situ capping in the remediation context, the sediments of concern are sufficiently contaminated to warrant some sort of cleanup action. The objective of capping in the remediation context may involve objectives over and above isolation of the sediment from the benthic environment. Guidance for in situ capping for sediment remediation is presented in Palermo et al. (1996).

Design issues for capping

Capping is a contaminant control measure to prevent impacts. However, dredged material capping requires initial placement of a contaminated material at an open-water site. Several issues, therefore, must be carefully considered within the context of a capping project design. These include the following:

a. Potential water column impacts during placement. Assessment should consider evaluation of potential release of contaminants to the water column, evaluation of potential water column toxicity, and evaluation of initial mixing. Elutriate test procedures for water quality, water column bioassay tests, and computer models for dispersion and mixing are available to address these requirements. The mass loss of contaminants during placement (fraction dispersed offsite and remaining uncapped) may also be predicted using these same tests and models.

b. Efficacy of cap placement. Assessment should consider available capping materials, methods for dredging and placement of both contaminated material and cap material, compatibility of site conditions, material physical properties, and dredging and placement techniques. Guidance on selection of appropriate methods, compatibility with site conditions and material properties, and computer models for predicting mound development and spreading behavior are available.

c. Long-term cap integrity. Assessment should consider the physical isolation of contaminants, potential bioturbation of the cap by benthos, consolidation of the sediments, long-term contaminant flux through the cap due to advection/diffusion, and potential for physical disturbance or erosion of the cap by currents, waves, and other forces such as anchors, ship traffic, ice, etc. Test procedures for contaminant isolation and consolidation and computer models for evaluation of long-term contaminant flux, consolidation, and resistance to erosion are available.

Each of these issues must be appropriately addressed by the project design.

Viability of capping as an alternative

Capping is only one of several alternatives that may be considered for dredged material that is excessively contaminated and would need isolation from the benthic environment if proposed for open-water placement. If the issues described above can be satisfactorily addressed in the project design for the specific set of sediment, site, and operational conditions under consideration, capping is a technically viable option.

Capping is not a technically viable option for a specific set of sediment, site, and operational conditions described below:

a. Contaminant release and dispersion behavior of the contaminated material (even with consideration of controls) results in unacceptable water column impacts during placement.

b. Spreading or mounding behavior of the contaminated material or cap material (even with consideration of controls) indicates that the required cap cannot be effectively placed.

c. Energy conditions or operational conditions at the site are such that the required cap thickness cannot be effectively maintained in the long term.

d. Institutional constraints do not provide the ability to commit to the long-term monitoring and management requirements.

Under such circumstances, other options for placement of the contaminated sediments must be considered.

Organization of this Report

The main body of this report describes specific procedures for all aspects of capping-project evaluation and design. A number of appendixes are also included that provide detailed information on specific testing procedures, predictive models, etc. Chapter 2 describes the recommended sequence of design activities, and specific design steps are organized into flowcharts as necessary.

2 Design/Management Sequence for Capping

Design Philosophy for Capping

Capping is not a form of unrestricted open-water placement. A capping operation is an engineered project with carefully considered design, construction, monitoring, and maintenance to ensure that the design is adequate. A successful capping project requires a team approach with input from engineers, biologists/ecologists, chemists, and dredging operations experts. The basic criterion for a successful capping operation is that the cap thickness required to isolate the contaminated material from the environment be successfully placed and maintained.

Dredged Material Capping Functions

A dredged material cap can serve three primary functions:

a. Physical isolation of the contaminated dredged material from the benthic environment.

b. Stabilization of contaminated material, preventing resuspension and transport to other sites.

c. Reduction of the flux of dissolved contaminants into the cap and overlying water column.

If a dredged material is unsuitable for open-water placement due to potential contaminant impacts, physical isolation of the dredged material from the benthic environment and from resuspension and transport offsite would normally be primary functions of a dredged material cap. Control of contaminant flux may be a desired function, depending on the sediment characteristics, site conditions, and other factors.

Summary of Design Sequence for Capping

The flowchart shown in Figure 2 illustrates the major design requirements for a capping project and the sequence in which the design requirements should be considered. There is a strong interdependence between all components of design for a capping project. For example, the initial consideration of a capping site and placement techniques for both the contaminated and capping materials strongly influence all subsequent evaluations, and these initial choices must also be compatible for a successful project (Shields and Montgomery 1984). Each step in the process must be clearly identified and documented before a decision can be made to proceed.

When an efficient sequence of activities for the design of a capping project is followed, unnecessary data collection and evaluations can be avoided. General descriptions of the various design requirements are given below corresponding to the recommended design sequence (Palermo 1991a). Each block in the flowchart (Figure 2) is numbered, and a description of each block is referenced by the number in parentheses in this chapter. More detailed guidance on various aspects of the design is provided in Chapters 3 through 9 and Appendixes B through I of this report. Chapter 10 describes capping case studies and field experience for major capping projects under a range of project conditions. Chapter 11 summarizes the guidance provided in this document.

Gather project data and select design criteria (1)

The first step in any capping project design is to gather and evaluate the existing project data, which normally include surveys of the dredging area, physical and chemical characteristics of the contaminated sediment, equipment used for dredging and placement, and characteristics of potential placement sites (i.e., area erosion trends, wind-wave resuspension, wave-current interaction effects). Since capping is under consideration, data on the suitability of the material to be dredged for open-water placement may exist. These data may include results of physical, chemical, and biological tests required under Section 404 of the CWA or Section 103 of the MPRSA. Data on potential placement sites may vary. Bathymetry, currents, storm frequencies, wave heights, and bottom-sediment characterization are normally available for open-water sites under consideration.

Once the existing data have been gathered, the design functions of the cap can be determined and design criteria selected. Specific design criteria will depend on the selected design functions for the cap, i.e., physical isolation, stabilization, or reduction of contaminant flux. Design criteria may be developed in a number of ways: providing cap thickness for isolation of benthic organisms to a given bioturbation depth; reducing contaminant flux rates to achieve specific sediment, pore water, or water column target concentrations; specific storm or flood flow return periods for cap stability; limits on mound elevation to meet navigation or erosion constraints; placement of all material within given site boundaries, etc. Such criteria should be defined prior to starting design of the capping project. Three main aspects of capping design must be examined: aspects related to

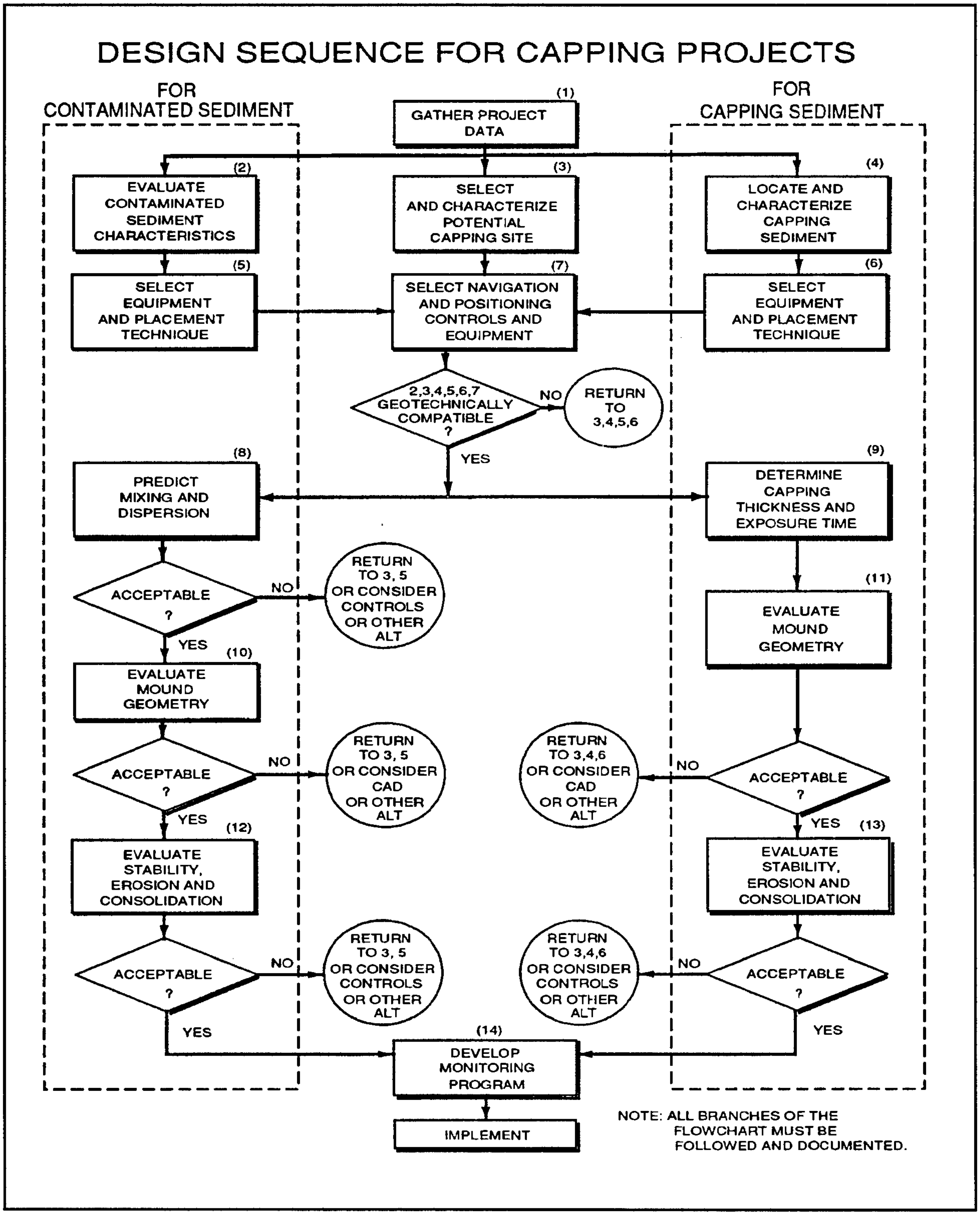


Figure 2. Flowchart illustrating design sequence for dredged material capping projects (after Palermo 1991a)

characterization and placement of the contaminated material, aspects related to the characterization and placement of the capping material, and aspects related to the capping site under consideration. Each of these aspects must be initially examined in a parallel fashion (see Blocks 2, 3, and 4 of Figure 2). Further, the interrelationship and compatibility of these three aspects of the design are critical.

Characterize contaminated sediment (2)

The contaminated sediment must be characterized from physical, chemical, and biological standpoints. Physical characteristics are of importance in determining the behavior of the material during and following placement at a capping site. In situ volume (to be dredged), in situ density (or water content), shear strength, compressibility, and grain-size distribution are needed for evaluations of dispersion and spread during placement, mounding characteristics, consolidation, and long-term stability and resistance to erosion. These data should be developed using standard techniques.

Some chemical and biological characterization of the contaminated sediment is normally performed as a part of the overall evaluation for suitability for open-water placement. Guidance on characterization of contaminated sediments is found in Chapter 3.

Select a potential capping site (3)

The selection of a potential site for capping is subject to the same constraints and tradeoffs as any other open-water placement site. The major considerations in site selection include bathymetry, bottom slopes, currents, water depths, water column density stratification, erosion/accretion trends, proximity to navigation channels and anchorages, bottom-sediment characteristics, and operational requirements such as distance to the site and wave climate. However, in addition to normal considerations, the capping site should ideally be in a relatively low-energy environment with little potential for erosion or disturbance of the cap. While capping at a low-energy site is desirable, such sites are not always available. Higher energy sites can be considered for dredged material capping, but a detailed study of erosion potential is required; increases in cap thickness to account for potential erosion or use of a coarser grain-size material may be required.

Consideration should be given to the following factors during selection of a potential capping site. Bathymetry forming a natural depression will tend to confine the material, resulting in a CAD project. Placement of material on steep bottom slopes should generally be avoided for a capping project. Water column currents affect the degree of dispersion during placement and the location of the mound with respect to the point of discharge. Of more importance are the bottom currents, which could potentially cause resuspension and erosion of the mound and cap. The effects of storm-induced waves on bottom-current velocities must be considered. For some sites, other processes such as prop wash may need to be considered. The deeper the water is at the site, the greater the potential is for water entrainment and dispersion during placement. However, deeper water depths also generally provide more stable conditions on the bottom with less potential for erosion. Numerical models for prediction of water column behavior, mound development, and long-term stability against erosion may be used in evaluating site conditions. Guidance on site selection for capping is found in Chapter 4.

Select and characterize capping sediment (4)

The cap sediment used in a project should be carefully selected. However, for economic reasons, a capping sediment is usually taken from an area that also requires dredging or is considered advanced maintenance dredging. If this is the case, there may be a choice between projects. Scheduling of the dredging is also an important consideration. In other cases, removal of bottom sediments from areas adjacent to the capping site may be considered.

The capping sediment is characterized as described above for the contaminated sediment. However, the capping sediment must be one that is suitable for open-water placement (i.e., a clean sediment). The evaluation of a potential capping sediment for open-water placement acceptability must be accomplished using appropriate techniques under either CWA or MPRSA. Physical characteristics of the capping sediment are also of particular interest in capping design. Density (or water content), grain-size distribution, and cohesiveness of the capping sediment must be evaluated. Selection of the capping sediment should be carefully considered because the capping material must be compatible with the contaminated sediment and this compatibility is related to dredging and placement equipment and techniques. Previous studies have shown that both fine-grained materials and sandy materials can be effective capping materials. Guidance on selecting and characterizing capping sediment is found in Chapter 3.

Select equipment and placement technique for contaminated sediment (5)

A variety of equipment types and placement techniques have been used for capping projects. The important factors in the placement of contaminated material are reducing water column dispersion and bottom spread to the greatest possible extent. This minimizes the release of contaminants during placement and provides for easier capping. For LBC the dredging equipment and placement technique for contaminated sediment must provide a tight, compact mound. This is most easily accomplished with mechanical dredging and barge release (point dumping). If CAD is under consideration, hydraulic placement of the contaminated material may be acceptable.

Specialized equipment and placement techniques can also be considered to increase control during placement and reduce potential dispersion and spread of contaminated material. These might include use of submerged diffusers or submerged discharge points for hydraulic pipeline placement, hopper dredge pump-down with diffuser, or gravity-fed tremie for mechanical or hydraulic placement or use of geosynthetic fabric containers. Guidance for equipment and placement techniques is found in Chapter 5.

Select equipment and placement technique for capping sediment (6)

The major design requirement in the selection of equipment and placement of the cap is the need for controlled, accurate placement and the resulting density and rate of application of capping material. In general, the cap material should be placed so that it accumulates in a layer covering the contaminated material. The use of equipment or placement rates that might result in the capping material displacing or mixing with the previously placed contaminated material must be avoided. Placement of capping material at equal or lesser density than the contaminated material or use of placement methods to spread thin layers to gradually build up the cap thickness usually meets this requirement.

Specialized equipment and placement techniques can be considered to increase control of capping material placement. The movement of submerged diffusers, energy dissipaters, submerged discharge points, or tremies can be controlled to spread capping material over an area to a required thickness. Incremental opening of split-hull or multicompartment barges along with controlled movement of the barges during surface release, direct pump-out through pipes, and direct washing by hoses have been used for placing mechanically dredged sandy capping material. Energy dissipaters for hydraulic placement of capping materials have been successfully used. Guidance on selection of equipment and placement techniques is found in Chapter 5.

Select navigation and positioning equipment and controls (7)

Placement of both the contaminated and capping material must be carefully controlled, regardless of the equipment and placement technique selected. Electronic positioning systems, taut-moored buoys, mooring barges, various acoustical positioning devices, and computer-assisted, real-time helmsman's aids should be considered in selecting the equipment and placement technique. Guidance on selection of navigation and positioning equipment and controls is found in Chapter 5.

Evaluate compatibility of site, materials, and equipment

At this point in the design, the contaminated material has been characterized; a site has been identified and characterized; a capping sediment has been selected and characterized; equipment and placement techniques have been selected for both materials and navigation; and positioning needs have been addressed. These essential components of the design (Blocks 2, 3, 4, 5, 6, and 7 in Figure 2) must now be examined as a whole, with compatibility in mind, to evaluate the efficacy of cap placement for the sediments, site conditions, equipment availability and capabilities under consideration, and cost. The primary concern with compatibility relates to geotechnical considerations and the ability of the contaminated material to support the cap, considering the material characteristics and dredging and placement techniques.

Guidance on the compatibility of various dredging and placement techniques for differing material types has been developed based on field experience and knowledge of the resulting dispersion and spreading behavior and physical stability of the materials. If the various site, sediment, and selected equipment components are compatible, additional and more detailed design requirements can be addressed. If there is a lack of compatibility at this point, a different capping site (3), a different capping sediment (4), or different dredging and placement equipment and techniques (5,6) must be considered. A close examination of the project design components at this decision point is essential before performing the more detailed and costly evaluations that come later in the design process. Guidance on evaluation of sediment, site, and equipment compatibility is found in Chapter 5.

Predict water column mixing and dispersion effects of contaminated sediment during placement (8)

If water column effects during placement of the contaminated material are of concern, an evaluation of the suitability of the material from the standpoint of water column effects must be performed. This evaluation involves the comparison of predicted water column contaminant concentrations with water quality criteria and predicted water column dredged material concentrations with bioassay test results. Use of available mathematical models and/or case study field-monitoring results to predict the water column dispersion and concentrations is an integral part of such evaluations. In addition, the prediction indicates what portion of the contaminated material is released during placement and thus is not capped. Evaluation of initial deposition and spread of material is used in determining the mounding characteristics for the entire contaminated material volume to be placed. If water column release is unacceptable, control measures need to be considered to reduce the potential for water column effects, or other dredging equipment and placement techniques (5) or use of another capping site (3) must be considered. Guidance on prediction of water column effects during placement is found in Chapter 6 and Appendix D.

Determine cap design (9)

The cap must be designed to adequately isolate the contaminated material from the aquatic environment and achieve the intended cap functions. The composition and dimensions (thickness) of the components of a cap can be referred to as the cap design. The composition of caps for dredged material projects is typically a single layer of clean sediments because relatively large volumes of cap material are involved; clean sediments from other dredging projects are often available as cap materials; and dredged material capping sites with low potential for erosion can be selected. Guidance on dredged material cap design therefore focuses on the thickness of the cap as the major design criterion.

The determination of the required cap thickness is dependent on the physical and chemical properties of the contaminated and capping sediments, the potential for bioturbation of the cap by aquatic organisms, the potential for consolidation and the resultant expulsion of pore water from the contaminated sediment, and the potential for consolidation and erosion of the cap material. The minimum required cap thickness is considered the thickness required for physical isolation plus any thickness needed for control of contaminant flux. The integrity of the cap from the standpoint of physical changes in cap thickness and long-term migration of contaminants through the cap should also be considered. The potential for a physical reduction in cap thickness due to the effects of consolidation and erosion (12,13) can be evaluated once the overall size and configuration of the capped mound is determined. A precise calculation of the erosion thickness component requires consideration of mound shape, mound height, and water depth. Since these parameters also depend on the total capping thickness, some iterative calculations may be required. The design cap thickness is the required cap thickness for isolation plus that required for consolidation and erosion and operational considerations. Guidance on cap design is found in Chapter 7, and details on specific testing and evaluation procedures and models to support cap design are found in Chapters 6 and 8 and Appendixes B, C, E, F, G, and H.

Evaluate spread, mounding and site geometry (10,11)

For LBC sites, the mound geometry, including contaminated material mound and cap, will influence the design of the cap and volume of capping material required. The smaller the footprint of the contaminated material as placed, the less volume of capping material is required to achieve a given cap thickness. The spread and development of the contaminated material mound is dependent on the physical characteristics of the material (grain size and cohesion) and the placement technique used (hydraulic placement results in greater spread than mechanical placement). Assuming that the material from multiple barge loads or pipeline can be accurately placed at a single point, mound side slope and the total volume placed dictate the mound spread. The formation of a thin layer or apron surrounding the central mound must also be considered in defining the footprint to be capped for LBC.

For CAD projects, in which lateral containment prevents spreading and apron formation, the footprint will be determined by the site geometry. However, the volume occupied by the sediments will govern the capacity of the CAD site and must be considered as a factor in site design. If the mound geometry or CAD site geometry is unacceptable, an alternative site (3), alternative capping sediment (4), or alternative placement techniques (5,6) can be considered. Guidance on mound spread and development and site geometry is found in Chapter 6 and Appendixes E and H.

Evaluate stability, erosion, and consolidation (12,13)

The deposit of contaminated dredged material must also be stable against excessive erosion and resuspension of material before placement of the cap. The cap material must be stable against long-term erosion for the required cap thickness to be maintained. The potential for resuspension and erosion is dependent on bottom current velocity, potential for wave-induced currents, sediment particle size, and sediment cohesion. Site selection criteria as described above normally results in a site with low bottom-current velocity and little potential for erosion. However, if the material is hydraulically placed (as for a CAD site) or a site with higher energy potential is considered, a thorough analysis of the potential for resuspension and erosion must be performed, to include frequency considerations. Conventional methods for analysis of sediment transport can be used to evaluate erosion potential. These methods can range from simple analytical techniques to numerical modeling.

Consolidation of contaminated material needs to be examined for its effect on LBC mound slopes and volumes and on the volume occupied within CAD sites. In general, consolidation of the contaminated dredged material will result in more stable conditions. The same is true for consolidation of the cap material. However, consolidation of the cap results in a reduced cap thickness. Therefore, the potential for cap consolidation must be accounted for in the overall design of the cap thickness.

If the potential for erosion and consolidation of either the contaminated material or cap is unacceptable, an alternative site (3), alternative capping sediment (4), or alternative placement techniques (5,6) can be considered. Guidance on evaluating long-term cap stability is found in Chapter 8 and Appendixes F, G, and I.

Develop a monitoring program (14)

A monitoring program or site monitoring plan is required as a part of any capping project design. The main objectives of monitoring normally are to ensure that the contaminated sediment is placed as intended and with acceptably low levels of contaminant release, the cap is placed as intended and the required capping thickness is maintained, and the cap is effective in isolating the contaminated material from the environment. Monitoring plans for capping projects need to include a more intensive effort during and shortly after placement operations and immediately after unusual events (e.g., severe storms), with a declining level of effort in future years if no adverse effects are detected. Physical, chemical, and biological elements may be included in a monitoring plan. In all cases, the objectives of the monitoring effort and any remedial actions to be considered as a result of the monitoring must be clearly defined as a part of the overall project design. Guidance on monitoring considerations for capping is found in Chapter 9. Case studies of capping projects including conclusions drawn from field monitoring efforts are described in Chapter 10.

3 Characterization of Contaminated and Capping Sediments

Need for Sediment Characterization

Characterization of both the contaminated sediment and potential capping sediments is necessary for evaluation of the environmental acceptability of sediments for open-water placement and to determine physical and engineering properties necessary for prediction of both short- and long-term behavior of the sediments. Some characterization data may have been obtained as a part of a more general investigation of disposal alternatives prior to consideration of capping.

Characterization of Contaminated Sediment

The contaminated sediments to be capped are likely to have been characterized to some degree prior to consideration of capping. In any event, the contaminated sediment must be characterized from a physical, chemical, and biological standpoint.

Physical characterization

The physical characteristics of the contaminated sediment are of importance in predicting the behavior of the material during and following placement at a capping site. Physical characterization is needed for evaluations of dispersion and spread during placement, mounding characteristics, and long-term stability and resistance to erosion.

Physical tests and evaluations on sediment should include visual classification, natural (in situ) water content/solids concentration/bulk density, plasticity indices (Atterberg limits), organic content, grain-size distribution, specific gravity, and Unified Soil classification. Standard geotechnical laboratory test procedures, such as those of the American Society for Testing and Materials (ASTM), the American Association of State Highway

Transportation Officials (AASHTO), or the USACE, should be used for each test. Table 1 gives the standard ASTM and USACE designations for the needed tests and also cross-references these procedures to those of several other organizations that have standardized test methods.

Table 1
Standard Geotechnical Laboratory Test Procedures

Test	Designation				
	ASTM	AASHTO	COE[1]	DoD[2,3]	Comments
Soils					
Water content	D 2216	T265	I	Method 105, 2-VII	
Grain size	D 422	T88	V	2-III, 2-V, 2-VI	
Atterberg limits	D 4318	T89 T90	III	Method 103, 2-VIII	
Classification	D 2487		III		
Specific gravity	D 854	T100	IV	2-IV	
Organic content	D 2974				Use Method C
Consolidation[4]	D 2435	T216	VIII		
Permeability[5]	D 2434	T215	VII		
Shear tests	D 2573				Field test

[1] Department of the Army Laboratory Soils Manual EM 1110-2-1906.
[2] Department of Defense Military Standard MIL-STD-621A (Method 100, etc.).
[3] Department of the Army Materials Testing Field Manual FM 5-530 (2-III, etc.).
[4] Do not use the standard laboratory test for determining consolidation. Instead, use the modified standard consolidation test and the self-weight consolidation test as described in USACE (1987).
[5] One value of permeability must be calculated from the self-weight consolidation test.

Additional geotechnical data should also be collected on contaminated sediments for capping projects, including consolidation, and shear strength data. These data are useful for geotechnical evaluations of stability of the capped deposit and the development of mound or deposit geometries. Detailed information on consolidation testing is presented in Appendix I.

Physical analysis of dredging site and/or disposal site water may also be required to include suspended solids concentration and salinity. Potential stratification due to temperature and salinity differences should be considered. These data must be developed using standard techniques.

Chemical/biological characterization

Capping as a control measure is normally considered only after a sediment to be dredged is found to be contaminated. In order to make such a determination, some chemical and biological characterization of the contaminated sediment is normally performed as a part of the overall evaluation for suitability for open-water placement (EPA/USACE 1991; EPA/USACE 1998). It should be noted that even though capping is being considered because of a determination of potentially unsuitable benthic effects, the data necessary for evaluation of potential water column effects are still required.

Chemical characterization of contaminated sediment may include a sediment chemical inventory and standard elutriate test results. The chemical sediment inventory is useful in determining contaminants of concern and in the development of appropriate chemical elements of a monitoring program to determine capping effectiveness. Elutriate data are used in estimating the potential effects on water quality due to placement of the contaminated material. Biological characterization may include water column bioassays, benthic bioassays, and bioaccumulation tests. The results of these biological tests are useful in determining potential water column effects during placement and acceptable exposure times before placement of the cap begins. If these data have not been developed for the contaminated sediment, additional testing may be required.

Selection of Capping Sediment

The capping sediment used in a capping project may be a matter of choice. For economic reasons, a capping sediment is usually taken from an area that also requires dredging. If this is the case, there may be a choice between projects, and scheduling of the dredging is an important consideration. In other cases, removal of bottom sediments from areas adjacent to the capping site may be considered. If CAD is under consideration, removal of material to create CAD cells may be stockpiled and used later in the capping operation (Averett et al. 1989; Sumeri 1989).

Characterization of Capping Sediment

All dredged material capping projects to date have utilized dredged material that is suitable for open-water placement for the capping material. Use of other materials for caps or for components of a multilayer cap such as quarry sand, soil materials, geotextiles, or armor stone are possible and have been implemented in in situ capping projects. Guidance (Palermo et al. 1996) on selection and use of such materials for caps is available. This section focuses on use of dredged material as capping material.

Physical characterization

Physical characteristics of the capping sediment are similarly determined as described above for the contaminated sediment. Visual classification, natural (in situ) water content/solids concentration, plasticity indices (Atterberg limits), organic content, grain-size distribution, specific gravity, and Unified Soil classification as well as geotechnical data should be evaluated as necessary.

The characteristics of the capping sediment should be compatible with the contaminated sediment, considering the placement technique for both. Previous studies have shown that both fine-grained materials and sandy materials can be effective capping materials.

Chemical/biological characterization

The capping sediment must be one that is acceptable for unrestricted open-water placement (that is a clean sediment). Further, the capping sediment must be acceptable for open-water placement from the standpoint of both potential water column and potential benthic effects. In order to make such a determination, some chemical and biological characterization of the contaminated sediment is normally performed as a part of the overall evaluation for suitability for open-water placement (EPA/USACE 1991; EPA/USACE 1998).

Sampling and Testing Plans

Samples of sediments must be obtained for physical, chemical, or biological characterization as described above. Samples may also be required for other engineering or environmental testing such as the capping thickness testing described in Chapter 7 and Appendix C.

General guidance on design of sampling plans is available (EPA/USACE 1991; EPA/USACE 1998), but most sampling plans will be site specific. The full range of anticipated testing must be considered in developing sampling plans. Appropriate sampling equipment, sampling techniques, and sample preservation procedures should be used.

Variability can be exhibited in vertical as well as horizontal location of specific samples. Sampling should define material to the total depth of dredging. Grab samplers or box corers are generally appropriate for shallow thickness of sediment, while core samples (by vibracore or conventional coring equipment) are normally required for thicker sediment deposits or deposits in which stratification must be defined. Detailed guidance on sampling equipment and procedures is available (Mudrock and McKnight 1991.)

Testing of samples from specific locations is usually done for characterization purposes. Compositing should be considered for some engineering or environmental testing (e.g., consolidation tests, elutriate tests, bioassays, capping effectiveness tests). Administrative agreement between all concerned regulatory agencies regarding the acceptability of the sampling and testing plan should be obtained prior to sampling and testing.

4 Site Selection Considerations for Capping

General Considerations for Site Selection

The selection of an appropriate site is a critical requirement for any capping operation. Since the cap must provide long-term isolation of the contaminated material, capping sites should generally be characterized as nondispersive sites, where material is intended to remain in a stable deposit. Therefore, the considerations for site selection for a conventional nondispersive open-water disposal site also apply to capping sites (Palermo 1991b).

Sites in ocean waters are regulated by MPRSA. For MPRSA sites, a formal site designation procedure includes a detailed evaluation of site characteristics. Sites in inland and near-coastal waters (inland of the baseline of the territorial sea) are regulated by CWA. The specification of disposal sites under the CWA is addressed specifically in the Section 404 (b)(1) guidelines. Any capping project in waters of the United States must occur at a specified 404 site.

A number of site characteristics must be considered in designating or specifying an open-water disposal site. These characteristics include the following:

- Currents and wave climate.
- Water depth (including consideration of navigable depth).
- Bathymetry (particularly slopes).
- Potential changes in circulation or erosion patterns related to refraction of waves around the disposal mound.
- Groundwater flow (consideration for some nearshore sites).
- Bottom sediment physical characteristics, including sediment grain-size differences.

- Sediment deposition versus erosion to include seasonal and long-term trends.

- Salinity and temperature distributions.

- Normal level and fluctuations in background turbidity.

- Chemical and biological characterization of the site and environs (for example, relative abundance of various habitat types in the vicinity, relative adaptability of the benthos to sediment deposition, presence of submersed aquatic vegetation, presence of unique, rare, or isolated benthic populations, contaminant concentrations in sediments, background water quality).

- Potential for site recolonization

- Previous disposal operations.

- Availability of suitable equipment for disposal at the site.

- Ability to monitor the disposal site adequately and economically for management decisions.

- Technical capability to implement management options should they appear desirable.

- Ability to control placement of the material.

- Volumetric capacity of the site.

- Other site uses and potential conflicts with other activities (i.e., sport or recreational fisheries).

- Established site management or monitoring requirements.

- Public and regulatory acceptability to use of the site.

The intent of the MPRSA criteria for site designation is to avoid unacceptable adverse impacts on biota and other amenities. The Section 404(b)(1) guidelines generally address the same concerns as the MPRSA criteria, but the primary emphasis is directed toward the potential effects of the disposal activity.

The USACE has prepared an ocean site designation manual (Pequegnat, Gallaway, and Wright 1990), which provides useful guidance and procedures for conducting the appropriate investigations and studies. In addition, overview manuals for site designation are available (USACE/EPA 1984; EPA 1986).

The selection of a potential site for capping is subject to the same constraints and tradeoffs as any other nondispersive open-water disposal site. However, beyond the normal considerations, the capping site should be in a relatively low-energy environment with little potential for erosion of the cap. While capping at a low-energy site is desirable, such sites are not always available. Higher energy sites can be considered for dredged material capping, but a detailed study of erosion potential is required; increases in cap thickness to account for potential erosion may be required. Monitoring and maintenance costs may also be higher for higher energy sites.

Special consideration of site bathymetry, currents, water depths, bottom-sediment characteristics, and operational requirements such as distance, sea state, etc., are required in screening or selecting sites for capping (Truitt 1987a; Truitt, Clausner, and McLellan 1989).

Bathymetry

Site bathymetry influences the degree of spread during placement of both contaminated and capping material. The flatter the bottom slope, the more desirable it is for LBC projects, especially if material is to be placed by hopper dredge. If the bottom in a disposal area is not horizontal, a component of the gravity force influences the energy balance of the bottom surge (the lateral movement of the disposed material as it impacts sea bottom) and density flows due to slope following impact of the discharge with the bottom. It is difficult to estimate the effects of slope alone, since bottom roughness plays an equally important role in the mechanics of the spreading process. To date, LBC projects in which the material was mechanically dredged and released from a barge have been executed at sites with slopes up to 1:60 (Science Applications International Corporation (SAIC) 1995a) and in which material was placed by hopper dredge at sites with slopes up to 1:225 (i.e., New York Mud Dump site). Placement of material on steep bottom slopes (steeper than one degree 1:60) should generally be avoided for a capping project (Truitt 1987a). Bathymetry forming a natural depression tends to confine the material, resulting in a CAD project. This is the most desirable type of site bathymetry for a capping project.

Currents

Water column currents affect the degree of dispersion during placement and mound location with respect to the point of discharge. Of more importance are bottom currents, which could potentially cause resuspension and erosion of the mound and cap. The effects of storm-induced waves on bottom-current velocities must also be considered. Capping sites need to have current and wave climate characteristics that result in long-term stability of the capped mound or deposit.

Collection of basic current information is necessary at prospective disposal sites to identify site-specific conditions. The principal influence of currents in the receiving water during placement is to displace or offset the point of impact of the descending jet of material with the bottom with respect to the point of release (by a calculable amount). Water column currents need not be a serious impediment to accurate placement, nor do they result in significantly greater dispersion during placement (though the offset needs to be taken into account). Further, currents do not appear to affect the surge phase of the disposal (Bokuniewicz et al. 1978; Truitt 1986a). However, water column currents and bottom slopes are important in slow placement of sand caps where the currents and density flows can cause some waste of capping material.

Long-term effects of currents at a prospective site may still need to be investigated from the standpoint of potential erosion of the mound and cap or potential recontamination of the site from adjacent sources. Storm-induced currents are also of interest in the long-term stability of the site. However, disposal operations are not conducted during storms, so the designer does not need to consider storm-induced currents during disposal. Measured current data can be supplemented by estimates for extreme events using standard techniques; for example, see the Shore Protection Manual (HQUSACE 1984). Selection of a nondispersive site in a relatively low-energy environment normally results in a site with low bottom-current velocity and little potential for erosion. However, in some cases, particularly if the material is hydraulically placed, a thorough analysis of the potential for resuspension and erosion is necessary. In the analysis of erosion, the effects of self-armoring due to the winnowing away of finer particles are a factor that increases erosion resistance over time but is difficult to quantify.

The same technical approaches used to evaluate erosion potential and/or magnitude and rate of erosion for purposes of cap design can be used in screening and/or selecting sites. The process of screening and site evaluation for erosion potential must consider current and wave conditions for both ambient and episodic events such as storms. Conventional methods for analysis of sediment transport can be used to evaluate erosion potential (Teeter 1988; Dortch et al. 1990). These methods can range from simple analytical techniques to numerical modeling (Scheffner et al. 1995). Modeling evaluations will normally result in a varying rate of erosion for various portions of a site or mounded feature (e.g., erosion would normally be greater at the crest of a mound or at the corners of a mounded feature).

Erosion criteria for site screening should also be based on both ambient and episodic events and should account for a varying rate of erosion over the site. For projects in which no subsequent capping is anticipated for a long time period (several decades or longer) or for which materials for cap nourishment are not easily obtained, it is suggested that net cap erosion over the major portion of the mound or deposit should not exceed 1 ft[1] over a period of 20 years of normal current/wave energies or for a 100-year extreme event. The recommended criteria of 1 ft of erosion, 20-year ambient time interval, and 100-year return interval for storms is based on engineering judgement, a common sense level of conservatism, and field experience gained to date. One foot is a round number that can be measured with some precision for most locations. Twenty and one hundred years as

[1] The U.S. customary units of measurement are used in lieu of metric (SI) units for those cases common in dredging practice. Metric (SI) units are used in this report when consistent with standard usage. A table to convert from non-SI units of measurement to SI units can be found on page xiv.

time periods are in the range of design periods for many engineering structures. Note that erosion at localized portions of the mound or feature greater than 1 ft would be allowed using these screening criteria. The corners of a mound would normally have an overlap of capping material, and the crest of a mound would normally have a greater cap thickness; therefore, somewhat larger erosion could be tolerated over these portions of a mound. Selection of other values of erosion thickness or time periods should be based on site-specific factors (e.g., the degree of contamination, distance to other resources), the level of confidence in the calculations, and the level of risk acceptable to the parties involved.

For projects in which subsequent material placement and/or capping is planned or for which materials for cap nourishment can be easily obtained, higher erosion rates or shorter return periods for episodic events may be considered as a criterion for purposes of site screening. In areas where available capping materials are scarce and current and wave conditions are severe, a coarse-grained layer of material (coarse sand, gravel, or larger size materials) may be incorporated into the cap design to provide protection against erosive currents at the site. Detailed guidance on evaluation of erosion is found in Chapter 8 and Appendixes F and G.

Average Water Depths

Case studies have indicated that water depth is of particular interest in evaluating the potential suitability of a site for capping operations (Palermo 1989). The deepest water depth for which a capping project has been executed (as of 1995) is approximately 100 ft. However, definable dredged material mounds have been created in water depths exceeding 400 ft (Wiley 1995). Greater water depths generally provide more stable bottom conditions with less potential for erosion. However, the greater the average water depth is at the site, the greater the potential is for water entrainment and dispersion during placement. The expense and difficulty in monitoring is also increased with a greater water depth.

As water depth increases, both the contaminated and clean material must descend through a greater water column depth. More material is released to the water column during placement as compared with shallower water placement, all other factors being equal. Therefore, the fraction of the contaminated material that is not finally capped is greater.

Entrainment of ambient water causes the descending material to become more buoyant; therefore, the effect of density stratification in the water column needs to be evaluated. Although density stratification in the water column may be encountered at some deep-water sites, stratification is not likely to prevent the descent of the dredged material mass during placement. The very cohesive fraction of mechanically dredged material (clods or clumps) attains terminal speed quickly after release from a barge and does not accelerate further with depth.

The increased water entrainment with deep-water placement may also result in a greater spread of the more fluid material on the bottom, but entrainment reduces the overall potential energy at bottom impact. Field studies indicate that the bottom surge does not spread at a faster rate than that occurring in shallower depths, although because of additional entrainment, the initial thickness of the surge increases as depth increases (Bokuniewicz et al. 1978). Greater care in control of placement may therefore be required as water depth increases to develop a discrete mound of contaminated material and adequate coverage of the mound with capping material.

Comparison of predictive models for fate of placed material and field monitoring of Puget Sound Dredge Disposal Analysis (PSDDA) sites in Seattle's Elliott Bay and Everett's Port Gardner Bay show the high degree of reliability of these models for prediction of mound footprint extent in water depths of 300 to 400 ft (Wiley 1995). Also, the accuracy of available electronic positioning equipment used during disposal is validated.

The use of a deep-water site for capping generally holds an advantage over a shallower site from the standpoint of cap stability from erosive forces. Deep water acts as a buffer to wave action, and the resulting wave-induced currents from storm events are smaller than in shallow water. Therefore, deep-water sites are usually quiescent, near bottom low-energy environments that are better suited to capping from the standpoint of cap stability, but this must be balanced against potential material loss during placement. Generally, a greater water depth at a site has more favorable influence on long-term cap stability than unfavorable influence on dispersion during the placement process (Truitt 1986b).

Operational Requirements

Among the operational criteria that need to be considered in evaluating potential capping sites are site volumetric capacity, nearby obstructions or structures, haul distances, bottom shear due to ship traffic (in addition to natural currents), location of available cap material, potential use of bottom drag fishing equipment, and ice influences. The effects of shipping are especially important since bottom stresses due to anchoring, propeller wash, and direct hull contact at shallow sites are typically of a greater magnitude than the combined effects of waves and other currents (Truitt 1987a). Methods for calculating prop-wash velocities are available (Palermo et al. 1996).

5 Equipment and Placement Techniques

Equipment and techniques applicable to placement of contaminated material to be capped and clean material used for capping include conventional discharge from barges, hopper dredges, and pipelines; diffusers and tremie approaches for submerged discharge; and spreading techniques for cap placement (Palermo 1991c, 1994). This chapter describes basic dredging, transportation, and placement processes as they relate to capping and considerations in selecting equipment and placement technique for both contaminated and capping materials. Considerations for scheduling for placement of the cap, navigation and positioning needs, placement options and tolerances, and inspection and compliance are also discussed.

Flow and Mounding Versus Dredging Method

The behavior of materials upon placement (especially their tendency to mound or to flow) and the ability to cap a deposit of contaminated material depend on several factors, including the method of dredging, the method of placement, material characteristics (cohesive/noncohesive), and site conditions such as water depth or current velocities (Headquarters, U.S. Army Corps of Engineers 1983).

The dredging process may be subdivided into two categories: mechanical and hydraulic dredging. During mechanical dredging, the sediments are physically lifted from the bottom by a mechanical process such as a bucket or clamshell. Mechanically dredged material is typically placed into and transported to the disposal area in barges (also commonly known as dump scows). Barges either have hoppers with doors through which material is released to the bottom or they can be split-hull, allowing the entire barge to open and release material to the bottom. Mechanically dredged material placed in this manner is ideally suited for creating subaqueous mounds because the dredged material stays close to the in situ density throughout the dredging process. This relatively constant density lends to effective mound construction because less water is entrained in the material, stripping during descent is minimized, and material spread on the bottom is reduced (Sanderson and McKnight 1986).

During hydraulic dredging, the bottom material is fluidized, lifted via pipeline by a centrifugal pump, and transported as a slurry. Material dredged by hopper dredges is also considered hydraulic dredging because of the fluidization process required to lift the material to the hoppers. Hydraulically dredged material is typically transported via pipeline to the disposal site and discharged with large amounts of entrained water. For hopper dredges, the material is transported in the hopper similar to a barge or scow as with the mechanical dredging, but excess water that is entrained during dredging remains with the material, thereby making the material less dense than when in situ or mechanically dredged. For both cases of hydraulic dredges (pipeline and hopper), the less dense material is more susceptible to stripping and creates a flatter feature covering a larger area on the bottom (Sanderson and McKnight 1986).

Alternatives are available to increase the mounding potential of material dredged by hydraulic means. For pipeline dredges, diffusers can be employed to reduce the material exit velocity from the pipe and reduce dispersion. Pump-down pipes can be added to transfer the material closer to the bottom and reduce losses due to stripping as the material falls through the water column. For hopper dredges, the spread of material on the bottom can be reduced by having the dredge come to a stop during placement.

Dredged material characteristics also contribute to mounding potential. Cohesive and noncohesive materials will tend to mound when dredged using mechanical means and point dumped (i.e., from a barge). Both cohesive and noncohesive material will tend to flow if hydraulically dredged and point dumped (i.e., discharged from a pipe). In cases where a pump-down pipe is incorporated for hydraulically dredged material, noncohesive material tends to mound, while cohesive material tends to flow.

Table 2 summarizes available information on the mounding or flowing characteristics of cohesive versus noncohesive sediments for various dredging and placement methods. This information can be used in evaluating various equipment and placement techniques for a given set of site conditions.

Considerations for Contaminated Material Dredging and Placement

Placement of contaminated material for a capping project should be accomplished so that the resulting deposit can be defined by monitoring and effectively capped. Therefore, the equipment and techniques for dredging, transport, and placement must be compatible with that of the capping material. Since capping is a contaminant control measure for potential benthic effects, the contaminated material should be placed such that the exposure of the material prior to capping is minimized. In most cases, the water column dispersion and bottom spread occurring during placement should also be reduced to the greatest possible extent. This minimizes the release of contaminants during placement and provides for easier capping. If the placement of the contaminated sediment has potentially unacceptable

Table 2
Flow Characteristics of Dredged Material Placed in Aquatic Sites (Shields and Montgomery 1994)

Dredged Material Characteristics	Placement Method: Point Dump	Placement Method: Pump Down
Nocohesive Material		
Mechanically Dredged	Tends to mound	Not applicable
Hydaulically Dredged	Tends to flow[1,2,3]	Tends to mound[4]
Cohesive Material		
Mechanically Dredged	Tends to mound[1,2]	Not applicable
Hydraulically Dredged	Tends to flow[1]	Tends to flow[2]

[1] JBF Scientific Corporation 1975.
[2] Morton 1983a.
[3] Sustar and Eker 1972.
[4] Nichols, Thompson, and Faas 1978.

water column impacts, controls to specifically reduce water column dispersion (for example, submerged discharge) may be required.

For LBC, the dredging equipment and placement technique for contaminated sediment must result in a tight, compact mound that is easily capped. Compact mounds generally result when the material is dredged and placed at or near its in situ density prior to dredging. This is most easily accomplished with mechanical dredging techniques and precision-point discharges from barges.

For CAD projects, the provision for lateral containment in the form of a bottom depression or other feature defines and limits the extent of bottom spread. For this reason, either mechanical dredging or hydraulic placement of the contaminated material may be acceptable for CAD. If the contaminated material is placed hydraulically, a suitable time period (usually a few weeks) must be allowed for settling and consolidation to occur prior to placement of the capping material to avoid potential mixing of the materials unless capped by slow sprinkling of sand.

Considerations for Capping Material Placement

Placement of capping material is accomplished so that the deposit forms a layer of the required thickness over the contaminated material. For most projects, the surface area of the contaminated material to be capped may be several hundred feet or more in diameter. Placement of a cap of required thickness over such an area may require spreading the material to some degree to achieve coverage.

The equipment and placement technique are selected and rate of application of capping material is controlled to avoid displacement or mixing with the previously placed contaminated material to the extent possible. Placement of capping material at equal or lesser density than the contaminated material or use of placement methods to spread thin layers to gradually build up the cap thickness generally meets this requirement. However, sand caps have been successfully placed over fine-grained contaminated material. Since capping materials are not contaminated, water column dispersion of capping material is not usually of concern (except for loss when slowly placing a sand cap); the use of submerged discharge for capping placement need only be considered from the standpoint of placement control.

Equipment and Placement Techniques

The equipment and placement techniques described in the following paragraphs apply to the contaminated dredged material to be capped as well as to the capping material, depending on the project conditions. Regardless of the equipment and placement techniques considered, the compatibility of contaminated material placement and capping operations must be determined considering the material characteristics and site conditions (Palermo 1991a,c).

Surface discharge using conventional equipment

Dredged material released at the water's surface using conventional equipment tends to descend rapidly to the bottom as a dense jet with minimal short-term losses to the overlying water column (Bokuniewicz et al. 1978; Truitt 1986a). Thus, the use of conventional equipment can be considered for placement of both contaminated and capping material if the bottom spread and water column dispersion resulting from such a discharge are acceptable.

The surface release of mechanically dredged material from barges results in a faster descent, tighter mound, and less water column dispersion as compared with surface discharge of hydraulically dredged material from a pipeline. Placement characteristics resulting from surface release of hydraulically dredged material from a hopper dredge fall between the characteristics resulting from surface release of hydraulically dredged material from barges and from surface discharge of hydraulically dredged material from a pipeline—that is, the descent is slower than the former but faster than the latter; the mound is looser than the former but tighter than the latter; and more water column dispersion results from the former than from the latter.

Field experiences with LBC operations in Long Island Sound and the New York Bight as described in Chapter 10 have shown that mechanically dredged silt and clay released from barges tend to remain in clumps during descent and form nonflowing discrete mounds on the bottom that can be effectively capped. Such mounds have been capped with both mechanically dredged material released from barges and with material released from hopper dredges (O'Connor and O'Connor 1983; Morton 1983a, 1987). In fact, mechanically dredged cohesive sediments often remain in a clumped condition, reflecting the shape of the dredge bucket. Mounds of such material are stable, resist displacement during capping operations, and present conditions ideal for subsequent LBC (Sanderson and McKnight 1986). However, these mounds may experience initial surface erosion due to irregular surface geometry and higher friction coefficients. A conceptual illustration showing the use of conventional equipment for capping is shown in Figure 3.

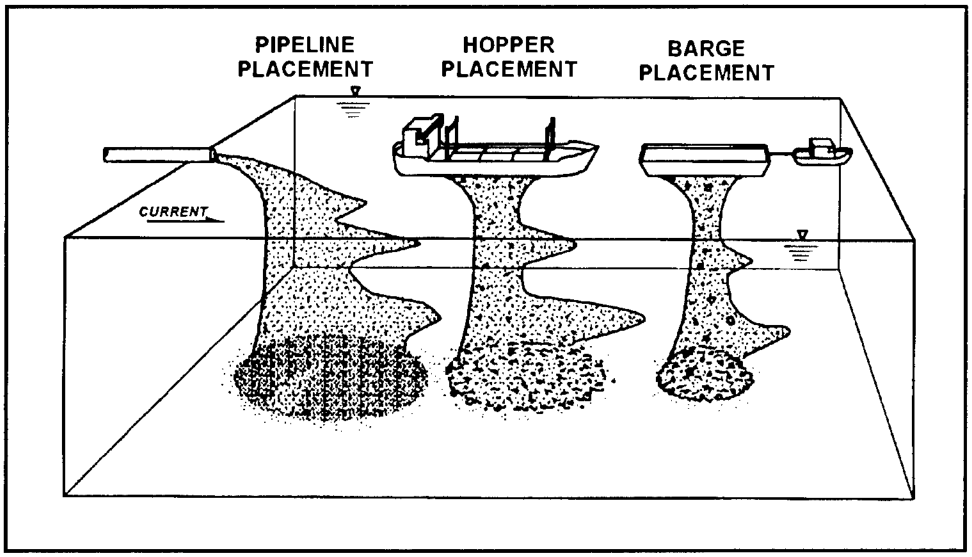


Figure 3. Conventional open-water placement for capping (after Palermo 1991c)

Spreading by barge movement

A layer of capping material can be spread or gradually built up using bottom-dump barges if provisions are made for controlled opening or movement of the barges. This can be accomplished by slowly opening a conventional split-hull barge over a period of tens of minutes, depending on the size of the barge and site conditions. Such techniques have been successfully used for controlled placement of predominantly coarse-grained, sandy capping materials (Sumeri 1989). The gradual opening of the split-hull or multicompartmented barges allows the material to be released slowly from the barge in a sprinkling manner. If tugs are used to slowly move the barge during the release, the material can be spread in a thin layer over a large area (Figure 4). Multiple barge loads are necessary to cap larger areas in an overlapping manner. The gradual release of mechanically dredged fine-grained silts and clays from barges may not be possible due to potential "bridging" action; that is, the cohesion of such materials may cause the entire barge load to "bridge" the split-hull opening until a critical point is reached at which time the entire barge load is released. If the water content of fine-grained material is high, the material exits the barge in a matter of seconds as a dense slurry, even though the barge is only partially opened.

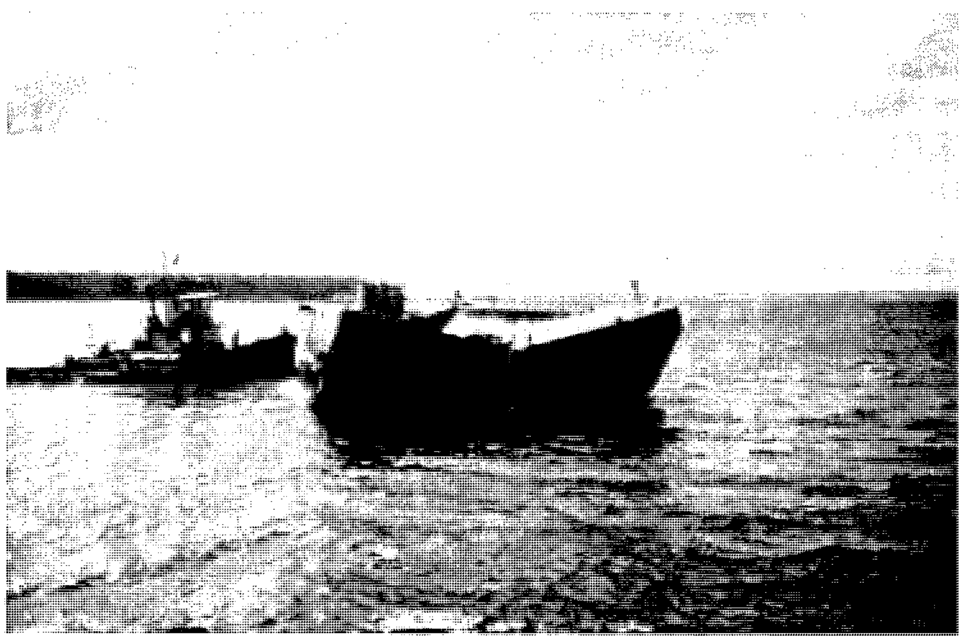


Figure 4. Spreading technique for capping by barge movement

Spreading of thin layers of cap material over large areas can also be accomplished by gradually opening a conventional split-hull barge while underway by tow. These techniques were used for in situ capping operations at Eagle Harbor, Washington (Sumeri 1995).

Hydraulic washing of coarse sand

Granular capping materials such as sand can be transported to a site in flat-topped barges and washed overboard with high-pressure hoses. Such an operation was used to cap a portion of the Eagle Harbor, Washington, Superfund site, forming a cap layer of uniform thickness (Figure 5) (Nelson, Vanderheiden, and Schuldt 1994). This technique produces a gradual buildup of cap material, prevents any sudden discharge of a large volume of sand, and may be suitable for water depths as shallow as 10 ft or less.

Spreading by hopper dredges

Hopper dredges can also be used to spread a sand cap. During the summer and fall of 1993, the Port Newark/Elizabeth capping project in New York Bight used hopper dredges to spread a sand cap over 580,000 cu yd of contaminated sediments. To facilitate spreading the cap in a thin layer (6 in.) to quickly isolate the contaminants and to lower the potential for resuspension of the contaminated material, conventional point dumping was not done. Instead, a split-hull dredge cracked the hull open 1 ft and released its load over a 20- to 30-min period while sailing at 1 to 2 knots. Also, as an alternative means of placing the cap, another dredge used pump-out over the side of the vessel through twin vertical pipes with end

Figure 5. Pressure-hose washing method of placement

plates to force the slurry into the direction the vessel was traveling. As with the cracked-hull method described above, injecting the slurry into the direction of travel of the vessel increased turbulence, reducing the downward velocity of the slurry particles and thus the potential for resuspension of the contaminated sediments. Computer models (see Chapter 6) were used to predict the width of coverage from a single pass and the maximum thickness produced (Randall, Clausner, and Johnson 1994).

Pipeline with baffle plate or sand box

Spreading placement for capping operations can be easily accomplished with surface discharge from a pipeline aided by an energy-dissipating device such as a baffle plate or sand box attached to the end of the pipeline. Hydraulic placement is well suited to placement of thin layers over large surface areas.

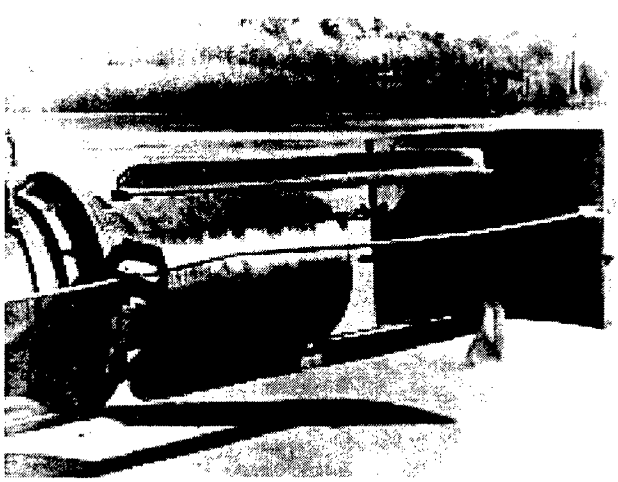


Figure 6. Spreader plate for hydraulic pipeline discharge

A baffle plate (Figure 6), sometimes called an impingement or momentum plate, serves two functions. First, as the pipeline discharge strikes the plate, the discharge is sprayed in a radial fashion; the discharge is allowed to fall vertically into the water column. The decrease in velocity reduces the potential of the discharge to erode material already in place. Second, the angle of the plate can be adjusted so that the momentum of the discharge exerts a force that can be used to swing the end of the floating pipeline in an arc. Such plates are commonly used in river dredging operations where material is deposited in thin layers in areas adjacent to the dredged channel (Elliot 1932). Such equipment can be used in capping operations to spread thin layers of material over a large area, thereby gradually building up the required capping thickness.

A device called a "sand box" (Figure 7) serves a similar function. This device acts as a diffuser box with baffles and side boards to dissipate the energy of the discharge. The bottom and sides of the box are constructed as an open grid or with a pattern of holes so that the discharge is released through the entire box. The box is mounted on the end of a spud barge so that it can be swung about the spud using anchor lines (Sumeri 1989).

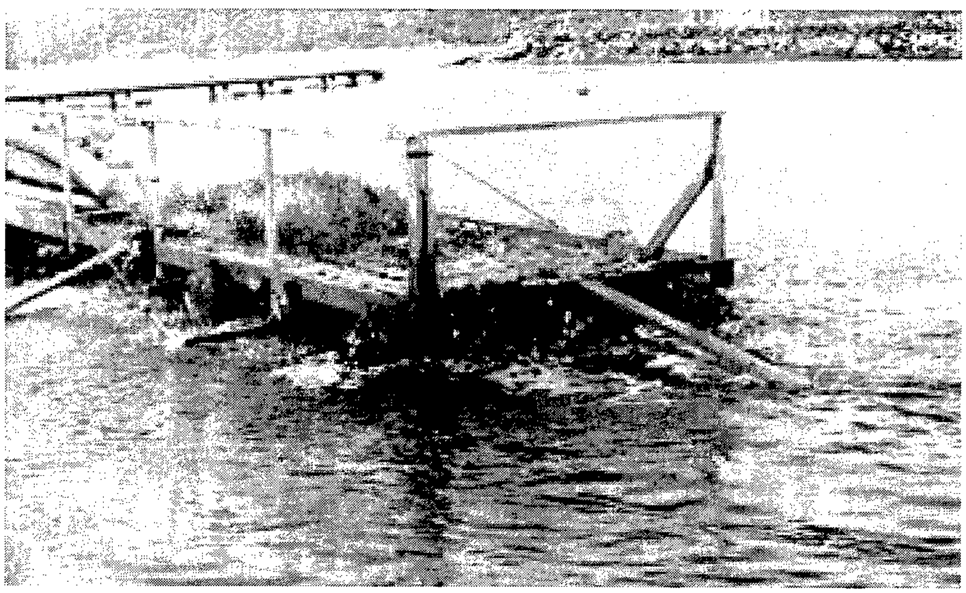


Figure 7. Spreader box or "sand box" for hydraulic pipeline discharge

Submerged discharge

If the placement of the contaminated sediment with surface discharge results in unacceptable water column impacts, or if the anticipated degree of spreading and water column dispersion for either the contaminated or capping material is unacceptable, submerged discharge is a potential control measure.

In the case of contaminated dredged material, submerged discharge serves to isolate the material from the water column during at least part of its descent. This isolation can minimize potential chemical releases due to water column dispersion and significantly reduce entrainment of site water, thereby reducing bottom spread and the area and volume to be capped. In the case of capping material, the use of submerged discharge provides additional control and accuracy during placement, thereby potentially reducing the volume of capping material required. Several equipment alternatives are available for submerged discharge (Palermo 1994) and are described in the following paragraphs.

Submerged diffuser

A submerged diffuser (Figures 8 and 9) can be used to provide additional control for submerged pipeline discharge. The diffuser consists of conical and radial sections joined to form the diffuser assembly, which is mounted to the end of the discharge pipeline. A small discharge barge is required to position the diffuser and pipeline vertically in the water column. By positioning the diffuser several feet above the bottom, the discharge is isolated from the upper water column. The diffuser design allows material to be radially discharged parallel to the bottom and with a reduced velocity. Movement of the discharge barge can serve to spread the discharge to cap larger areas. The diffuser can also be used with any hydraulic pipeline operation including hydraulic pipeline dredges, pump-out from hopper dredges, and reslurried pump-out from barges.

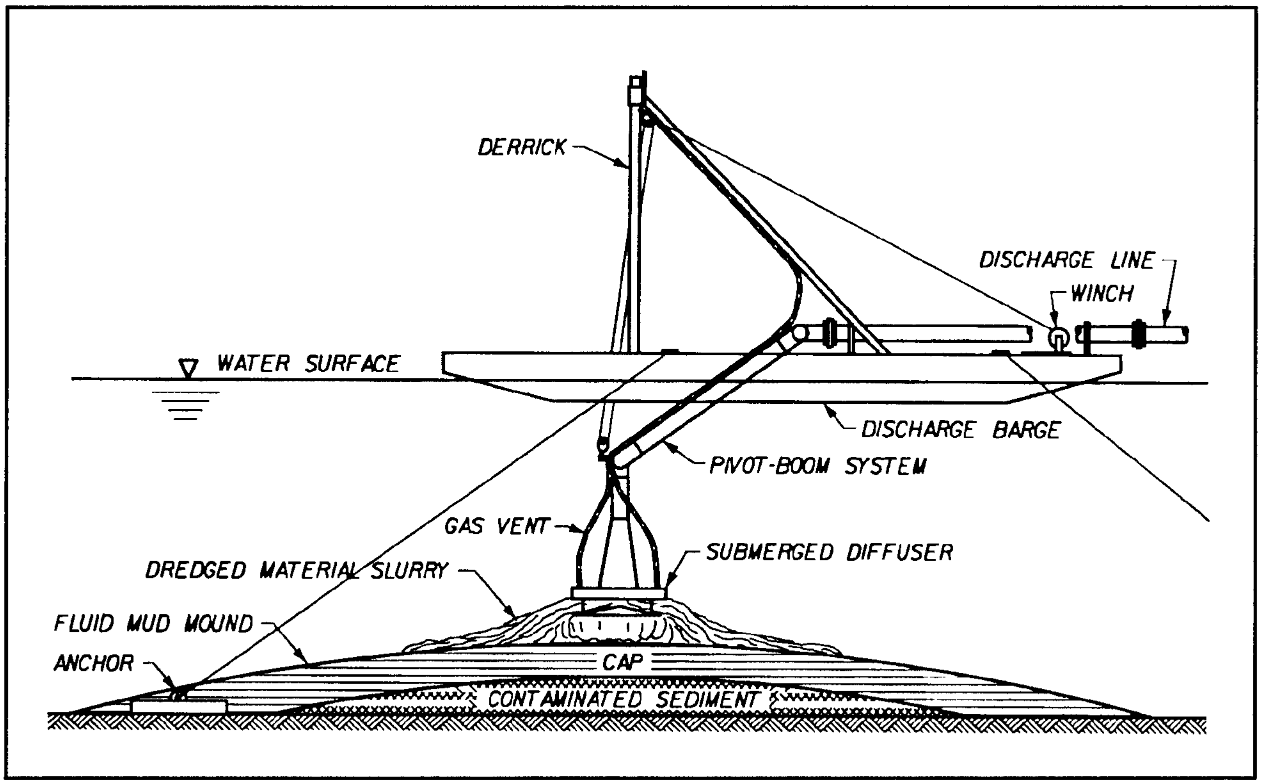


Figure 8. Submerged diffuser system, including diffuser and discharge barge

A design for a submerged diffuser system was developed by JBF Corporation as a part of the USACE Dredged Material Research Program (DMRP) (Barnard 1978; Neal, Henry, and Greene 1978). This design consists of a funnel-shaped diffuser oriented vertically at the end of a submerged pipeline section that discharges the slurry radially. The diffuser and pipe section are attached to a pivot boom system on a discharge barge.

Design specifications for this submerged diffuser system are available (Neal, Henry, and Greene 1978; Palermo, in preparation).

A variation of the DMRP diffuser design was used in an equipment demonstration at Calumet Harbor, Illinois. Although not constructed to the DMRP specifications, this diffuser significantly reduced pipeline exit velocity, confined the discharged material to the lower portion of the water column, and reduced suspended solids in the upper portion of the water column (Hayes, McLellan, and Truitt 1988). Diffusers have been constructed using the DMRP design and used at a habitat creation project in the Chesapeake Bay (Earhart, Clark, and Shipley 1988) and at a Superfund pilot dredging project at New Bedford Harbor, Massachusetts, involving subaqueous capping (USACE 1990). At the Chesapeake Bay site, the diffuser was used to effectively achieve dredged material mounding prior to placement of a layer of oyster shell to provide substrate for attachment of oyster spat. At the New Bedford site, the diffuser was used to place contaminated sediment in an excavated subaqueous cell and was effective in reducing sediment resuspension and in controlling placement of contaminated sediment. However, capping operations were started immediately, and positioning of the diffuser within 2 ft of the contaminated sediment layer resulted in mixing of cap sediment with contaminated sediment. These results indicate the need for a high degree of control when capping newly placed slurry with a diffuser and the need for adequate time to allow for some self-weight consolidation of slurry material prior to capping. Diffusers have also been successfully used to place and cap contaminated sediments at projects in Rotterdam Harbor in the Netherlands (d'Angremond, de Jong, and de Waard 1986) and in Antwerp Harbor in Belgium (Van Wijck and Smits 1991).

Figure 9. Submerged diffuser

Sand spreader barge

Specialized equipment for hydraulic spreading of sand for capping has been used by the Japanese (Kikegawa 1983; Sanderson and McKnight 1986). This equipment employs the basic features of a hydraulic dredge with submerged discharge (Figure 10). Material is brought to the spreader by barge, where water is added to slurry the sand. The spreader then pumps

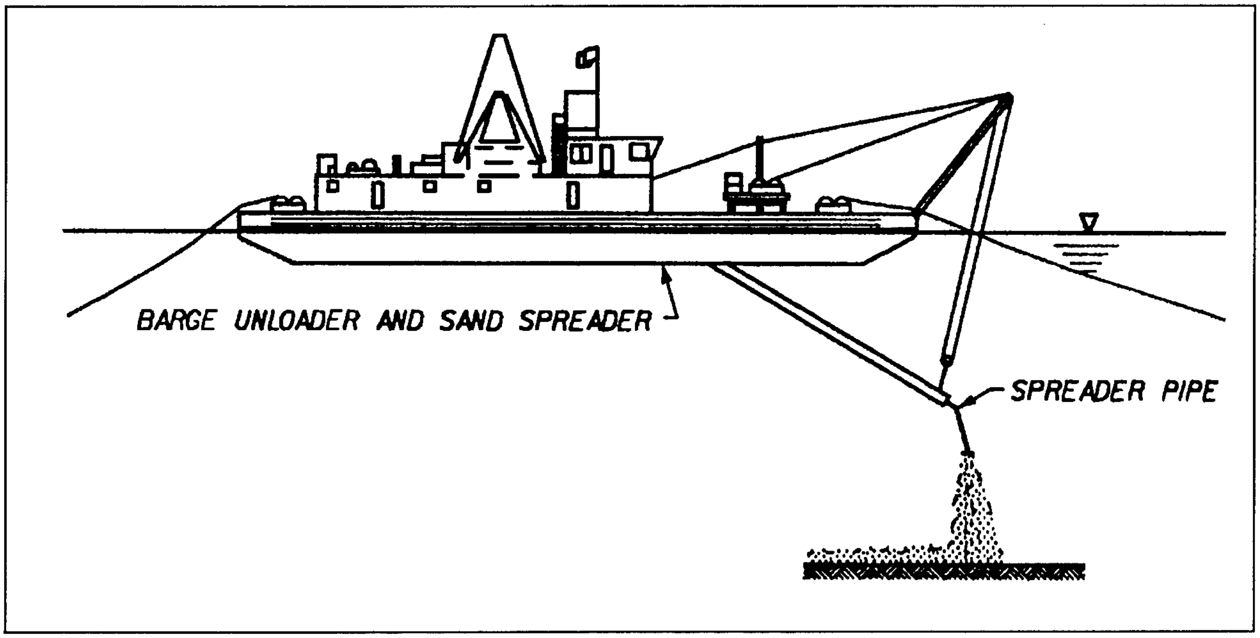


Figure 10. Hydraulic barge unloader and sand spreader barge (from Kikegawa 1983)

the slurried sand through a submerged pipeline. A winch and anchoring system are used to swing the spreader from side to side and forward, thereby capping a large area.

Gravity-fed downpipe (tremie)

Tremie equipment can be used for submerged discharge of either mechanically or hydraulically dredged material. The equipment consists of a large-diameter conduit extending vertically from the surface through the water column to some point near or above the bottom. The conduit provides the desired isolation of the discharge from the upper water column and improves placement accuracy. However, because the conduit is a large-diameter straight vertical section, there is little reduction in momentum or impact energy over conventional surface discharge. The weight and rigid nature of the conduit require a sound structural design and consideration of the forces due to currents and waves.

The Japanese have used tremie technology in the design of specialized conveyor barges for capping operations (Togashi 1983; Sanderson and McKnight 1986). This equipment consists of a tremie conduit attached to a barge equipped with a conveyor (Figure 11). The material is initially placed in the barge mechanically. The conveyor then mechanically feeds the material to the tremie conduit. A telescoping feature of the tremie allows placement at depths of up to approximately 40 ft. Anchor and winch systems are used to swing the barge from side to side and forward so that larger areas can be capped, similar to the sand spreader barge.

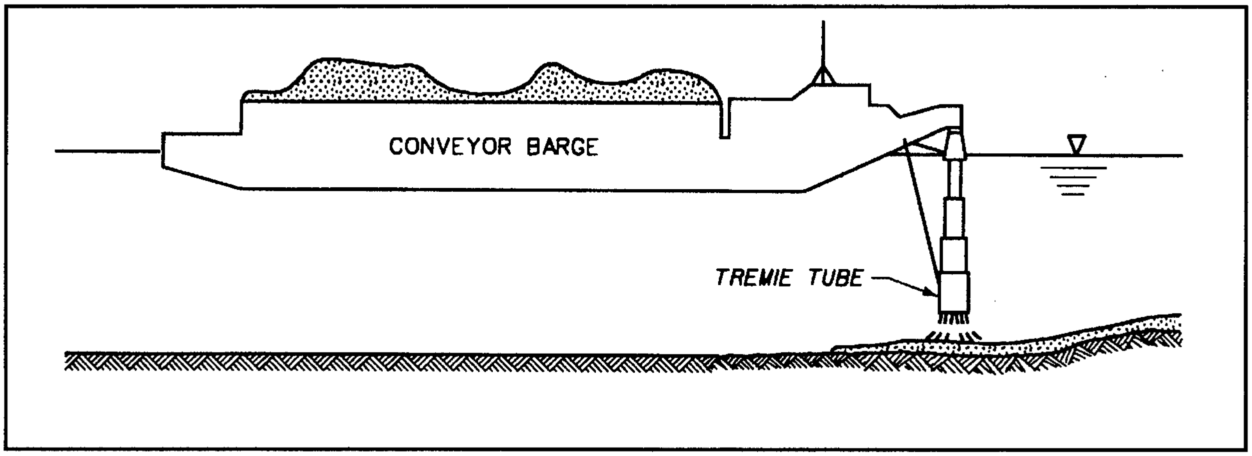


Figure 11. Conveyor unloading barge with tremie (from Togashi 1983)

Hopper dredge pump-down

Some hopper dredges have pump-out capability by which material from the hoppers is discharged like a conventional hydraulic pipeline dredge. In addition, some have further modifications that allow pumps to be reversed so that material is pumped down through the dredge's extended dragarms. Because of the expansion at the draghead, the result is similar to using a diffuser section. Pump-out depth is limited, however, to the maximum dredging depth, typically about 60-70 ft.

Use of geosynthetic fabric containers (GFCs)

Geosynthetic fabric containers (GFCs) are containers made from geosynthetic fabric that line barges. Contaminated dredged material is placed in the GFCs (either mechanically or hydraulically), which are then sewn closed prior to placing the GFC at the disposal site. The GFC acts as a filter cloth, allowing the water to escape but retaining almost all the fine (silt and clay) particles. Containing contaminated sediments in GFCs for subsequent placement from split-hull barges offers the potential to eliminate the wide, thin apron normally associated with conventional bottom dumping of fine-grained sediments, thus substantially reducing the volume of cap material required and reducing the potential for contaminated sediments to extend beyond the site boundary. GFCs also have the potential to eliminate water quality problems at the disposal site by essentially eliminating loss of fine sediment particulates and associated contaminants to the water column.

As of 1996, GFCs have been used on only two USACE projects. The first was construction of training dikes in the lower Mississippi River (Duarte, Joseph, and Satterlee 1995), and the second was placement of sandy sediment with heavy metal contaminants in a CAD site in Los Angeles Harbor (Mesa 1995). At present, costs of using GFCs are much higher than for conventional bottom placement due to costs of materials, increased dredge cycle times, increased labor requirements associated with installation of the GFCs in the barge, and possible reductions in dredge production rate. There are also considerable engineering problems associated with successfully deploying the GFCs without having them rupture. The decision to use GFCs for a capping project should be made based on the benefits versus costs rather than a blanket decision based solely on the desire to reduce losses to the water column. Data collected from a 1996 demonstration of GFCs conducted jointly by New York District and the Port of New York and New Jersey should provide additional data on GFC viability. However, additional research is needed to better define GFC abilities to reduce water column losses of contaminants and to refine engineering aspects associated with deployment. Clausner et al. (1996) summarizes the present state of the art on using GFCs with contaminated sediments.

Geotechnical Compatibility of Operations

Geotechnical considerations are important in capping because of the fact that most contaminated sediments are fine-grained silts and clays and usually have high water contents and low shear strengths in situ. Once sediments are dredged and placed at a subaqueous site, the water contents may be initially higher and the shear strengths initially lower than in situ.

Capping involves the placement of a layer of clean sediment of perhaps 3 ft or more in thickness over such low-shear-strength material. Field-monitoring data have definitively shown that contaminated sediments with low strength have been successfully capped with slow placement of sandy material. The geotechnical considerations involved can be described in terms of the ability of a capped deposit with given shear strength to support a cap from the standpoint of slope stability and/or bearing capacity (Ling et al. 1996).

Only limited geotechnical evaluations have been considered in past capping projects. In virtually all of past capping projects the design was empirical, i.e., prior field experience showed that it worked, but actual geotechnical design calculations were not conducted. Limited research on this topic is now underway, and more detailed guidance on this aspect of capping design will be provided in the future. Additional research is also planned to define geotechnical design for bearing capacity, slope failure, loading rate, impact penetration, etc. For the present time, geotechnical aspects of capping-project design are limited to the evaluation of compatibility of equipment and placement technique for contaminated and capping sediments with sediment properties. An acceptable match of equipment and placement techniques for contaminated and capping material is essential to avoid displacement of the previously placed contaminated material or excessive mixing of capping and contaminated material. The availability of certain types of equipment and the distance between dredging and placement sites may also influence selection of compatible equipment types.

The nature of the materials (cohesive versus noncohesive), the dredging method (mechanical versus hydraulic), the method of discharge (instantaneous dump from hopper dredge or barge versus continuous pipeline), the location of discharge (surface or submerged), frequency and scheduling of discharges, physical characteristics of discharge material, and other factors influence the tendency of the material to mound or flow and the tendency to displace or mix with material already placed. The primary concern with compatibility relates to geotechnical considerations and the ability of the contaminated material to support the cap, considering the material characteristics and dredging and placement techniques.

In general, if the contaminated material were mechanically dredged and released from barges, the capping material can be similarly placed or could be placed hydraulically. However, if the fine-grained contaminated material were hydraulically placed, then only hydraulic placement of the capping material is appropriate due to the potentially low shear strength of the contaminated material. An exception may be the slow controlled placement of a sand cap. The exposure of the contaminated material to the environment and need to allow consolidation of the contaminated material to occur prior to cap placement must be balanced in scheduling both placement operations.

The flow characteristics data in Table 2 plus the field experience with capping operations to date were used to develop the compatibility information shown in Table 3 (Palermo 1994). This table may be used as an initial guideline in selecting compatible equipment and placement operations. It is anticipated that the table will be updated as more field experience and monitoring data become available for a wider range of project conditions.

Exposure Time Between Placement of Contaminated Material and Cap

Scheduling of the contaminated material placement and capping operation must satisfy environmental and engineering/operational constraints. Following the placement of contaminated material, there is necessarily some time lag prior to completion of the capping operation. This results in some degree of unavoidable exposure of colonizing benthic organisms to surficial portions of the contaminated material deposit. Placement of the cap material must begin as soon as practicable following completion of the placement of contaminated material to minimize this exposure time. However, a delay of 1 to 2 weeks is desirable from an engineering standpoint to allow initial consolidation of the contaminated material to occur, with an accompanying increase in shear strength, prior to placement of the cap.

Factors to consider in arriving at an appropriate exposure time are as follows:

a. Potential effects due to exposure prior to capping.

b. Estimates of time required for initial colonization of the site by benthic organisms.

Table 3
Compatibility of Capping and Contaminated Material Placement Options

Contaminated Material		Cap Material: Hopper or Barge Spread	Barge Point Disposal: Sandy[1]	Barge Point Disposal: Clumps[2]	Barge Point Disposal: Maint. silt/clay	Hopper Point Disposal: Sandy	Hopper Point Disposal: Clay balls[3]	Hopper Point Disposal: Slurry[4]	Pipeline: Sandy	Pipeline: Clay balls	Pipeline: Slurry
Pipeline[5]	CAD slurry[6]	I[7]	I	I	I	I	I	I	C[8]	I	C
	Slurry clay balls	C	C	I	C	C	C	C	C	C	C
	Sandy	C	C	C	C	C	C	C	C	C	C
Hopper[9]	CAD slurry	I	I	I	I	I	I	I	C	I	C
	Slurry clay balls	C	C	I	C	C	C	C	C	C	C
	Sandy	C	C	C	C	C	C	C	C	C	C
Barge[10]	Maint. silt/clay	C	I	I	C	I	I	C	C	I	C
	Clumps	C	C	C	C	C	C	C	C	C	C
	Sandy	C	C	C	C	C	C	C	C	C	C

Note: The compatibility designation of incompatible (Footnote 7) and compatible (Footnote 8) is a general recommendation. Site-specific or material-specific considerations could over-ride these general designations.

1 Sand - Predominantly cohesionless material (sand).
2 Clumps - Predominantly fine-grained material mechanically dredged with in situ water content sufficiently low to cause clumping to occur and be maintained.
3 Clay balls - Small balls of clay formed during hydraulic dredging of fine-grained material.
4 Slurry - Predominantly fine-grained material hydraulically dredged (pipeline or hopper) with water content sufficiently high to allow slurry.
5 Pipeline - Material is used by hydraulic pipeline dredge (slurried) with direct pipeline transport for placement. May include use of submerged diffusers. Would include hopper dredge or barge pump-out (reslurried). For capping operations, appropriate means to spread the material is recommended. Clay balls are assumed to act as slurry.
6 Contaminated material in slurry form placed without lateral confinement (CAD) is not recommended for a capping project.
7 Generally incompatible.
8 Generally compatible.
9 Hopper - Material is dredged by trailing suction hopper (slurried) and transported directly to site for surface release. This would also include hydraulically filled barges.
10 Barge - Material is mechanically dredged, placed in barges, and transported to site for surface release (no slurry). Could either point dump or incorporate provision to sprinkle or spread material by controlled release from the barge.

c. Estimates of time required for initial consolidation of the contaminated material due to self-weight.

d. Monitoring requirements prior to cap placement.

The process of recolonization by opportunistic species may begin as soon as contaminated material placement operations are completed (Rhoads and Boyer 1982; Rhoads and Germano 1982). However, recruitment and colonization processes for many assemblages of coastal benthic organisms show definite seasonal peaks, usually a primary peak in spring and a secondary peak in fall. For example, Scott et al. (1987) determined that recolonization at a Long Island Sound dredged material disposal site showed peaks during October and December of separate years. Ideally, to minimize exposure durations of benthic organisms, placement of contaminated material and initiation of cap construction should occur prior to the onset of a seasonal recruitment pulse. During intervals between peaks, rates of colonization should be sufficiently slow to assume minimal exposure over a period of 3 to 4 weeks. Once cap construction has begun, those early colonizers of the contaminated deposit will be buried and thus physically isolated. Assuming that cap placement proceeded at a reasonable rate, it would be unlikely that any bioaccumulation that had occurred prior to cap placement would result in unacceptable effects.

Some delay between completion of contaminated material placement and initiation of capping is desirable from an engineering standpoint. Consolidation of the contaminated material and a corresponding increase in density and strength occur due to the weight of the material as it is placed in the deposit. This process is called self-weight consolidation. The contaminated material should be allowed to undergo initial self-weight consolidation prior to capping to increase its stability and resistance to displacement during cap placement. This is especially important for slurried materials placed by pipeline or by hopper dredge. For slurried materials, a large portion of the self-weight consolidation occurs within a few weeks of placement. Mechanically dredged materials placed by barge release are initially deposited at essentially the same density at which they were dredged, and the potential degree of self-weight consolidation is less than for slurried materials.

Monitoring is required to determine the areal extent of the contaminated deposit prior to capping. Surveys and other sampling and monitoring activities may require several weeks to complete. An appropriate delay between contaminated material placement and capping must balance environmental exposure with the engineering requirements of stability and scheduling constraints for monitoring and dredging required for capping. If appropriate precautions are taken to schedule the lag time for consolidation during periods of low benthic recruitment, a period of 3 to 4 weeks between completion of contaminated sediment placement and initiation of capping should have minimal environmental effect.

Navigation and Positioning Controls

Once the dredging equipment and placement techniques and potential capping site have been selected, the needs for navigation and positioning equipment and controls can be addressed. The objective here is to place both the contaminated and capping materials (whether by the bargeload, hopperload, or by pipeline) at the desired location in a consistently accurate manner so that adequate coverage by the cap is attained.

Navigation (the science of getting vessels from place to place) and positioning (accurately locating an object) are two of the most important factors in designing and implementing a successful capping project. Accurate positioning is necessary for any dredged material disposal operation in open water to ensure the material is located within the appropriate disposal site boundaries. For a capping project, contaminated material placement requirements are similar, but may be more restrictive in that placement of material within a specified radius, along a given linear transect, or similar location may be required. For the capping phase, materials must be adequately placed to cover the previously placed contaminated material. Therefore, knowing the precise navigation and positioning is of principal importance to allow proper capping.

For pipeline placement in shallow water, the desired positioning of the pipeline discharge can be maintained with little difficulty. Accurate navigation to the placement site and precise positioning during material placement by bottom-dump barge or hopper dredge is more difficult, especially for sites well offshore.

There exist a number of methods to position barges and hopper dredges for placement of dredged and cap material. One of the most common is placement near a taut-moored buoy. The other common methods are electronic positioning systems (EPS) including range-azimuth, LORAN-C (low-frequency), microwave (high-frequency), and differential global positioning system (DGPS). Detailed guidance on all aspects of hydraulic surveying to include these positioning methods is found in USACE Engineer Manual 1110-2-1003, Hydrographic Surveying (USACE 1991). Estimated positional accuracy for each of the electronic positioning systems is shown in Table 4.

Taut-moored buoys

Taut-moored buoy positioning requires locating and placing a buoy anchored and moored in such a way as to minimize buoy movement during placement operations. At USACE New England Division[1] disposal sites in 20- to 25-m depths, the taut-moored buoy has a watch circle diameter of about 20 m. Positioning of dredged material placement equipment is specified to occur within some distance of the buoy during disposal. Electronic placement errors are minimized with this method (except for initial

[1] The New England Division has been changed to the New England District.

Table 4
Accuracy of Common Positioning Systems (from USACE EM 1110-2-1003)

Positioning System	Estimated Accuracy, Meters RMS
Range-azimuth	0.5 to 3
LORAN-C (low-frequency)	50 to 2,000
Microwave (high-frequency)	1 to 4
GPS	50 to 100
DGPS	0.1 to 1.0

buoy placement), and the exact dredged material placement location is subject only to the tug or dredge captain's discretion of buoy offset distance. Placement offset from the buoy depends on local weather and safety concerns. Specific guidance varies from site to site, but the New England Division has found success with specifying placement within 25 to 50 m of buoy location depending on weather/sea conditions. Experience has shown that this type of placement tends to concentrate material at one point or in a transect along the direction of travel of the tug and barge. This factor should be taken into consideration in buoy placement or in placement specifications for tug operators.

Range-azimuth

Range-azimuth positioning is a traditional surveying technique where a shore-based station (transit, theodolite, or total station) is used to determine an angular azimuth to the vessel of interest. This azimuth is then coupled with an electronically determined distance obtained from an electronic distance measurement (EDM) device (microwave EPS, laser EDM, or infrared EDM) at the same location. Range-azimuth positioning is very accurate, but because of the shore station requirement, it is applicable only at sites where dredged material placement is relatively close to shore (USACE EM 1110-2-1003). Range-azimuth positioning has been used by the Seattle District for several capping projects, e.g., the Duwamish Water project in 1984 (Truitt 1986b) and the Denny Way project (Sumeri 1989).

Electronic positioning systems (EPS)

Generally, the higher the frequency is of EPS, the more accurate the positioning. LORAN-C is a low-frequency, time-differencing hyperbolic phase/pulse system that triangulates vessel position based on relative distances from shore-based stations. Because LORAN-C is a low-frequency system, it has a low accuracy and is the least desirable for vessel positioning. For hydrographic surveys, LORAN-C is only suitable for Class 3 surveys (reconnaissance level), and absolute accuracy without onsite calibration is 0.25 mile (USACE EM 1110-2-1003). Therefore, LORAN-C is not recommended as the sole navigation and positioning system for a capping project, and its use with other systems (e.g., a taut-moored buoy) should be thoroughly scrutinized. Some of the earlier less than fully successful capping projects conducted by the New England Division, where the initial cap did not fully cover the contaminated sediments, were due in part to problems with LORAN-C (SAIC 1995a). High-frequency systems (particularly UHF and microwave) are more commonly used for positioning offshore vessels. In general, operating distances are limited to radio line of sight, which allows use in riverine, harbor, and coastal locations (USACE EM 1110-2-1003).

The most accurate positioning system and rapidly becoming the standard for horizontal positioning is the satellite-based global positioning system (GPS). The NAVSTAR GPS is a real-time, passive satellite-based navigation system operated by the U.S. Department of Defense. The 24 GPS satellites orbit the earth such that from any place on earth at any time, at least four (the minimum required by the GPS receiver for positioning) are visible above the horizon. Standard GPS accuracies (50 to 100 m with DoD selective availability) are not ideal for capping operations. Increased accuracies can be obtained with differential GPS (DGPS). DGPS uses the same NAVSTAR GPS satellite system but requires two receivers with precise coordinates of one of the receivers known (usually a fixed land-based receiver). Accuracies of DGPS range from 0.1 to 1.0 m (USACE EM 1110-2-1003) (Hales 1995).

Kinematic DGPS is an additional refinement of DGPS that can provide accuracies of a few centimeters (USACE EM 1110-2-1003) and thus can eliminate the vertical datum problem that often occurs in the open ocean.

Kinematic DGPS is not yet routinely available, but the rapidly advancing EPS market may soon make its use commonplace. One of the more severe limitations of kinematic DGPS is the need to have the fixed shore station within 12 to 20 km of the surveying platform. However, industry advances will likely extend this distance.

An additional factor that should be considered in barge positioning is the placement of receiving/transmitting equipment on the barge or vessel. For instance, when a barge is being towed to the disposal site by a tug, there may be significant offsets between actual material disposal location and positioning antennae. If the positioning antennae is located on the tug, then the recorded placement location may differ by as much as 200 m from the actual placement due to offsets from the positioning antenna on the tug to the center of the barge. In addition, there may also be lateral offsets from the vessel track line that are on the order of a barge width. Therefore, for most capping projects where placement location is critical and will be recorded, it is recommended that the antennae be located on the barge. To be most effective, the EPS requires a visual display in the vessel's pilot house to accurately navigate and position the vessel.

Placement Options, Restrictions, and Tolerances

Several options are possible for placement of materiel using hopper dredges, barges, or pipeline dredges, depending on the particular needs for the project. These include stationary placement, placement at multiple points or along multiple lanes, or options aimed at spreading materials over large areas.

Stationary placement

Stationary placement is where the tug/barge or hopper dredge comes to essentially a complete stop for disposal. This method is ideal for concentrating the material to minimize mound spread. Dredged material will settle to the bottom without the imparted vessel velocity and associated turbulence and thus reduce total mound coverage. On its capping projects, the New England District has specified that the dredged material be placed while the barge is stationary or moving at less than 2 knots. The disadvantage of this method is the loss of vessel control by the operator during placement. Most operators prefer some forward movement of the vessel, particularly if waves, winds, and/or currents are strong enough to affect positioning. Vessel speeds up to 2 to 3 knots are preferred in the open ocean. However this scenario will increase the mound spread as the material is released over a greater area. In some cases this greater spread may be desirable to prevent creation of too much relief or to spread material evenly over a larger disposal area.

The time required for material to exit a barge or hopper should also be considered when specifying stationary or moving placement. Material exit time depends on the barge opening width, time to open, and type of material being placed. In general, barges open in 20 to 60 sec to a width of approximately the bin width. Barge modifications (including installation of false sides) can be made to effectively increase the opening width/bin width ratio thus facilitating material exit, though this is an extreme (and costly) modification. Typically, sandy material will exit the barge in 30 sec to 2 min, and fine-grained material will take 10 to 30 sec to exit. For split-hull hopper dredges, exit time can take from 3 to 5 min for sandy material, with fine-grained material exiting in roughly 30 sec, with silty sand mixtures exiting in about 2 to 5 min. Hopper dredges with doors and pocket barges require longer times for the material to exit. For example, the STUYVESANT (industry hopper) has 20 hopper doors, and sandy material takes approximately 5 min to exit (Sanderson and McKnight 1986).

An often encountered problem during the disposal phase is that as the hull is opened and material begins to exit the barge, some material will form a bridge across the hull opening and thereby reduce the rate of discharge. Additionally, the material may bridge to the extent that it will not fall until the hull has opened beyond the angle of repose of the material. When this occurs, this bridged material can discharge quickly and exit the barge with a large initial velocity. The net effect can be an increased impact velocity on the bottom, which may displace previously placed material (Parry 1994). Additional discussion of this phenomena is provided later in this section. Bridging of sand over the hull opening is typically much less of a problem in modern hopper dredges that have water cannons in the hoppers to help fluidize the sand.

Barge towing and positioning are generally a factor of weather conditions. In good weather, barges may be transported and positioned with a tug directly alongside. This allows for more precise dump positioning. Also, if the barge is under tow, the line length may be as short as 30 or 45 m with lateral offsets on the order of one barge width. In poor weather, the tow length may be increased to 175 to 300 m where lateral offsets may be several barge widths.

For even placement of material around a point, vessel approach headings should be varied. Vessel operators generally prefer to approach the disposal site from the direction of travel to the site because that direction affords the shortest time to travel and dispose. However, continuous dumping along one transect may concentrate material in a manner or location that is less than ideal for the capping project. When weather permits, approach direction should be specified so that the most even coverage of dredged material can be accomplished. But, for poorer weather conditions, operators should be afforded the flexibility to approach the placement area from the safest direction based on the prevailing winds and waves at that time.

Use of multiple disposal points or lanes

For large projects (say 100,000 to 200,000 m^3 or more) in shallow water (say 20 m and less), point dumping of contaminated material at a single location may create a mound unacceptably tall. To avoid this, placement can be divided among multiple buoy locations to create a larger (footprint) but less thick mound. This was done for the 1993 New Haven Harbor Project (Fredette 1994). The other option is to place material along a line or in lanes. For example, the 1993 Port Newark/Elizabeth project had an EPA Region II restriction not to have the capped mound extend above the 23-m (75-ft) depth contour. Because the existing depth averaged about 25 m (83 ft), point dumping the 448,000 m^3 (586,000 yd^3) of contaminated dredged material would have created a mound extending well above the 23-m depth restriction. To keep the mound elevation below the limit, a triangular mound was designed, with three lanes with a width of 150 m (500 ft) wide by 350 to 450 m (1,150 to 1,480 ft) long (see additional discussion in Chapters 6 and 10). To assist the contractor in siting the placements, each apex of the triangle had taut-moored buoys. To reduce the chance of placing material outside the lanes, the contractor was directed to dispose of all material within 60 m (200 ft) of an imaginary line connecting the apex buoys. Additional details on this project can be found in Chapter 10.

For capping projects, both point dumping and spreading material over specific lanes have been used, sometimes both on the same project. For small projects (say 25,000 m^3 or less) where the contaminated sediment mound was created by point dumping at a taut-moored buoy, the New England District will place the majority (say 65 to 70 percent) of the capping material in similar fashion. However, the capping material is placed within 50 to 75 m of the buoy as opposed to the 25-m limit used for the contaminated material. The remaining 30 to 35 percent of the material is spread around the outer edge of the mound, say 100 to 150 m from the buoy.

Spreading over large areas

For larger projects, a series of specific lanes can be defined to spread the capping material. This technique is generally used when the sand is sprinkled. The sprinkling can be accomplished by cracking the hull of the barge or split-hull hopper dredge or by direct pumpout from a hopper through over-the-side pipes. The most straight-forward method to determine lane spacing for the cracked-hull technique is to compute the footprint from an individual load using either the Multiple Dump Fate of Dredged Material (MDFATE) or Short-Term Fate (STFATE) model (see Chapter 6 and Appendixes D and E). Of interest will be the footprint's maximum thickness, maximum width, and width at 0.5 the maximum thickness. Table 5 shows the results of MDFATE runs used to design the capping operation for the Port Newark/Elizabeth project. Based on this information, disposal lanes 30 m (100 ft) wide, or approximately equal to the maximum width of the footprint predicted by the model lanes, were

Table 5
Summary of Modeling Results for Capping Contaminated Sediments Using the Split-Hull Hopper Dredge Dodge Island and Hopper Barge Long Island

Disposal Type	Dredge Speed m/s	Disposal Time min	Maximum Thickness, cm	Maximum Width m	Width at 0.5 Max Thickness, m
Split-Hull Hopper Dredge Dodge Island					
Cracked hull	1.54	20	4.3	32.0	18.3
Cracked hull	1.54	30	2.7	32.0	18.3
Cracked hull	1.03	20	6.4	41.0	18.8
Cracked hull	1.03	30	4.3	32.0	18.3
Hopper Barge Long Island					
Counterflow	0.51	120	7.3	155.4	64.0
Counterflow	1.03	120	3.0	155.4	82.2
Counterflow	0.51	180	4.9	137.2	64.0
Counterflow	1.03	180	2.0	137.2	82.2
Counterflow	0.51	180	4.9	137.2	64.0
Counterflow	1.03	180	2.0	137.2	82.2

selected for the split-hull hopper dredge Dodge Island, which started the capping operation with the goal of quickly covering the contaminated mound with 15 cm (6 in.) of sand cap. Variations in the vessel's track line down the lane were expected to spread the material evenly over the area. Sediment profile image (SPI) profiles (see Chapter 9) at a spacing of a 5-m run perpendicular to the lanes conducted after a few passes had been made showed no area without sand and most areas to have a 15-cm (6-in.)-thick cover, apparently confirming the model predictions. Lanes 75 m (250 ft) wide were selected for the hopper barge Long Island. This value is about equal to the width at 0.5 of the maximum thickness. The majority of the cap was placed with the Long Island. See Chapter 10 for additional details on this project.

Several factors have to be considered when using disposal lanes for cap placement. Hopper dredges have superior seakeeping abilities compared with towed barges and thus will be better suited to open-ocean placement. Towed barges for lane disposal probably should be restricted to protected areas. When the cracked-hull technique is used, once the hull is cracked it cannot be closed until the vessel is empty. Thus, when the vessel reaches the end of a line, it continues to discharge cap material while turning. So, to reduce the spread of cap material beyond the contaminated footprint, the vessel should turn before reaching the edge of the contaminated material. It is likely more effective to cap the outer edge of a contaminated mound using a series of straight segments around the perimeter of the footprint. Also, while a vessel that is using direct pump-out to discharge material can stop the pump during turns, the dredge operators would much prefer to keeping pumping. Thus, similar considerations will have to be made regarding where the turn is conducted.

Turning radius is another factor that needs to be considered for cap placement using disposal lanes. Modern hopper dredges have bow thrusters and can turn in less than their own length; therefore, they can often proceed down adjacent disposal lanes. Older hopper barges and less maneuverable hopper dredges have larger turning radii and therefore may only be able to cap every 2nd or 3rd disposal lane. This is not a problem, but requires more accurate record keeping to confirm no lanes are missed. The decision on how the dredge or barge is operated, i.e., adjacent lanes, or every 2nd, 3rd, 4th lane, etc., should be made in consultation with the operator. Keeping a record of track plots is highly recommended. In protected waters, a 1,000-m^3 towed hopper barge needs about 120 m to turn while maintaining speed and control (Parry 1994). Because of individual variations between vessels, it is prudent to consult with the vessel operators early on in the process to obtain the best estimates of sea-keeping abilities turning radii, etc.

How long it takes to discharge the capped material is another factor to be considered for cap "sprinkling." When the Dodge Island cracked its hull 0.3 m (1 ft) during the Port Newark/Elizabeth project, the 2,000-m^3 (2,600-yd^3) load of sand exited in 20 to 30 min, translating to a rate of 65 to 100 m^3/min. During direct pump-out, the Long Island emptied its roughly 9,600-m^3 load in 2 to 3 hr, translating to a discharge rate of 53 to 89 m^3/min. Hopper dredges can use their water cannons to produce reasonably continuous discharge rates. In fact, they can turn off their water cannons to reduce the discharge rate during turns.

Conversely, it is much more difficult to control the rate sand is discharged from a split-hull barge. Based on the Seattle District's experience using split-hull barges to place caps, Parry (1994) recommends discharge rates of 30 to 42 m^3/min to reduce the size of the end pulse caused by bridging to about 5 percent of the load. At higher discharge rates, say 600 m^3/min, Parry (1994) notes that the size of the pulse can be up to 33 percent of the total load. Nelson, Vanderheiden, and Schuldt (1994) report discharge rates of 41 to 70 m^3/min using a split-hull barge at the Eagle Harbor in situ capping project.

Controlling and monitoring extended discharge from a split-hull barge is a nontrivial matter. The small barges, typically about 1,000 m^3 used by the Seattle District, are opened 6 to 8 deg to start sand flowing. Discharge rate can be monitored by change in draft measured by pressure sensors radio linked to a display on the tug, and with experience it can be done visually. As the load is lightened, the barge has to be opened more to continue a constant flow of sand.

Inspection and Compliance

Proper tracking of dredged material placement prior to capping includes adequate records of barge position, environmental conditions, vessel headings and velocities, start/end times of discharge, and load/draft of barge. In most cases, dredging contractors keep records detailing much of this information in their dredge logs.

The information from the inspector's or contractor's logs can be useful in identifying volumes of material placed, locations of placement, and correlation of material placement with hydrographic survey results. Dredge logs can also be the primary source of information for locating material that is short-dumped. Short-dumping can result for various reasons including human error, inadequate positioning information, malfunction of electronic positioning instruments, and safety. When material is short-dumped, it usually ends up outside of the specified disposal site, and postdisposal survey information may be limited or nonexistent. However, the dredged material must still be capped, and the more information that is available (from dredge logs), the better the capping job that can be done. In one instance on the Port Newark/Elizabeth project, a short dump of one barge load of material (2,300 m^3) was covered with 31,000 m^3 of cap material because of a substandard positioning system (LORAN-C), lack of knowledge of the tug/barge offset (the antenna was on the barge not the tug), and incomplete records.

Dredged material placement inspection can be conducted by onboard personnel provided by either the USACE District or dredging contractor. Many USACE dredging projects already require onboard inspectors to document proper dredging location, volumes dredged, and appropriate depths attained. For capping projects, both the New England Division and the New York District use inspectors. New England Division inspectors are contractors (but not employees of the dredging company). The New York District uses Corps employees as inspectors.

A new technology for dredging inspection that is being implemented is the Silent Inspector (SI). The SI uses state-of-the-art computer hardware and software to measure multiple dredge state parameters and provide output to automatically create USACE dredging reports. At this time, the SI is most readily applied to hopper dredges. Future work involves developing similar automatic inspection systems for hydraulic pipeline and mechanical dredge types. Many types of information are recorded by the SI including vessel speed, heading and position, hopper door status, vessel draft, and water depth. For capping projects that use hopper dredges, the SI can provide much of the needed information from dredging throughout placement (Cox, Maresca, and Jarvela 1995).

SI technology has also been applied to dredged material placed from a barge. A data logger on the barge records position and draft (from a pressure sensor). When the barge doors or hull are opened, the change in draft and location are recorded. The data can be downloaded to a computer at a later time or broadcast via radio link to a shore station for real-time monitoring. Commercial systems are available, and the New England Division has also provided some custom systems to the Districts. Both the Seattle and San Francisco Districts have used this type of system to monitor placement of dredged material.

During the placement of dredged material, periodic hydrographic surveys may be desirable to track mound growth. These surveys can allow the project manager to make midcourse adjustments in placement operations to effect changes in mound heights (either greater or less). Track plots from dredge logs or placement positions provide good information for long-term project placement locations.

Weather plays an important role in placement of dredged material not only for barge positioning but also in exposing the dredged material mound to unwanted erosion. As with most dredging projects, capping projects should be conducted in the less energetic summer months. During this time of year, storms are usually less frequent, thereby reducing the near-bottom currents that tend to move bottom sediments. For capping projects, this is particularly important to prevent the spread of contaminated material. Therefore, capping projects should afford adequate time for contaminated material placement and cap material placement to be conducted prior to the onset of fall/winter storms. Contingency plans that include phased capping or staging cap material for easier postconstruction placement should be considered for areas that are susceptible to hurricanes or other summer storms.

6 Sediment Dispersion and Mound Development and Site Geometry During Placement

The physical behavior of a dredged material discharge depends on the type of dredging and disposal operation used, nature of the material (physical characteristics), and hydrodynamics of the disposal site. For capping operations, it is essential to determine beforehand the nature of the discharge for both contaminated and capping material. The degree of dispersion and associated water column contaminant release dictates whether a given discharge is acceptable from the standpoint of water column impacts. The geometry of the subaqueous deposit or mound dictates the required area to be capped and cap configuration.

Sediment Dispersion During Placement

A knowledge of the short-term physical fate of both the contaminated material and capping material is necessary to determine the acceptability of the equipment and placement operation under consideration. Short-term fate is defined as the behavior exhibited by the material during and immediately following discharge. The dispersion of material released into the water column and the deposition of the material on the bottom are also of interest. These processes occur over a time period of a few minutes to several hours for a single release from a barge or hopper dredge.

In addition to physical dispersion of suspended material, an evaluation of water column mixing of released contaminants or suspended dredged material is necessary whenever potential water column contaminant effects are of concern. Such an evaluation may involve comparison of predicted water column contaminant concentrations with water quality criteria (or standards) or predicted suspended dredged material concentrations with bioassay test results. Water column effects measured in the field on actual projects may be valuable in quantifying water quality effects. For capping operations, such evaluations are normally required for the contaminated material to determine if water column control measures (i.e., submerged discharge) are necessary during placement. In addition, the prediction indicates what portion of the contaminated material is dispersed during placement and is not capped.

Methods for evaluation of potential water-column contaminant release are available ((USACE/EPA 1992). The contaminant release is predicted by an elutriate test, and results are compared with applicable water-quality criteria or standards as appropriate. In addition, acute water-column toxicity bioassays considering initial mixing may be needed. The procedures to be used in elutriate or water-column bioassays are provided in the MPRSA and CWA testing manuals (EPA/USACE 1991; EPA/USACE 1998). For disposal operations under the MPRSA, specific criteria for water quality and water-column toxicity must be met, and specific allowances are specified for initial mixing (EPA/USACE 1991). For disposal operations under CWA, water quality and water-column toxicity standards and allowances for initial mixing are specified by the States as a part of the Section 401 water-quality certification requirements.

The physical development of a mound or deposit on the bottom due to a number of barge or hopper releases or prolonged discharge from a pipeline is also of interest. Such information can be used to define the areal extent of the mound or deposit for the contaminated material. This dictates the required volume of capping material.

A computer model is available for evaluating the short-term fate of dredged material discharges in open water from hoppers or barges. The model is called the Short-Term FATE (STFATE) model (Johnson et al. 1993; Johnson and Fong 1995) and can be run on a personal computer (PC). This model is available as a part of the Automated Dredging and Disposal Alternatives Management System (ADDAMS) (Schroeder and Palermo 1990). Versions of the model are also included in the Ocean and Inland testing manuals (EPA/USACE 1991; EPA/USACE 1998). Appendix D describes the STFATE model in greater detail.

Input data required to run the model include (a) description of the disposal operation, (b) description of the disposal site, (c) description of the dredged material, (d) model coefficients, and (e) controls for input, execution, and output. More detailed descriptions and guidance for selection of values for many of the parameters are provided directly on-line in the system software or default values may be used.

Model output includes a time history of the descent and collapse phases of the discharge and suspended sediment concentrations for various particle size ranges as a function of depth and time. At the conclusion of the model simulation, the thickness of the deposited material on the bottom is given. Examples of model output are given in Figures 12 and 13. This allows an estimate of the areal extent or "footprint" of contaminated material as deposited on the bottom for a single disposal operation (i.e., a single barge or hopper load of material).

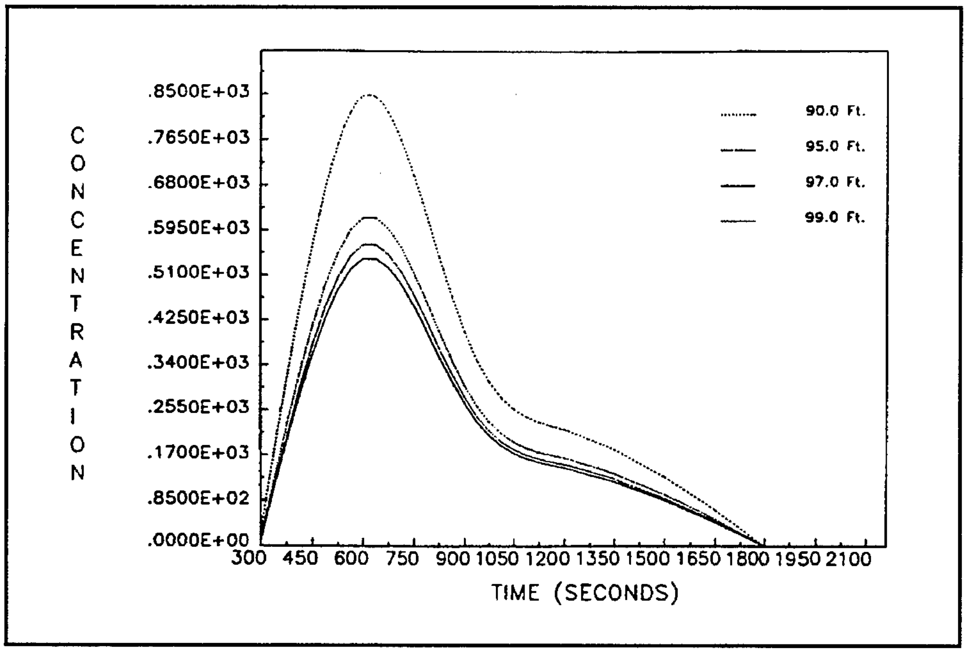


Figure 12. Typical STFATE model results showing concentration above background of clay (mg/l) (from Johnson 1992)

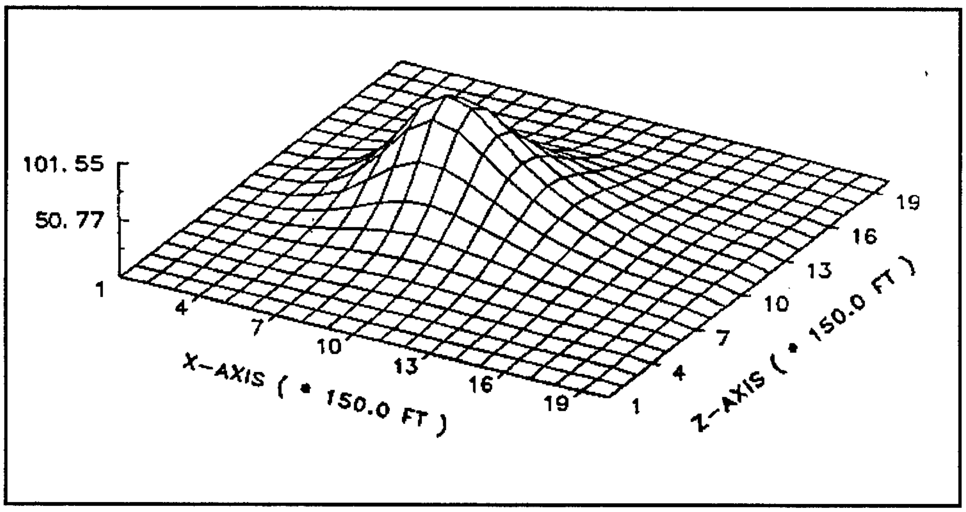


Figure 13. Typical STFATE model results showing total volume (ft^3/grid square) of new material (from Johnson 1992)

Evaluation of Spread and Mounding

The mound or deposit geometry, including contaminated material and cap, will influence the design of the cap and volume of capping material required. The smaller the footprint is of the contaminated material as placed, the less volume of capping material will be required to achieve a given cap thickness.

For LBC sites, the geometry of the contaminated material mound depends on the physical characteristics of the material (grain size and cohesion) and the placement technique used (hydraulic placement will result in greater spread than mechanical placement). Assuming that the material from multiple barge loads or pipeline can be accurately placed at a single point, the angle of repose taken by the material and the total volume placed will dictate the mound spread.

However, few data are available on the volume changes resulting from entrainment of water during open-water placement or the shear strengths of dredged material initially deposited in open-water sites. For these reasons, a priori estimates of mound spread made to date have been made based on the observed characteristics of previous mounds created with similar placement techniques and similar sediments (Palermo et al. 1989).

Models have been developed that will account for the development of mounds due to a number of barge or hopper discharges (Moritz and Randall 1995; SAIC 1994). The Corps' mound building model that models Multiple Disposals from barges and hopper dredges and their FATE (MDFATE) is a modification of the STFATE model. In the MDFATE model, a streamlined version of the STFATE model is run for each barge disposal. Thus, the input requirements for MDFATE are similar to those for STFATE. In MDFATE, the program keeps track of the mound thickness in each grid cell, then algebraically adds the thickness from subsequent disposals with avalanching when mound steepness exceeds critical values. MDFATE allows a number of typical disposal patterns to be automated; it allows moving barges and can import actual site bathymetry in real-world coordinates. MDFATE also allows interaction with the LTFATE model (Scheffner et al. 1995). This allows the mound created in MDFATE to be eroded by waves and currents during mound creations that may last months. A more detailed description of MDFATE can be found in Appendix E, and a more detailed description of LTFATE can be found in Appendix F.

Similar to the output from STFATE, output from the MDFATE model includes the volume of material on the bottom and contour and cross-section plots of mound bathymetry. Figures 14 and 15 show typical MDFATE output. One limitation of MDFATE is that it has been verified on only one actual project to date (Moritz and Randall 1995).

A model developed for the New England Division Disposal Area Monitoring System, the DAMOS capping model (Wiley 1994), is also based on the STFATE model. While it does not consider moving vessels or erosion by waves and currents, it has the advantage of having been verified for a number of mounds constructed by the New England Division in Long Island Sound.

Typical Contaminated Mound Geometry

As noted in the previous chapter, for LBC projects, virtually all of the mounds created have been constructed using mechanical dredging with transportation and placement by bottom-dump barges. The resulting

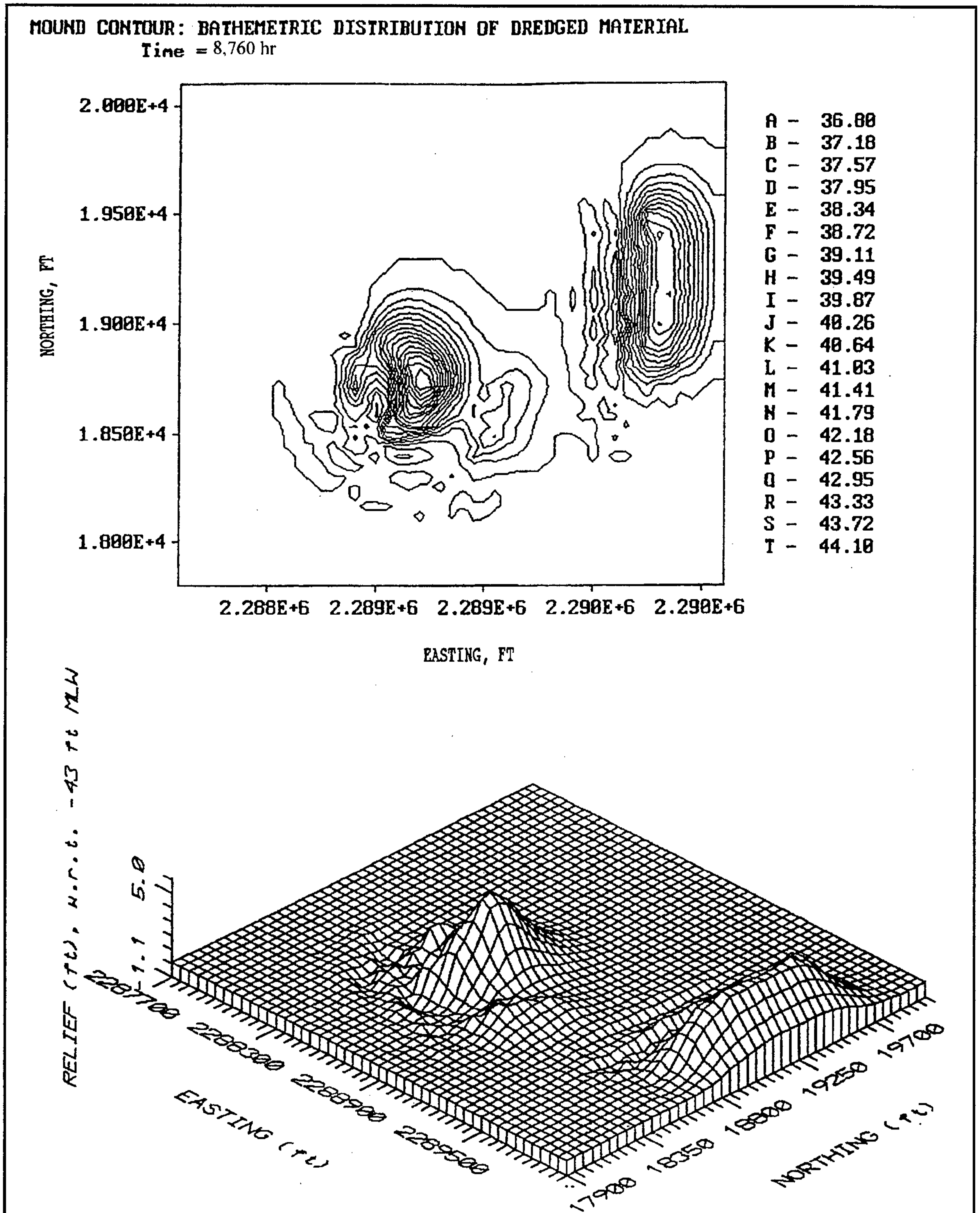


Figure 14. Typical MDFATE model output showing differences between predisposal and post-disposal bathymetry

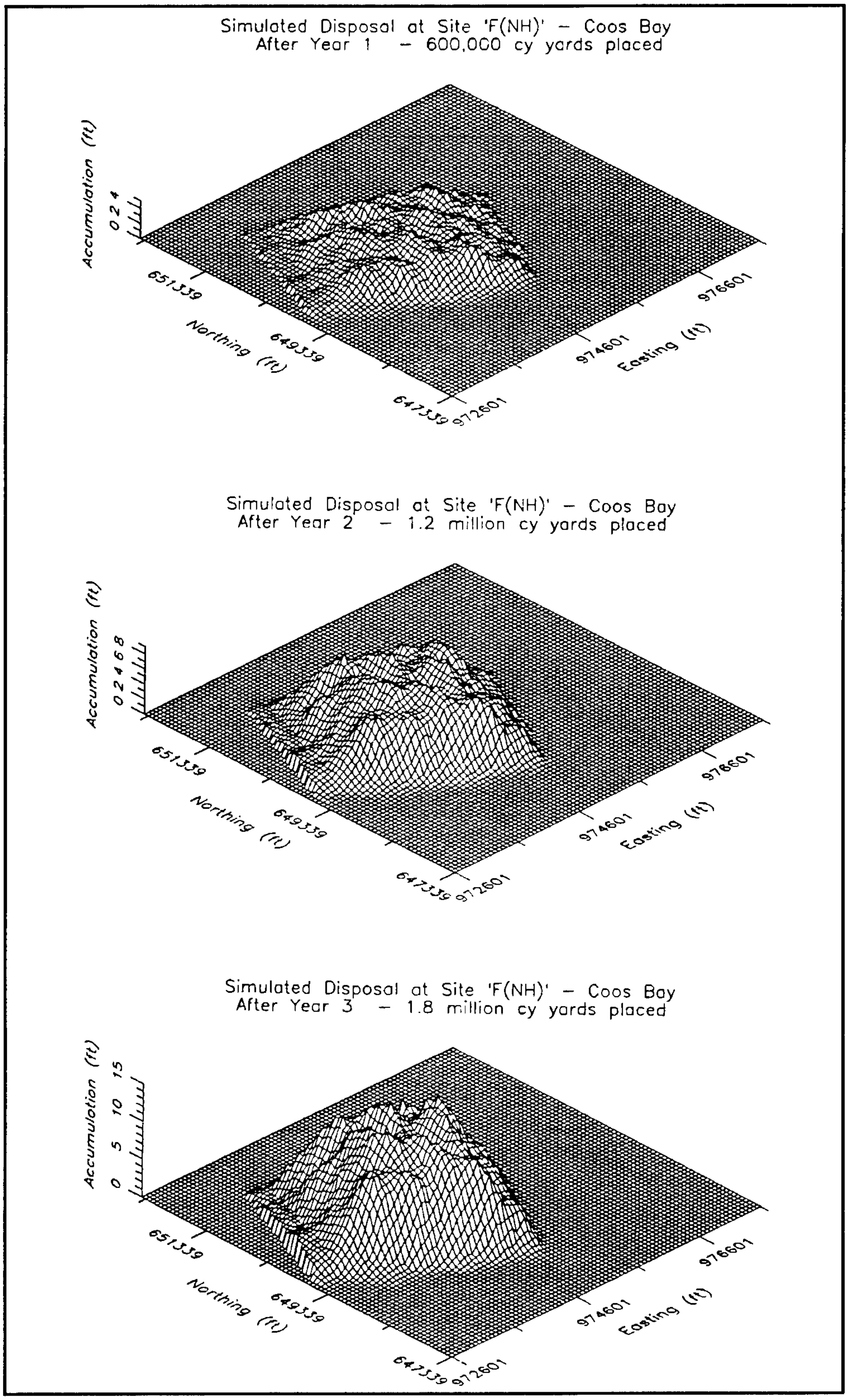


Figure 15. Typical MDFATE model output showing mound formation 1 to 3 years of disposal at Coos Bay

mounds created have had reasonably consistent geometries. Most mounds have been round or elliptical in shape, with a defined crest that is relatively flat, a main mound side slope (also termed the inner flank), sometimes an outer flank, and a thin outer apron. Figure 16 shows a generic contaminated mound. The dimensions for the side slopes and apron widths are based on those seen at the Port Newark/Elizabeth mound created in the Mud Dump site in 1993. The following paragraphs describe each of the mound features in more detail.

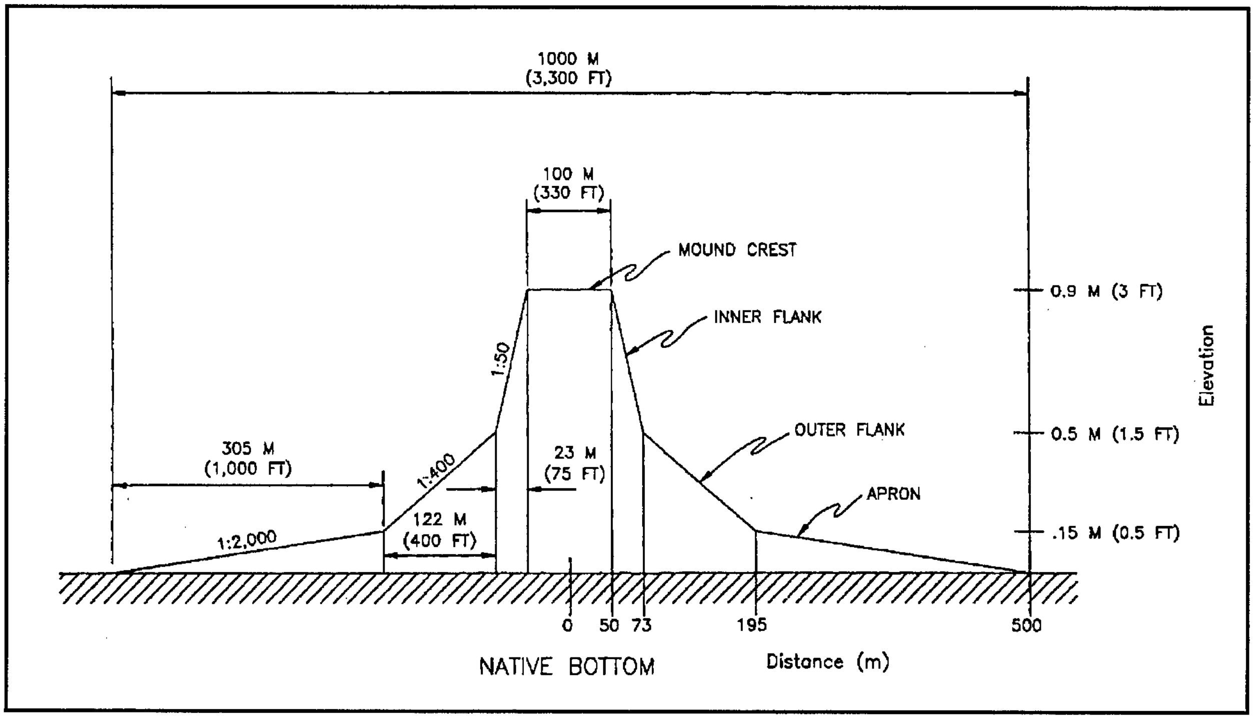


Figure 16. Typical mound geometry

Mound crest

Most contaminated mounds to date have had main mound crest elevations of 1 to 2 m, though some contaminated mounds with elevations of 3+ m have been constructed. Higher mounds have been constructed from noncontaminated material. For point-dumped projects in the New England Division, mound crests have generally been circles or ellipses approximately 100 to 200 m in diameter, reflecting good control of the disposal process around a taut-moored buoy (disposal within about 25 m of the buoy), for moderate-sized projects, generally 20,000 to 100,000 yd^3. The 1993 Port Newark/Elizabeth project used disposal lanes, 150 m in width and 300 to 420 m long, to create a triangular-shaped mound, approximately 630 by 645 m, with peak elevations of 1.5 to 2.4 m.

Inner flank

At the edge of the main mound, the inner flank of the mounds slope downward at a slope of approximately 1:35 to 1:70 with most of the mound slopes between 1:35 and 1:50. For the Port Newark/Elizabeth mound, the inner flank extended from the mound crest down to an elevation of about 1.0 m above the preplacement bottom.

Outer flank

For the Port Newark project, a break in slope generally occurred at the 1.0-m elevation; the outerflank then sloped down to an elevation of about 0.30 to 0.15 m at a slope of about 1:115. Data from the New England Division projects have not been examined in sufficient detail to determine if a similar feature exists for those mounds.

Apron

During the dynamic collapse phase (when the energy of the vertically descending jet of material disposed from a barge or hopper dredge is converted to horizontal velocity), some portion of the low shear strength, fine-grained material with high water contents may be transported a considerable distance from the disposal point. At the completion of the contaminated material placement, an apron of fine-grained material, typically 1 to 15 cm in thickness but extending up to several hundreds of meters beyond the main mound flanks, has occurred on almost all LBC projects. The apron has been defined as that portion of the material less than about 15 to 30 cm in thickness, because 20 to 30 cm is the resolution limit for high-quality bathymetry in water depths of 25 m or less.

A sediment profiling camera (SPC) can reliably measure apron thickness from 1 to 2 cm up to 20 cm. Thus, the outer limit of the apron should be defined as the point at which the apron can no longer be conclusively distinguished by the SPC, a thickness of 1 to 2 cm. Some contaminated material extends beyond the apron edge as defined by the 1- to 2-cm SPC limit; however, the percentage of the total volume is likely extremely small.

The apron typically exhibits an overall slope of 1v:1000+h at the Port Newark/Elizabeth project, and overall apron slope of about 1:2,000 was observed on downward sloping bottoms. If the inner edge of the apron is assumed to be 15 cm in thickness, the width of the apron for the Port Newark/Elizabeth project was about 300 m. The STFATE model and MDFATE model and the DAMOS capping model can be used to predict the apron dimensions.

Recent experience with a New York District 1997 capping project placed in the Mud Dump site illustrated the potential for slope adjustments when fine-grained mounds are created with heights exceeding about 10 ft. In one case, a portion of a contaminated mound with a height of 12 ft had a slope adjustment resulting in an after adjustment height of 6 to

8 ft and a movement of material outward of about 1,000 ft. This section of mound was placed on an ambient slope of up to 1.45 deg, which likely contributed to the adjustment and the outward movement. In a second case, a portion of the same mound with an elevation exceeding 10 ft experienced an apparent slope adjustment after capping began. Losses in elevation of 3 to 4 ft occurred as a result of the adjustment, though the significant outward movement seen on the upcapped section did not occur. This section of the mound was placed on a nearly flat slope. The above illustrates the need to consider the potential for slope adjustments in mounds over 6 to 8 ft tall. Analysis of slope stability for taller mounds, particularly those placed on slopes, is recommended (Moritz 1997).

Mound Geometry for Level-Bottom Capping

Evaluation of contaminated material mound geometry for an LBC project requires a series of steps:

a. **Determine volume of material to be disposed**. The first step in a capping project is to compute the volume of contaminated material to be dredged. An accurate estimate of the volume of contaminated material to be dredged should be a fairly straightforward process. Normally computer programs that compare authorized channel dimensions with existing bathymetry determine the volume of material to be dredged, with a combination of core, subbottom profiler, and sediment chemistry and bioassay/bioaccumulation testing done to determine the volume of contaminated sediments. The designer should consider including possible overdepth in the volume calculation. Normal clamshell allowed overdepth is about 2 ft. Some of the "environmental" clamshells claim lower overdepths 6 in. to 1 ft. Very high-quality instrumentation in addition to a special bucket is needed to achieve the lower overdepth values.

b. **Bulking**. Some bulking of the sediments during the dredging process may be factored into computing the volume required for capping. For mechanically dredged sediments, bulking of 10 to 20 percent (Herbich 1992) is reasonable. For materials dredged by hopper, a large volume of excess water is initially stored in the hopper, but the volume of water may be reduced prior to material placement by overflow. Following placement by hopper, a large portion of the excess water is almost immediately expelled from the material as it settles to the bottom.

In most instances capping will involve mechanical dredging of maintenance material with relatively low densities. These materials can experience fairly rapid consolidation. Most contaminated dredged projects will require several weeks or longer to conduct dredging. Thus, by the time capping is ready to begin, some consolidation will have taken place such that the volume to be capped may be nearly the in situ volume. Without site-specific data, a net bulking volume (including the apron) of 10 to 20 percent is reasonable.

c. **Predict contaminated mound geometry**. An accurate prediction of contaminated mound geometry is one of the most critical steps in LBC project design. There are two primary methods to determine mound geometry ranging from fairly simple to complex. The simple method is to assume a basic shape (e.g., a truncated cone or rectangular prism with sloping sides), then estimate side slopes and an apron width. A spreadsheet is an effective method to test a range of expected heights and crest dimensions on footprint dimensions and the corresponding cap volume required. A more rigorous method is to use a numerical model such as the MDFATE model (Moritz 1994; Moritz and Randall 1995) to predict mound geometry. Use of a numerical model allows the user to investigate the impact of changing operations (disposal pattern, barge size, barge velocity, etc.) on mound geometry.

d. **Is the calculated contaminated mound geometry suitable?** After the contaminated mound footprint and elevation have been calculated, the project manager/designer must decide if the predicted contaminated mound geometry meets project needs. The two basic concerns are as follows: Will all the contaminated material (and cap material) stay within any surface area constraints? Is the elevation of the capped mound sufficiently low so as not to interfere with navigation and not experience excessive erosion? A reasonable buffer distance between the edge of the contaminated mound and the site boundary is 100 to 200 m. If the answer to both questions is yes, then the designer can proceed to the next step, computing cap volume required (described in more detail in Chapter 7 and Appendix H). If the contaminated mound is predicted to spread too near or over the site boundary or is too high, then the following options should be investigated.

e. **Calculated contaminated mound footprint is too large.** If the contaminated mound footprint extends beyond the site boundary or is so large that the cost or volume of cap material required is a problem, several options are possible. Once again the simplest solution (but probably unattractive from the project perspective) is to reduce the volume of material being placed. One option to reduce spread is to make the mound taller by reducing the size of the area over which disposal takes place. The mound shape can be changed to make better use of available space; e.g., for the 1993 Port Newark/Elizabeth project conducted in New York District, a triangular-shaped mound was used. Figure 17 shows the rectangular mound dimensions in the original design and Figure 18 shows the triangular mound design modification. Other options include dredging pits and/or placing confining berms around the area (essentially creating a CAD) or using a diffuser to reduce spread. A operational change such as reducing the barge velocity, changing approach direction of the disposal vessels, or disposing only when the currents are in a favorable direction are other possible options. To evaluate such options will require using a numerical model.

Long-term planning can help to create a de facto CAD site. Over a period of several years, the New England Division made a series of small mounds around a portion of their Central Long Island

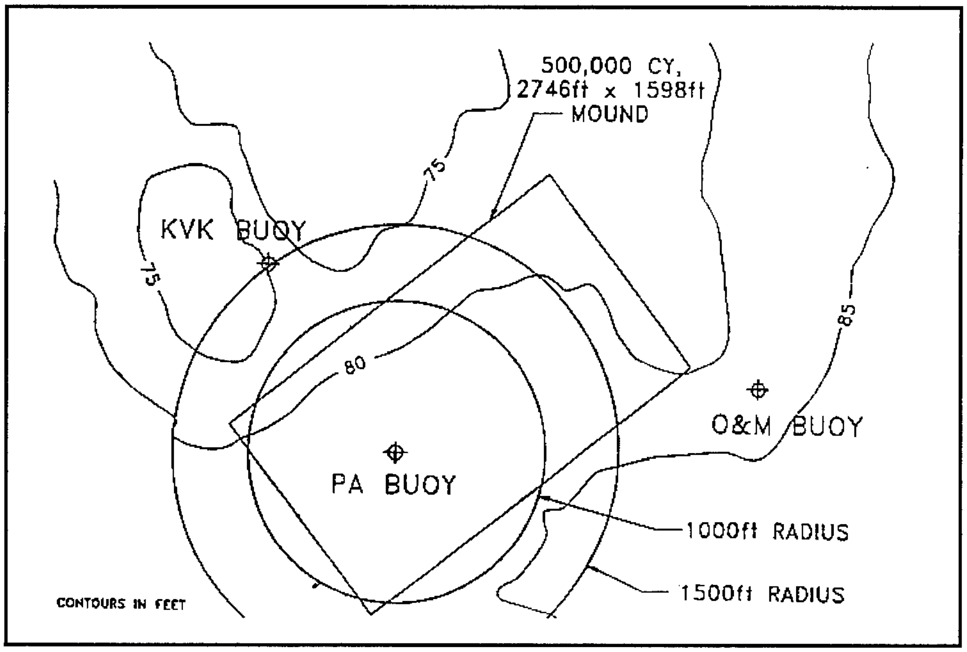


Figure 17. Original contaminated mound design for Port Newark/Elizabeth project

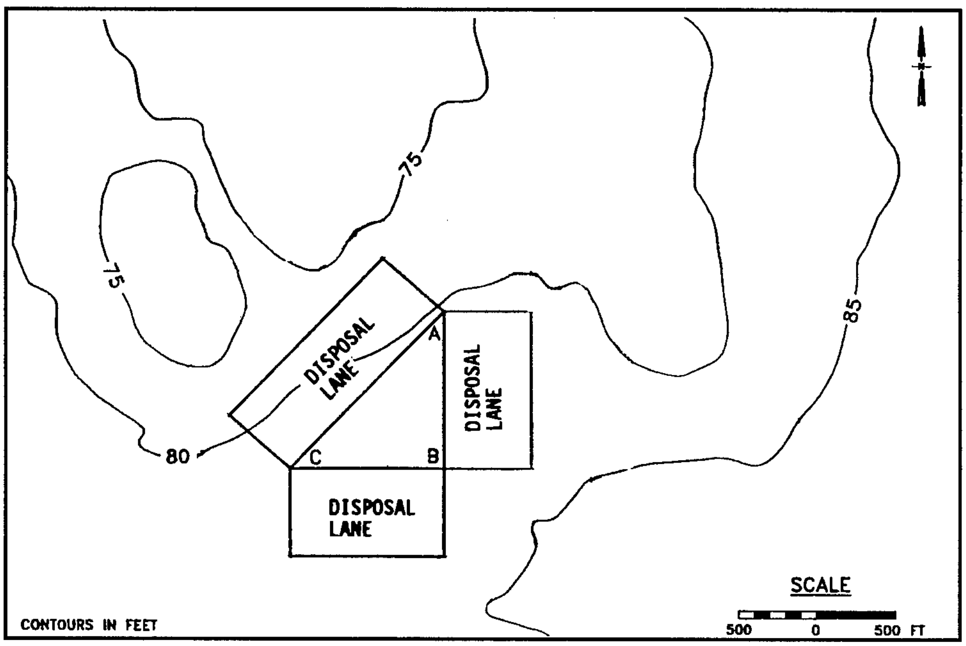


Figure 18. Disposal lanes used for triangular mound placement of contaminated material in Port Newark/Elizabeth project

Sound (CLIS) disposal site. This depression was then filled with over 500,000 m^3 of contaminated sediments in 1993/94 from the dredging of New Haven Harbor. By confining the contaminated material within the series of mounds from the smaller projects, the spread of the contaminated material was greatly reduced, requiring a relatively small volume of material to cap the contaminated sediments. Fredette (1994) describes the project in more detail.

f. **Calculated contaminated mound is too high.** If the calculated mound peaks exceed the maximum depth limit, it may be possible to increase barge velocity to make a mound of more constant elevation without substantially increasing the footprint. If much of the mound exceeds the minimum depth restriction, two obvious solutions are to (a) find a deeper portion of the site or another site (if available), or (b) reduce the volume of contaminated material. Perhaps a more feasible solution is to spread out the area of placement to reduce mound height. This will increase the surface area of the mound and thus the amount of cap required. It may also create problems with contaminated material coming too close to the site boundary. Another option is to consider a dredging method that increases the density of the contaminated material, a difficult proposition for mechanically dredged sediments.

g. **Cap geometry**. The same tools and approaches used for evaluation of contaminated mound geometry can be used to evaluate geometries for LBC caps. However, the major consideration for cap geometry is the placement of a layer of the required cap thickness over the central portion of the mound and over the apron as appropriate.

Geometry for CAD Projects

The geometry of the deposit for CAD sites is largely controlled by the geometry of the depression or subaqueous berms that form the lateral containment. If hydraulic methods are used to dredge the contaminated materials going into the CAD site, and if the site has a relatively small surface area, the materials will tend to spread in a layer of even thickness over the entire area. If the site has a large surface area, or if the contaminated material is mechanically dredged and placed by barges, the material may tend to form a mound within the site not covering the entire surface area. If this is the case, methods for intentionally spreading the contaminated material within the CAD site boundaries may be appropriate. Contaminated materials should be placed in CAD sites as a layer of uniform thickness, so that the required thickness of cap material can be placed using a minimum volume of cap material.

Cap geometry for CAD sites should be developed as the design cap thickness placed uniformly over the entire contaminated deposit. Assuming the contaminated material has been placed as a fairly uniform layer, the cap would essentially be placed from bank to bank within a depression, pit, or contained area formed by subaqueous berms.

The same tools as described above for LBC projects can be used for evaluation of deposit geometry for CAD sites. The major consideration for CAD geometry is the placement of both contaminated and cap layers in a uniform and level configuration.

Bulking is an important consideration for CAD geometry. The volume of contaminated material and cap and associated bulking must be closely estimated to ensure that all the material and cap can be placed within the available contained volume. For mechanically dredged sediments, bulking of 10 to 40 percent (Bray, Bates, and Land 1997) is reasonable. For hydraulically dredged sediments, dredged and placed by hopper or pipeline, much of the excess water will be expelled as the material is placed within the CAD site, but the volume occupied during the placement operation must be closely estimated. A project-specific investigation of the expected increase in volume for a particular dredging/placement method and sediment is warranted. Sedimentation analysis to determine a volume occupied by hydraulic pipeline placement to a CAD site has been conducted using procedures developed for diked confined disposal facilities (Averett et al. 1989). Procedures for such an analysis are outlined in detail in the USACE Engineer Manual 1110-2-5027, Confined Disposal of Dredged Material (USACE 1987).

7 Dredged Material Cap Design

This chapter presents procedures for designing subaqueous dredged material caps and a sequence for determining the design cap thickness components to account for bioturbation, erosion, consolidation, operational considerations, and chemical isolation. Methods for determining the required volume of cap material and design considerations for intermediate caps are also discussed.

General Considerations

The composition and dimensions (thickness) of the components of a cap can be referred to as the cap design. This design must physically isolate the contaminated sediments from the benthic environment and achieve the intended cap functions. The design must also be compatible with available equipment and placement techniques.

The composition of caps for dredged material projects is typically a single layer of clean sediments because relatively large volumes of cap material are involved; clean sediments from other dredging projects are often available as cap materials; and dredged material capping sites with low potential for erosion can be selected. Guidance on dredged material cap design in this chapter therefore focuses on the thickness of the cap as the major design criterion.

In contrast, in situ capping projects usually involve smaller volumes or areas; clean sediments are not always readily available as capping material; and site conditions are a given. For these reasons, caps composed of multiple layers of granular materials as well as other materials such as armor stone or geotextiles are often considered, and the in situ cap design cannot always be developed in terms of cap material thickness alone. Procedures for design of caps composed of nonsediment components are available in the EPA guidance document for in situ capping projects (Palermo et al. 1996).

Required Cap Thickness

Determining the minimum required cap thickness depends on the physical and chemical properties of the contaminated and capping sediments, hydrodynamic conditions such as currents and waves, potential for bioturbation of the cap by aquatic organisms, potential for consolidation of the cap and underlying sediments, and operational considerations. Total thickness can be composed of components for bioturbation, consolidation, erosion, operational considerations, and chemical isolation. Schematics of the cap thickness components and potential physical changes of the cap thickness due to erosion, consolidation, etc., are shown in Figure 19.

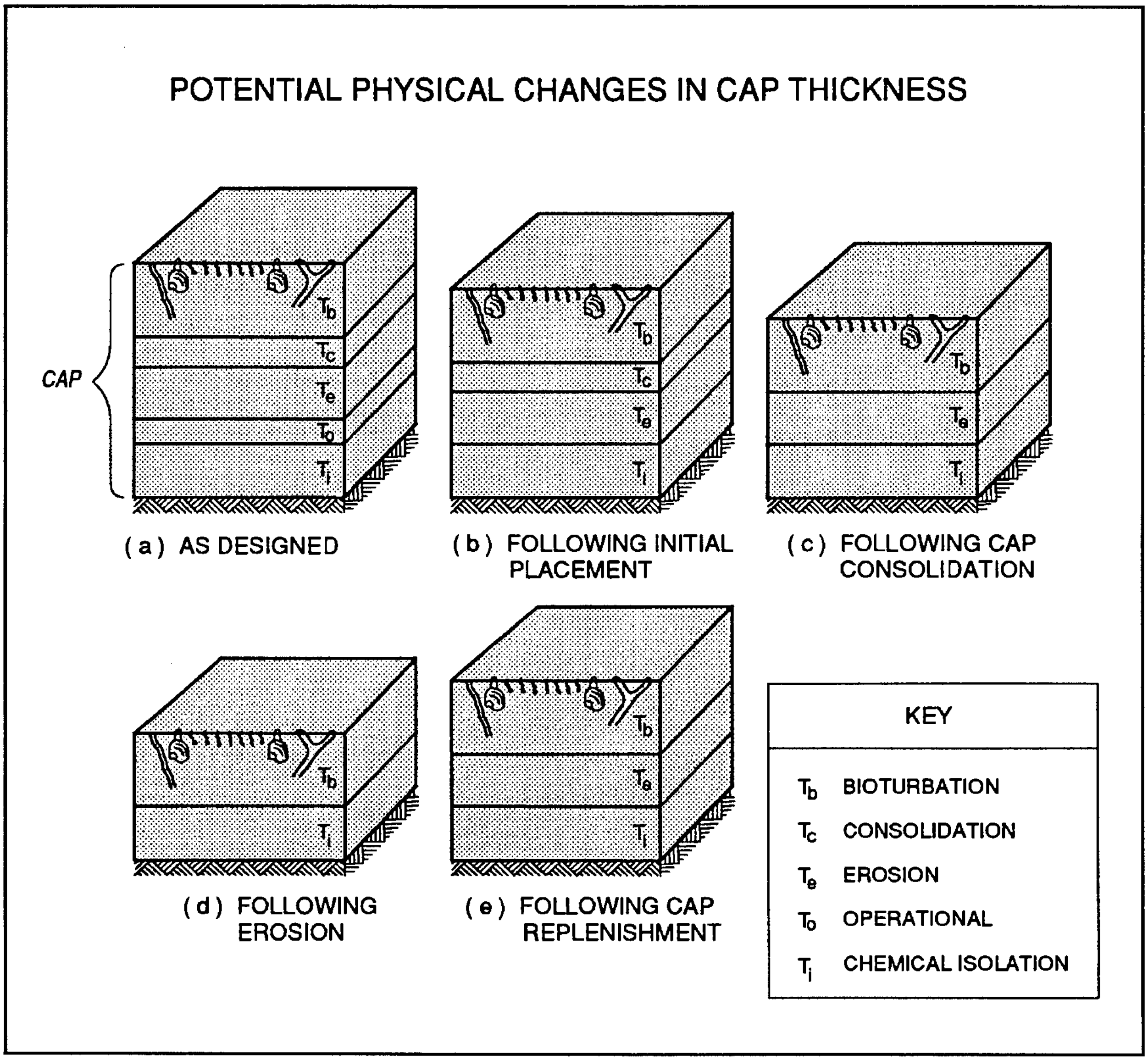


Figure 19. Schematics of cap thickness components and potential physical changes in cap thickness

The thickness for chemical isolation (if required) and/or the thickness for bioturbation must be maintained to ensure long-term integrity of the cap. The integrity of the cap from the standpoint of physical changes in cap thickness and potential for a physical reduction in cap thickness due to the effects of consolidation and erosion can be evaluated once the overall size and configuration of the capped mound or deposit and resulting water depth over the cap are determined. The design cap thickness for the various components can then be adjusted by iterative calculations if needed.

At present, the design of caps composed of clean sediments is based on a combination of laboratory tests and models of the various processes involved (contaminant flux, bioturbation, consolidation, and erosion), field experience, and monitoring data. Since the number of carefully designed, constructed, and monitored capping projects is limited, the design approach is presently based on the conservative premise that the cap thickness components are additive. No dual function performed by cap components is considered. As more data become available on the interaction of the processes affecting cap effectiveness, this additive design approach can be refined.

Before the design cap thickness can be determined, the following must be resolved: (a) the intended functions and design objectives of the cap must be defined (see Chapter 1); (b) suitable capping material must be identified (see Chapter 3); (c) a specific site must be identified and characterized (see Chapter 4); (d) equipment and placement techniques must be selected (see Chapter 5); and (e) overall geometry of the contaminated mound or deposit must be evaluated (see Chapter 6). The recommended sequence for determining the design cap thickness is as follows:

a. Assess the bioturbation potential of indigenous benthos and determine an appropriate cap thickness component for bioturbation.

b. Determine if the capping material is compressible, and if so, evaluate potential consolidation of the cap material after placement. If contaminated sediments or native underlying sediments are compressible, evaluate potential consolidation of those materials. If required, add a thickness component to offset consolidation of the cap.

c. Considering the mound or deposit geometry and site conditions, conduct a screening evaluation of potential erosion. If there is potential for erosion, conduct a detailed evaluation, considering both ambient currents and episodic events such as storms. If required, add a thickness component to offset potential erosion.

d. Evaluate operational considerations and determine restrictions or additional protective measures (e.g., institutional controls) needed to ensure cap integrity. If needed, add a thickness component to offset operational considerations.

e. If a design function of the cap is to control contaminant flux, evaluate the potential for short-term and long-term flux of contaminants through the cap as necessary. Determine any necessary additional cap thickness component for chemical isolation based on modeling and/or testing.

A flowchart illustrating the sequence of cap thickness evaluations and the interdependence of the components is shown in Figure 20. More detailed discussions of these design steps are given in the following paragraphs.

Bioturbation

A design objective of a dredged material cap is to physically isolate the contaminated material from benthic organisms. In the context of capping, bioturbation may be defined as the disturbance and mixing of sediments by benthic organisms. The importance of bioturbation by burrowing aquatic organisms to the mobility of contaminants cannot be overestimated. In addition to the disruption (breaching) of a thin cap that can result when organisms actively rework the surface sediments, there is the problem of direct exposure of infaunal organisms to the underlying contaminated sediment. The best available knowledge on local infauna must supplement generic assumptions concerning the bioturbation process.

Aquatic organisms that live on or in bottom sediments can greatly increase the movement of contaminants (solid and dissolved) through the direct movement of sediment particles or irrigation of pore water, increasing the surface area of sediments exposed to the water column, and as a food for epibenthic or pelagic organisms grazing on the benthos. The specific assemblage of benthic species that recolonizes the site, the bioturbation depth profile, and the abundances of dominant organisms are key factors in determining the degree to which bioturbation will influence cap performance. The depth to which organisms will bioturbate is dependent on behaviors of specific organisms and the characteristics of the substrate (i.e., grain size, compaction, organic content, pore water geochemistry, etc.). In general, the depth of recolonization by marine benthos is greater than that of freshwater benthos. Recolonization by benthic infauna at marine dredged material caps is primarily by suspension feeders as opposed to burrowing organisms (Morton 1989; Myers 1979). The intensity of bioturbation is greatest at the sediment surface and generally decreases with depth. Three zones of bioturbation are of importance (see Figure 21). A surficial layer thickness of sediment will be effectively overturned by shallow bioturbating organisms and can be assumed to be a continually and completely mixed sediment layer for purposes of cap design. This layer is generally a few centimeters in thickness. Depending on the site characteristics, a number of middepth burrowing organisms over time recolonize the site. The level of bioturbating activity for these organisms will decrease with depth as shown in Figure 21. The species and associated behaviors of organisms that occupy these surface, and middepth zones are generally well known on a regional basis. There may also be potential for colonization by deep-burrowing organisms (such as certain species of mud shrimp), which may burrow to depths of 1 m or more. However, knowledge of these organisms is very limited. These cap design criteria assume that deep bioturbators are not present in significant numbers.

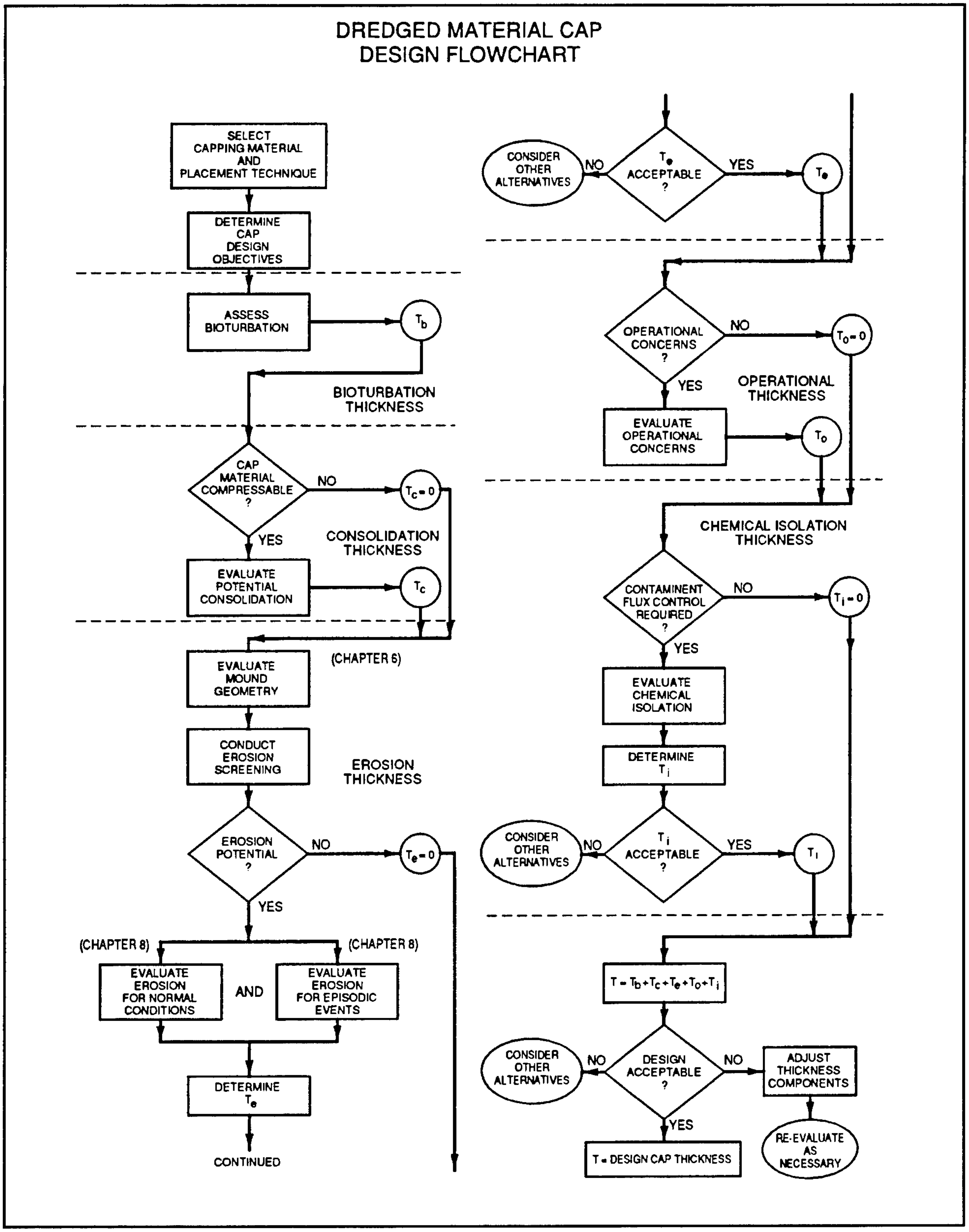


Figure 20. Flowchart illustrating sequence of evaluations for determining cap thickness

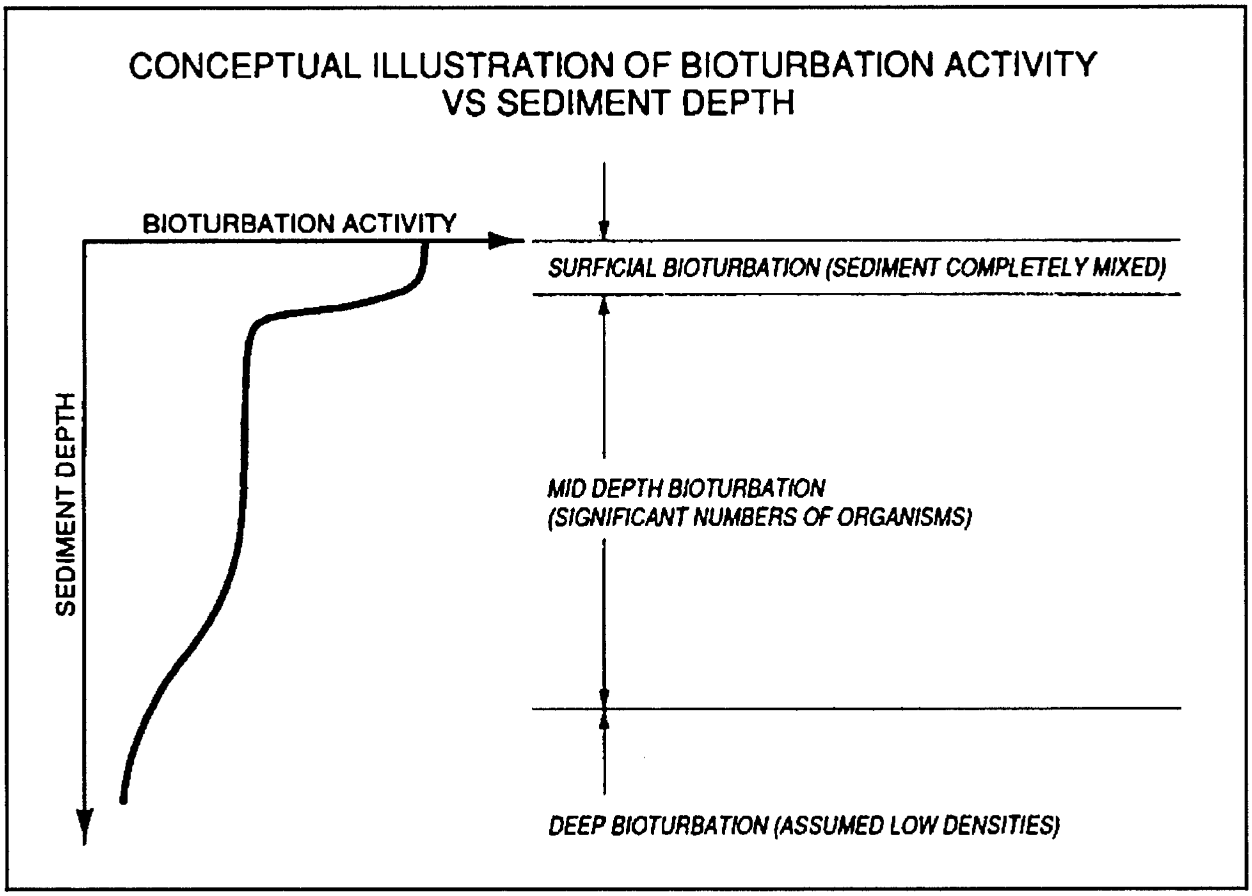


Figure 21. Conceptual illustration of bioturbation activity versus sediment depth

Cap thickness required for bioturbation, T_b, should be determined based on the known behavior and depth distribution of infaunal organisms likely to colonize the site in significant numbers. Bioturbation depths are highly variable, but have been on the order of 30 to 60 cm (1 to 2 ft) for most infaunal organisms that populate a site in great numbers. Consulting with experts on bioturbation in the region of the disposal site location is desirable. The thickness needed to prevent breaching of cap integrity through bioturbation can be determined indirectly from other information sources. For example, the benthic biota of U.S. coastal and freshwater areas have been fairly well examined, and estimates of the depth to which benthic animals burrow should be available from regional authorities.

Consolidation

Consolidation of the cap, contaminated material, or underlying native sediments may occur over a period of time following cap placement, but does not occur repeatedly. If a fine-grained cap material will be used, consolidation of the cap may require an added cap thickness component in the design such that the consolidated cap will remain at the required thickness. If any of the sediments (cap, contaminated, or native sediment) are compressible, a prediction of consolidation is important in interpreting monitoring data to differentiate between changes in surface elevation due to consolidation as opposed to those potentially due to erosion. It is important to note that the total mound height for an LBC project or fill height for a CAD project can decrease (due to consolidation of the contaminated layer or underlying native sediment) without the need to nourish the cap.

The consolidation analysis also holds importance for any required assessment of potential long-term flux of contaminants through the cap. The magnitude of consolidation of underlying sediments will determine the amount of water potentially moving (advecting) upward into the cap. Changes in the void ratio of the cap must also be considered in determining the distance to which this water is expressed upward into the cap.

If the selected material for the cap is fine-grained material (defined as material with more than 50 percent by weight passing a #200 sieve), the change in thickness of the material due to its own self-weight or due to other cap components should be considered in the overall design of the cap thickness. An evaluation of cap consolidation should be made in this case, and an additional cap thickness component for consolidation, T_c, should be added so that the appropriate cap thickness is maintained. Such consolidation occurs over a period of time following cap placement, but does not occur more than once.

If the cap material is not a fine-grained material, no consolidation of the cap may be assumed, and no additional increase in the isolation thickness is necessary. However, consolidation of the underlying contaminated sediments may occur, and a consolidation analysis may be necessary to properly interpret monitoring data. Procedures for evaluation of consolidation are given in Chapter 8 and Appendix I.

Erosion

If there is potential for erosion, the total cap thickness should include a thickness component for erosion, T_e, which may occur primarily due to long-term continuous processes (i.e., tidal currents and normal wave activity) or episodic events such as storms. This portion of the total thickness can be lost after many years of normal levels of wave and current activity, after an abnormally severe storm season, or in a few days during extreme events. Monitoring activities should result in detecting the loss of cap followed by a management decision to place additional material to bring the cap back to its design thickness.

A screening level assessment of erosion potential should first be conducted. This assessment may be conducted as a part of the site screening process described in Chapter 4. This assessment can be based on simple analytical or empirical methods. If the screening assessment indicates little or no potential for erosion, no detailed assessment need be conducted, and no erosion cap thickness component is needed. If the screening assessment indicates a potential for erosion, a more detailed assessment should be conducted. If the contaminated material is to be hydraulically placed (as for a CAD site) or a site with higher energy potential is being considered, a thorough analysis of the potential for resuspension and erosion must be performed, to include frequency considerations.

Based on the detailed assessment, a value of T_e should be added as the erosion cap thickness component. The criteria used to calculate the thickness to be added are equivalent to that used for the site screening discussed in Chapter 4. For projects in which no subsequent capping is anticipated for a long time period (several decades or longer) or for which materials for cap nourishment are not easily obtained, the recommended cap thickness component to be added, T_e, should be equivalent to the calculated net cap erosion over the major portion of the mound over a period of 20 years of normal current/wave energies or for a 100-year extreme event. The 20-year ambient time interval and 100-year return interval for storms are based on field experience gained to date. Twenty and one hundred years as time periods are in the range of design periods for many engineering structures. Note that calculated erosion at localized portions of the mound or feature may be somewhat greater than the value of T_e selected. The corners of a mound would normally have an overlap of capping material, and the crest of a mound would normally have a greater cap thickness; therefore, somewhat larger erosion could be tolerated over these portions of a mound.

Selection of other values of ambient time periods, return intervals, etc., for calculating erosion thickness should be based on site-specific factors (e.g., the degree of contamination, distance to other resources), the level of confidence in the calculations, and the acceptable level of risk. For projects in which subsequent capping is planned or for which materials for cap nourishment can be easily obtained, higher erosion rates may be considered. In areas where available capping materials and current and wave conditions are severe, a coarse-grained layer of material may be incorporated into the cap design to provide protection against erosive currents at the site.

Selecting a cap thickness component for erosion is a function of the acceptable level of risk. Definitive guidance is difficult because the level of risk acceptable will likely vary from project to project. Detailed guidance on erosion thickness evaluation is found in Chapter 8, along with additional discussion of the risk-related aspects associated with design cap thickness.

Operational concerns

At some locations, other considerations, termed operational, may have to be considered when determining the final cap thickness. These include ice gouging, anchoring, ability to place thin layers, unevenness of material placement, etc. If these are serious considerations, then locations that have significant potential for these types of operational considerations would be poor choices for capping projects.

For most open-water disposal sites, the sites will be located sufficiently far from shore and in sufficiently deep water that ice gouging should not be a concern. Ice gouging is obviously only a problem in areas that receive significant amounts of ice in the winter (e.g., the Great Lakes). Ice gouging occurs as ice thickness builds up, usually nearshore or adjacent to structures, to such a thickness that the lower portion of the ice gouges and displaces the bottom sediments. The thickness of the ice buildup decreases as distance from shore increases. Also as water depth increases, ice gouging will be less of a concern. For those locations where ice gouging may be problem, e.g., in situ capping sites nearshore, local experts should be consulted as to the locations where ice gouging occurs and the depth of the sediments disturbed.

Another operational concern is anchoring. Vessel anchors have the potential to disturb bottom sediments (as do trawlers). While most any location in shallow water (say 30 m or less) is subject to potential anchoring, for most locations where open-water dredged material placement sites are located, anchoring to such a degree that cap integrity is impacted will be extremely rare. The anchors used by recreational vessels typically only penetrate the bottom 1 to 2 ft. The relative area impacted by anchors compared with the size of a cap is very small. Also, when the anchors are removed, the area disturbed by the anchor is quickly filled. This is not true for anchors from large ships, which can penetrate up to 5 to 10 ft. Thus an area where ships routinely anchor would be a very poor choice for a capping project.

Another operational concern is the ability to place a relatively thin cap layer. Until recently, open-ocean capping operations made the controlled placing of small thicknesses (less than 30 cm) difficult. For many of those projects, the minimum cap thickness for most projects has been on the order of 75 to 120 cm (2.5 to 4 ft). Recent experience from the Port Newark/Elizabeth project at the Mud Dump (Randall, Clausner, and Johnson 1994) and Puget Sound capping projects (Nelson, Vanderheiden, and Schuldt 1994; Sumeri 1995) has shown that the sprinkling techniques developed were successful and that layers about 15 to 20 cm (0.5 to 0.75 ft) thick can be placed with reasonable assurance (though at increased cost due to increased operational controls).

The placement process will likely result in some unevenness of the cap thickness. This unevenness should be considered in calculation of the volume of capping material required.

If any of the above factors are significant for the site under consideration, an additional cap thickness component for operational concerns, T_o, should be added to the design cap thickness.

Chemical isolation

If a design function of the cap is to control contaminant flux, the potential for short-term and long-term flux through the cap should be evaluated. The need for such an evaluation is dependent on the types of contaminants, the potential for contaminant impacts, site and operational conditions, and other factors. For example, if the reason for capping is to isolate a sediment that is nontoxic to benthic organisms and exhibits bioaccumulation only marginally above that for a reference sediment, the isolation provided by the bioturbation thickness component will likely provide sufficient control, and there is little reason to conduct a detailed assessment. Conversely, if the sediment to be capped has exhibited toxicity to benthic organisms, a detailed assessment of long-term effectiveness would be advisable.

The additional cap thickness component for chemical isolation may be defined as T_i and should be determined based on modeling and/or testing as described in this section. The basis of design of a contaminant flux thickness component will be project specific. The flux rates (mass of contaminant per unit area per unit time) pore water concentrations in the cap and long-term accumulation of contaminants in cap sediments may be evaluated and used in the design. For example, flux and the resulting impact on overlying water quality may be compared with a water quality standard or criterion in much the same way as water column contaminant releases during the placement process. Compliance of the flux concentrations at the boundary of the site or edge of an established mixing zone would be appropriate. In this way, the cap thickness component for isolation required to meet the water quality standards can be determined.

Chemical flux processes

Properly placed capping material acts as a filter layer against any migration of contaminated sediment particulates. There is essentially no driving force that would cause any long-term migration of sediment particles upward into a cap layer. Most contaminants of concern also tend to remain tightly bound to sediment particles. However, the movement of contaminants by advection (movement of pore water) upward into the cap is possible. Molecular diffusion over extremely long time periods will always occur. Advection refers to the movement of pore water. Such movement could occur as an essentially continuous process if there is upward groundwater gradient acting below the capped deposit. Advection could also occur as a result of compression or consolidation of the contaminated sediment layer or other layers of underlying sediment. Movement of pore water due to consolidation would be a finite, short-term phenomena, in that the consolidation process slows as time progresses and the magnitude of consolidation is a function of the loading placed on the compressible layer. The weight of the cap will "squeeze" the sediments, and as the pore water from the sediments moves upward, it displaces pore water in the cap. The result is that contaminants can move part or all the way through the cap in a short period of time. This advective movement can cause a short-term loss, or it can reduce the breakthrough time for long-term advective/diffusive loss.

Diffusion is a molecular process in which chemical movement occurs from material with higher chemical concentration to material with lower concentration. Diffusion results in extremely slow but steady movement of contaminants. The effect of long-term diffusion on the design cap thickness is normally negligible, because long-term diffusion of contaminants through a cap is an extremely slow process and contaminants are likely to adsorb to the clean cap material particles.

Properly designed caps act as both a filter and buffer during advection and diffusion. As pore waters move up into the relatively uncontaminated cap, the cap sediments can be expected to scavenge contaminants so that any pore water that traveled completely through the cap theoretically would carry a relatively small contaminant load to the water column. Furthermore, through-cap transport can be minimized by using a cap that has sufficient thickness to contain the entire volume of pore water that leaves the contaminated deposit during consolidation. For example, Bokuniewicz (1989) has estimated that the pore water front emanating from a consolidating 2-m-thick mud layer would only advance 24 cm into an overlying sand cap (Sumeri et al. 1991). Contaminant flux processes are very much dependent upon the nature of the cap materials. For example, a cap composed of pure sand would not be as effective in containing contaminants as a naturally occuring sand with an associated fraction of fines and organic content.

Some components for cap thickness should not be considered in evaluating long-term flux. For example, the depth of overturning due to bioturbation can be assumed a totally mixed layer and will offer no resistance to long-term flux. The component for erosion may be assumed to be absent for short periods of time (assuming the eroded layer would be replenished). Components for operational considerations, such as an added thickness to ensure uniform placement would provide long-term resistance to flux. The void ratio or density of the cap layer after consolidation should be used in the flux assessment.

Any detailed assessment of flux must be based on modeling since the processes involved are potentially very long term. Laboratory testing to more precisely determine parameters for the available models may also be conducted.

Modeling applications for cap effectiveness

A model has been developed by EPA to predict long-term movement of contaminants into or through caps due to advection and diffusion processes. This model has been developed based on accepted scientific principles and observed diffusion behavior in laboratory studies (Bosworth and Thibodeaux 1990; Thoma et al. 1993; Myers et al. 1996). The model considers both diffusive and advective fluxes, the thickness of sediment layers, physical properties of the sediments, concentrations of contaminants in the sediments, and other parameters. This model is described along with example calculations in Appendix B.

The results generated by the model include flux rates, breakthrough times, and pore water concentrations at breakthrough. Such results can be compared with applicable water quality criteria or interpreted in terms of a mass loss of contaminants as a function of time, which could be compared with similar calculations for other remediation alternatives. The model in Appendix B is applicable to the case of a single contaminated material layer and a single cap material layer, each with a homogenous distribution of material properties. The diffusion relationships used in the model have been verified against laboratory data. However, no field verification studies for the model have been conducted.

There is a need for a comprehensive and field-verified predictive tool for capping effectiveness, and additional research on this topic is planned.

The USACE has applied a refined version of an existing sediment flux model (Boyer et al. 1994) for capping evaluations, and more refinements to the model are planned to account for a comprehensive treatment of all pertinent processes. But in absence of such a tool, analytical models such as that in Appendix B should be used in calculating long-term contaminant loss for capped deposits as long as conservative assumptions are used in the calculations.

Laboratory tests for flux evaluation

Several testing approaches have been applied to define cap thicknesses and the sediment parameters necessary to model their effectiveness in chemical isolation. Laboratory tests may be used to define sediment-specific and capping-material-specific values of diffusion coefficients and partitioning coefficients. But no standardized laboratory test or procedure has yet been developed to fully account for advective and diffusive processes and their interaction.

The USACE developed a first-generation capping effectiveness test in the mid-1980s as part of the initial examination of capping as a dredged material disposal alternative. The test was developed based on the work of Brannon et al. (1985, 1986), Gunnison et al. (1987a), and Environmental Laboratory (1987). Louisiana State University has conducted laboratory tests to assess diffusion rates for specific contaminated sediments to be capped and materials proposed for caps (Wang et al. 1991). Diffusion coefficients for long-term modeling of diffusive transport of contaminants from contaminated sediment into cap material have also been measured using diffusion tubes (DiToro, Jeris, and Clarcia 1985). Environment Canada has performed tank tests on sediments to investigate the interaction of capping sand and compressible sediments, and additional tests are planned in which migration of contaminants due to consolidation-induced advective flow will be evaluated (Zeman 1993). The USACE has also developed leach tests to assess the quality of water moving through a contaminated sediment layer into groundwater in a confined disposal facility environment (Myers and Brannon 1991). This test is being applied to similarly assess the quality of water potentially moving upward into a cap due to advective forces.[1]

Results of laboratory tests conducted with samples of the contaminated sediments to be capped and the proposed capping sediments should yield sediment-specific and capping-material-specific values of diffusion coefficients, partitioning coefficients, and other parameters needed to model long-term cap effectiveness. Model predictions of long-term effectiveness using the laboratory-derived parameters should be more reliable than predictions based on so-called default parameters. More detailed descriptions of test procedures for evaluation of capping effectiveness are presented in Appendix C.

---

[1] Personal Communication, 1995, Tommy E. Myers, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Field data on long-term effectiveness

Some field studies have been conducted on long-term effectiveness of caps. Sequences of cores have been taken at capped dredged material sites in which contaminant concentrations were measured over time periods of up to 15 years (Fredette et al. 1992; Brannon and Poindexter-Rollings 1990; Sumeri et al. 1994). Core samples taken from capped sites in Long Island Sound, the New York Bight, and Puget Sound exhibit sharp concentration shifts at the cap/contaminated layer interface. For the Puget Sound sites, these results showed no change in vertical contaminant distribution in 5 years of monitoring with 18-month and 5-year vibracore samples taken in close proximity to each other. In the New York Bight and Long Island Sound sites, respectively, cores were taken from capped disposal mounds created approximately 3 and 11 years prior to sampling. Visual observations of the transition from cap to contaminated sediment closely correlated with the sharp changes in the sediment chemistry profiles. The lack of diminishing concentration gradients away from the contaminated sediments strongly suggests that there has been minimal long-term transport of contaminants up into the caps. Additional sampling for longer time intervals is planned.

These results confirm that no gross movement of contaminated sediments or contaminants occurs with a properly placed cap, that only pore water advection and molecular diffusion would act to move contaminants into a cap over the long term, that such processes move contaminants at extremely slow rates, and therefore contaminants are effectively isolated from the aquatic environment for extremely long periods (Brannon and Poindexter-Rollings 1990).

Acceptability of flux component design

If the flux evaluation indicates the design objectives are not met, additional cap thickness can be added or cap materials with differing properties (grain size and TOC) can be considered to further decrease the contaminant flux. The evaluation process could then be run in an iterative fashion if necessary to determine the chemical isolation component needed to meet the design objectives. Of course, if no reasonable combination of cap thickness and cap material properties can meet the objectives, other alternatives or control measures must be considered.

Required Design Cap Thickness and Area and Volume of Capping Material

Calculation of design cap thickness

The total design cap thickness, as initially placed, is determined as follows:

$$T_t = T_b + T_e + T_c + T_o + T_i$$

where

T_t = total cap thickness, cm

T_b = thickness for bioturbation, cm

Te = thickness for erosion, cm

T_c = thickness for consolidation, cm

T_o = thickness for operational considerations, cm

T_i = thickness for physical/chemical isolation, cm

Areal coverage of the full cap versus apron cap

For a capping operation to be successful, the required cap thickness must be placed over the deposit of contaminated material. Typically, the edge of the contaminated mound will be detected with an SPC, which can reliably detect contaminated layers of thickness of 1-2 cm. Within this context, the contaminated material deposit is considered that which can be detected. However, it is not possible or necessary to cap every particle of contaminated material with the full design cap thickness.

For LBC projects, capping operations should be aimed at placing the full design cap thickness over the central portion of the mound and inner and outer flanks of the mound as defined in Chapter 6. As contaminated material is placed to form the mound, material settles to the bottom as the apron in ever-decreasing thicknesses with increasing distance from the point of discharge. The capping material is similarly dispersed, especially if the grain size and placement methods are similar. Therefore, operations aimed at placing the design thickness over the geometry of the mound that can be defined by bathymetric surveys will result in somewhat thinner layers of capping material being placed over the apron, as defined in Chapter 6.

Monitoring techniques are discussed in Chapter 9. Differential bathymetric surveys can determine the extent of a deposit down to a thickness of approximately 15 to 30 cm, while an SPC can detect sediment thicknesses from 2 to 20 cm. A combination of these approaches can be used to define the areal extent of the contaminated material mound and subsequently the required areal extent of the full capping thickness.

For CAD projects in which the contaminated material is placed as a layer of uniform thickness within the contained area, the full design cap thickness should be placed over the entire surface area.

Volume calculations

Once the design cap thickness and required areal extent of the cap are determined, the required volume of capping material can be estimated. There is no minimum acceptable ratio of capping to contaminated sediment volumes for capping. The requirement is to cap the deposit of contaminated material with the required thickness of capping material. The areal extent of the contaminated material deposit and required cap thickness are the key factors in calculating the volume of cap material. For example, if a large volume of contaminated material were placed in a subaqueous depression or pit (a CAD project), the deposit could be satisfactorily capped with a relatively small volume of capping material. Additional considerations on cap areas and volumes are provided in Appendix H.

Acceptability of design

Once the total cap thickness is determined, the calculations used to arrive at each of the components should be reexamined and the acceptability of the design evaluated. Some recalculations using an iterative process may be necessary because total cap thickness influences the water depth above the cap, which influences erosion potential, and total cap thickness as placed influences the magnitude of consolidation of the cap. However, in most cases, the calculations will not be overly sensitive to the overall cap thickness, and recalculation of specific thickness components should not be required.

The overall design of the cap should also be examined with respect to acceptability from the operational, logistical, and economic perspectives. If the total cap thickness is too large for effective placement, or the needed volume of cap material is not available, or the anticipated cost of capping too great, alternate sites or other disposal alternatives should be considered.

Considerations for Intermediate Caps

Some capping projects could be designed in the context of anticipated multiuse or multiuser applications. In such a case, one site (e.g., a subaqueous borrow pit) could be selected for placement of contaminated sediments from several projects. If several placements of contaminated sediments are to be placed with such frequency that the site could not effectively recolonize, there would be no pathway for bioaccumulation or benthic toxicity. Also, if the site is located in a sheltered area, or the energy from low-frequency events would not cause significant erosion, no placement of cap material or placement of a intermediate cap with a lesser thickness. That is, one that has a shorter return period level of erosion protection or less capabilities for chemical or biological isolation than the full design cap could be considered. Determining an appropriate thickness for an intermediate cap would require an evaluation of the same processes as described above, but the design parameters (especially those for long-term flux, return periods for storms, etc.) should be selected to represent the time periods anticipated between dredged material and intermediate cap placement and final cap placement.

8 Long-Term Cap Stability

Considerations in Long-Term Stability

When contaminated material is isolated from the environment through a dredged material capping operation, it is essential that not only the precision and thoroughness of initial cap placement be considered but also the long-term integrity, or stability, of the capped deposit be evaluated on a regular basis. A critical element in successful performance of a cap is preservation of an adequate thickness of this clean material to control flux of contaminants and isolate the contaminated sediments from benthic organisms. In evaluating long-term cap stability, factors that must be addressed include the following:

a. Possible consolidation (of capping material, contaminated sediment, and foundation material) for effect on long-term site capacity, differentiation from erosion, and quantification of contaminated pore water volume expelled.

b. Potential for erosion (considering the wave and current conditions at the disposal site and dredged material particle size and cohesion).

If erosion or consolidation causes the cap to be too thin to effectively isolate the contaminated material from the surrounding environment, then remedial actions will be required to reestablish cap integrity. This chapter presents detailed procedures to evaluate long-term physical stability of subaqueous dredged material caps, considering consolidation and erosion processes. These processes are discussed in the following paragraphs, along with recommended techniques and computer models available for analysis.

A critical step in cap design is to use the information from Chapter 7 in determining a design cap thickness (or a trial thickness for detailed evaluations such as decribed in this chapter). Selecting a design cap thickness is a function of an acceptable level of risk. Assessment of consolidation is mathematically straightforward, while the very stochastic nature of erosion makes it much more complicated to predict. Definitive guidance on cap stability is difficult because the level of acceptable risk will likely vary from location to location. Further discussion of risk-related cap design topics are found at the end of this chapter.

Evaluation of Consolidation

For LBC projects, dredged material typically forms a mound of material on the bottom of the water body. If a clean sediment is placed to isolate the contaminated material from the surrounding environment, the capping material increases the size of the existing mound and also places a surcharge load on the underlying dredged material and further increases the surcharge load on the foundation soil. Because the contaminated sediments are usually fine grained and have a relatively high moisture content, they are often susceptible to large amounts of consolidation. For CAD projects, the materials are layered but are subject to the same consolidation processes.

Assessing consolidation potential of capped dredged material mounds or deposits requires consideration of the consolidation potential of three elements: the cap, the contaminated dredged material, and the native or substrate sediments (foundation soils). The contaminated dredged material (which is usually fine-grained, cohesive material) likely will undergo consolidation resulting both from its own self-weight and from the surcharge load of the capping material. If the capping material is fine grained (e.g., silt or clay), it will also be susceptible to consolidation. Coarse-grained capping material (e.g., sand or gravel) would not normally be expected to consolidate. The final element to be considered is consolidation potential of the foundation soils. If these soils are fine-grained materials susceptible to consolidation, the loading applied by the contaminated and capping material will probably be sufficient to cause consolidation.

Quantifying consolidation is necessary for three reasons. First, changes in elevation due to consolidation must be delineated from those due to erosion. Decreases in the elevation of the mound or deposit surface caused by erosion of the cap may require remedial actions to replenish and restore the cap to its required thickness. If consolidation of constituent materials accounts for the change in elevation, then no cap replenishment is necessary, particularly if cap thickness design accounted for, a priori, potential cap consolidation. Thus it is imperative that consolidation be distinguished from erosion. Second, consolidation should be considered when determining long-term site capacity. As a mound consolidates and decreases in elevation, additional volume becomes available between the mound surface and the plane of maximum acceptable mound elevation; this volume can be used for storage of additional dredged material. The increases in the storage capacity of subaqueous disposal sites due to consolidation are especially important when these sites will be used to store large quantities of material from several dredging operations occurring over a number of years. Thus the ultimate holding capacity of repeated-use sites will be significantly increased if consolidation is considered. Third, a consolidation analysis will provide data needed to evaluate the potential movement of pore water from the contaminated sediment upwared into the cap, and this is necessary in evaluating the potential for long-term flux of contaminants.

Many soft fine-grained materials may undergo on the order of 50-percent vertical strain during the consolidation process. Therefore, the objective of consolidation analysis is to determine the amount and rate of consolidation that the mound and/or foundation soils will undergo as a result of self-weight consolidation and/or surcharge loading. One-dimensional (1-D) consolidation analysis is normally used in geotechnical engineering. In a 1-D analysis, pore water is expelled vertically (upward and/or downward) from soil layers; no horizontal flow or strain is allowed. Few 2-D or 3-D analyses are ever performed, and these are usually conducted on research projects. Because of the configuration of subaqueous sediment mounds (relatively flat slopes and thin lifts), a 1-D analysis of mound consolidation should provide adequate results for either design or analysis of these mounds. However, in the future, development and use of 2-D or 3-D consolidation models would permit more accurate prediction of the actual direction and magnitude of flows and movements.

Fine-grained dredged sediments, especially those placed by pipeline or hopper dredge, are initially soft and have a high water content, with an associated high compressibility. Potential changes in height (strains) due to consolidation are large; therefore, a finite strain approach that accounts for the large strains should be used to evaluate consolidation (Rollings 1994; Poindexter 1989).

Consolidation testing

Laboratory consolidation test data are necessary for an evaluation of consolidation; however, standard procedures for consolidation tests (USACE 1970) may not be applicable for testing of soft sediment samples. A modified version of the standard oedometer consolidation test (USACE 1987) and a self-weight consolidation test (Cargill 1985) have been developed that provide data for the wide range of void ratios that may be encountered in the context of dredged material placement operations. Additional details on consolidation testing are given in Appendix I.

Consolidation models

The complexity and number of calculations required to predict consolidation of deposits using large strain consolidation theory require use of a computerized solution technique. The theory of finite strain consolidation (Gibson, England, and Hussey 1967) has been incorporated into several generations of computer models for analyzing consolidation of capped sediment mounds (Cargill 1985; Poindexter-Rollings 1990; Stark, in preparation). To run any of these models, consolidation test data from self-weight consolidation tests and/or standard oedometer tests (USACE 1970; USACE 1987) are required (See Appendix I).

Initial work on consolidation of dredged material was done with the computer model PCDDF (Primary Consolidation and Desiccation of Dredged Fill) (Cargill 1985), which was later modified and released as PCDDF89 (Stark 1991); these programs were developed specifically for analysis of confined upland disposal sites. Subsequent work on consolidation of subaqueous capped mounds was done with MOUND (Poindexter 1989; Poindexter-Rollings 1990). This program incorporated capabilities for analyzing deposits that were subjected to surcharge (cap) loads and included an empirical relationship between shear strength and void ratio, plasticity index, and activity of the sediment particles. Most recently, PCDDF89 has been updated to include secondary compression; this version is known as PSDDF (Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill) and is likely the most user-friendly version (Stark, in preparation). Each of these computer programs is based on the same 1-D theory of consolidation and is capable of predicting the consolidation of multiple compressible layers. Computational details and processing speeds vary among the programs, but similar consolidation estimates should be obtained from each.

In evaluating consolidation, both the rate and the magnitude of consolidation should be determined separately for the contaminated sediment, the capping material, and the foundation layers, as appropriate. Then for any given time of interest, the individual settlement values for the foundation, contaminated sediment, and capping sediment should be summed to provide an estimate of the total amount of settlement to be expected at that particular time. This information can be used in conjunction with field-monitoring data in the ongoing assessment of cap integrity. The change in thickness of the capping layer is of primary concern from an environmental containment perspective. However, the total amount of consolidation settlement, or decrease in elevation, of the cap surface over time is necessary to delineate between mound height changes caused by erosion and those accounted for by consolidation of constituent materials.

Because consolidation settlement of capped mounds can be mistaken for erosion of the cap, estimates of consolidation of capped mounds should be made when mound geometry is established and should be routinely compared with field-monitoring data thereafter. Estimating consolidation of capped mounds requires collection of appropriate samples, conducting necessary geotechnical testing (as described in Chapter 3), and conducting a consolidation analysis for each compressible material (foundation, contaminated sediment, and/or capping material).

The MOUND model and another consolidation model, CONSOL (Gibson, Schiffman, and Cargill 1981; Wong and Duncan 1984), were used to predict consolidation of three capped dredged material mounds in Long Island Sound (Silva et al. 1994). Bathymetry of these sites showed reductions in mound elevations of up to 3.5 m over time periods of 10 to 13 years after cap placement. Comparisons between consolidation and bathymetry estimates were made to show that the reductions in mound elevation could be attributed to consolidation rather than cap erosion. These results compare favorably with earlier analyses of the same capped mounds in which the predictions were also validated by field measurements (Poindexter 1989). Results showed the two models used in the recent study were reasonably accurate in predicting consolidation, that consolidation of the base (native) sediments can constitute a majority of the observed consolidation, and that the caps had not experienced erosion losses. The work also pointed out the need to obtain more accurate geotechnical information on the void ratios and initial effective stress of the contaminated materials.

Typical consolidation results

As in all consolidation analyses in geotechnical engineering, the profile of the deposit (including thickness and extent of each material) must be determined. An idealized mound geometry for an LBC project is shown in Figure 22. The consolidation of the mound is then predicted using an appropriate finite strain consolidation model, and the results should then be plotted.

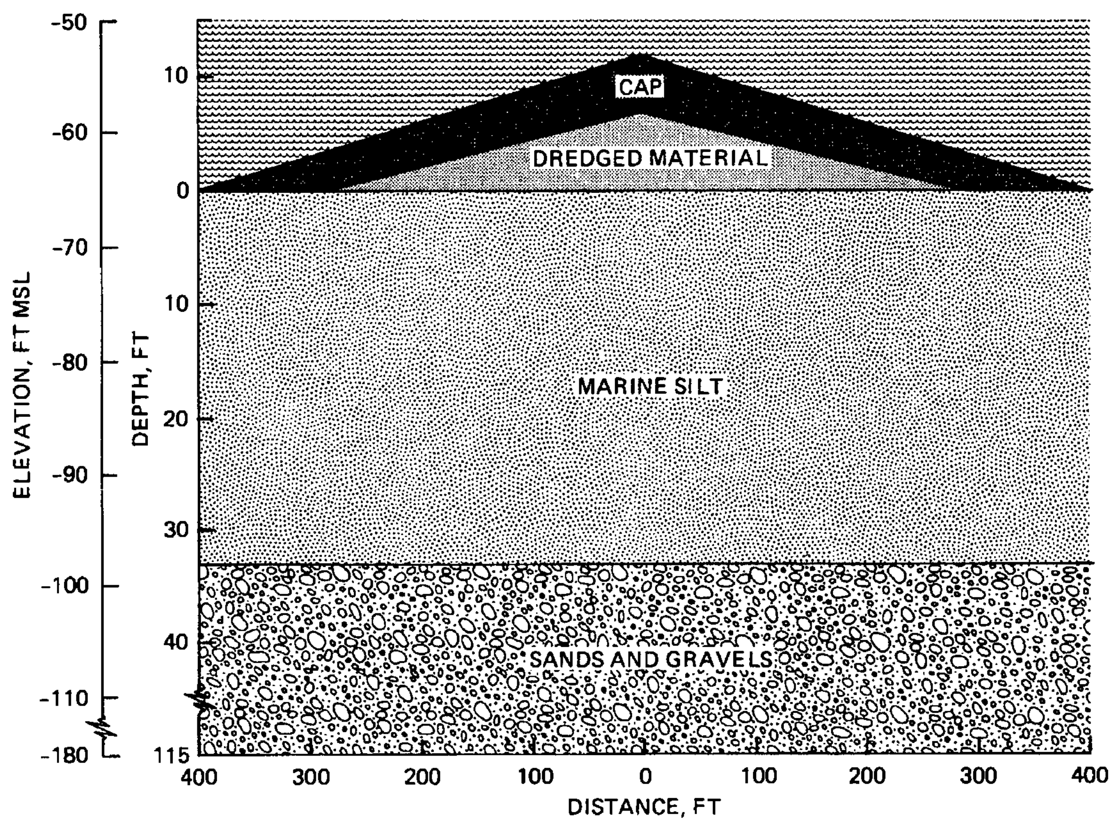


Figure 22. Idealized soil profile of mound and foundation soils

Two types of plots are often used to show the amount of consolidation that is expected to occur in a dredged material mound. The ultimate change in elevation of the mound surface is often plotted to show the change in configuration that can be expected following consolidation. Figure 23 shows the original and final mound height when consolidation only (i.e., no erosion) is considered. Secondly, a plot is usually constructed of settlement over time at a particular point or points in the mound. This plot can show the individual quantities of consolidation settlement predicted for the capping material, the contaminated dredged material, and the foundation soil; it will normally also show the total settlement expected. This type of plot is very useful for comparing predicted settlement (or surface elevation) with field-monitoring data. Figure 24 shows

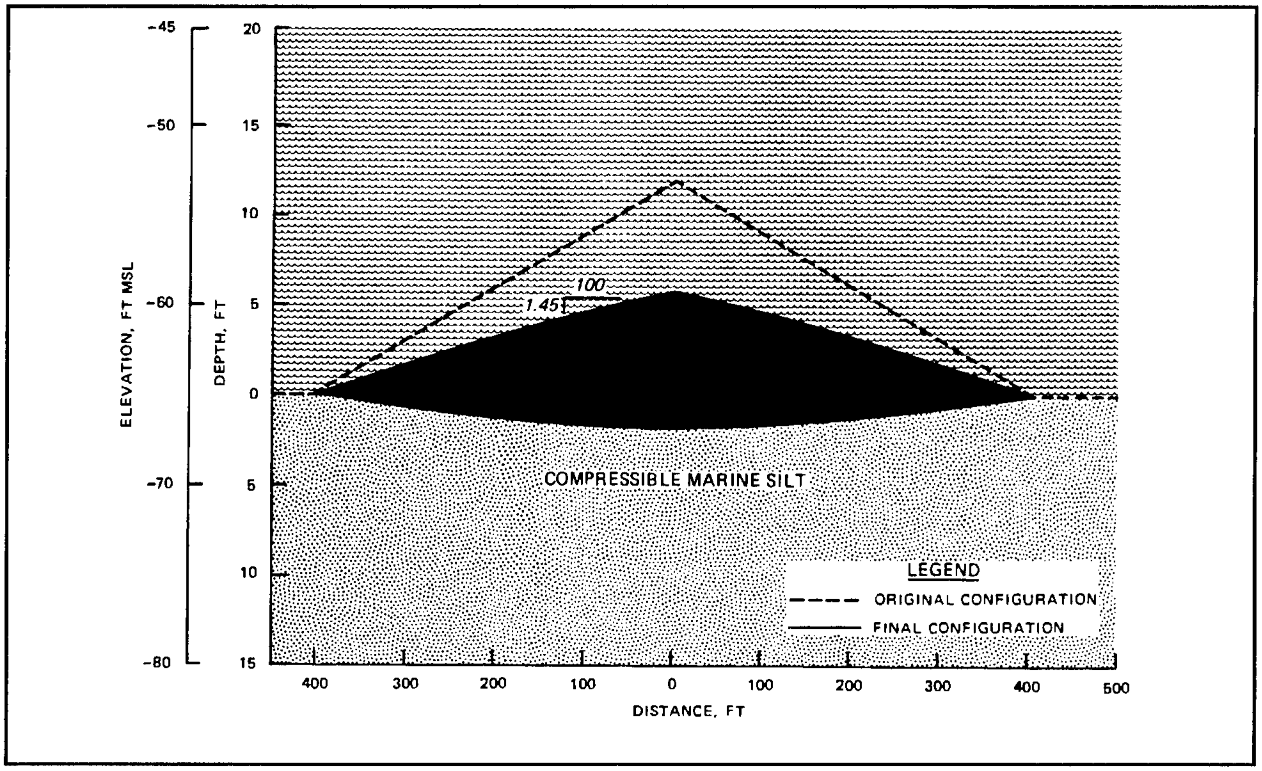


Figure 23. Predicted final mound configuration at completion of consolidation

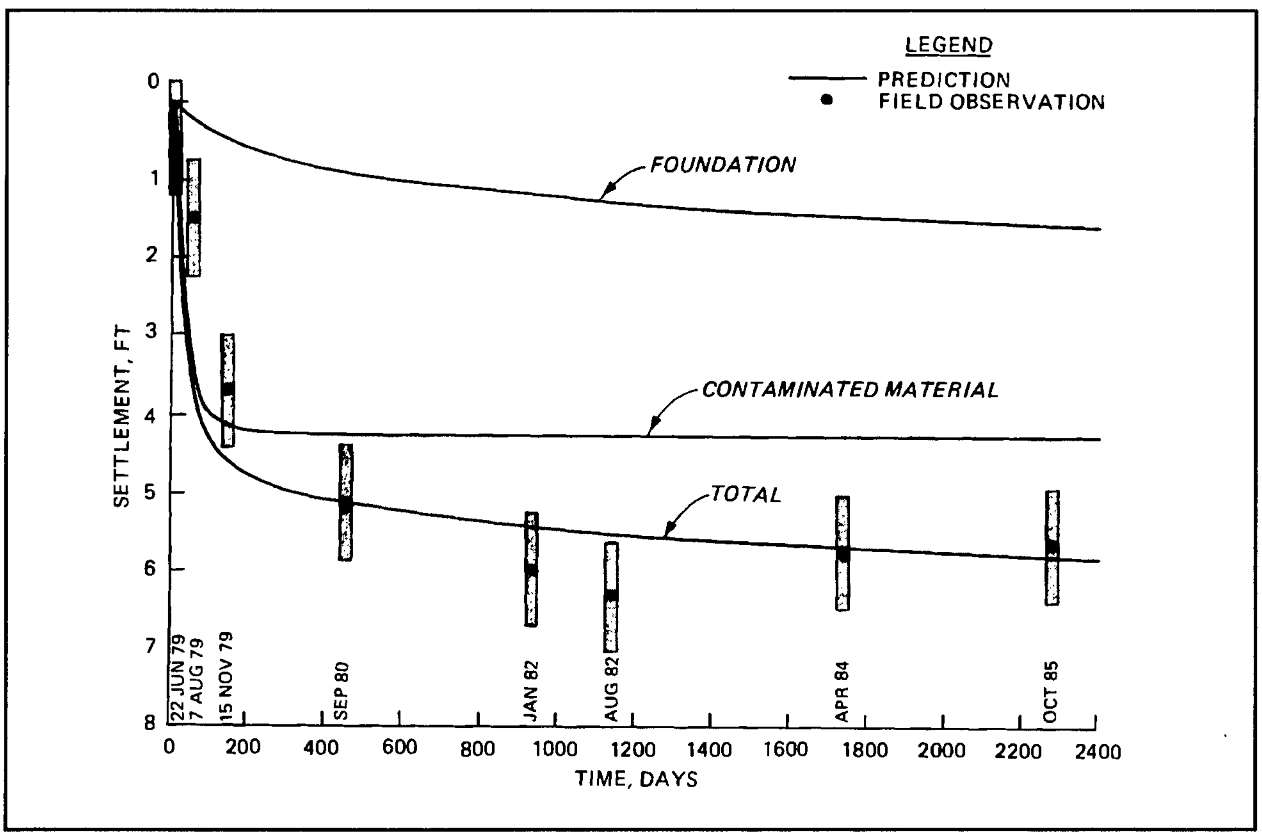


Figure 24. Time rate of consolidation at center of mound

the predicted time rate of consolidation as compared with actual field data.

Evaluation of Erosion Potential

If practical, capping should normally be conducted predominantly at sites that are classified as nondispersive, i.e., sites with relatively little potential for erosion. However, existing sites with more frequent potential for erosion can be used for capping projects after completing studies of the frequency of erosion of a specific capping material (considering grain size, mound geometry and sediment cohesion) for expected wave and current conditions (to include storms) over time predicted in the area. The results from such a study will provide data that can be used to predict the expected cumulative amount of erosion over time along with confidence intervals on the answers. The estimated erosion amounts can then be used to define the design cap thickness component for erosion protection required for a given length of time (say 20 to 100 years). Cap thickness should be monitored periodically as well as after large storm events to verify cap stability and measure cap erosion rates. In addition, minimum thicknesses for contaminant isolation should be predetermined. If monitoring indicates that cap thickness has been reduced below the minimum values, contingency plans should be enacted to place additional capping sediments.

The deposit of contaminated dredged material must also be stable against excessive erosion and resuspension of sediment before placement of the cap. The potential for resuspension and erosion depends on bottom-current velocity, potential for wave-induced currents, sediment particle size, and sediment cohesion. Site selection criteria as described above would normally result in a site with low bottom-current velocity and little potential for erosion during the window for placement of the contaminated sediments and cap. However, if the contaminated sediment is hydraulically dredged, erosion potential is greatly increased due to the high water content of the slurry (eventually this water content decreases, thus reducing erosion potential). In this case, a thorough analysis of the potential for resuspension and erosion should be performed to estimate the short- and long-term effects on resuspension potential. Conventional methods for analysis of sediment transport are available to evaluate erosion potential (Teeter 1988; Dortch et al. 1990; Resio and Hands 1994; Scheffner 1991a,b). The first level of investigation of cap stability against erosion involves examination of the normal wave and current regime to determine if these cause measurable amounts of erosion. However, sites where day-to-day waves and currents cause measurable amounts of erosion would be poor sites for capping projects.

Estimating critical conditions for initiation of motion in wave or current environment

For most sediment bed compositions, a critical stress value exists below which no or negligible sediment movement occurs. Stress is the force per unit area applied to the sediment bed surface by water movement. This critical value is usually called the critical shear stress for initiation of motion. Estimating the shear stress for given conditions is not a simple calculation and may depend on a multitude of variables. However, under many conditions, given a few basic parameters, an estimate can be made for the shear stress that can tell the engineer if sediment deposits are in the range where sediment movement may occur (i.e., above the critical value). This can be done for a wave environment or a current environment. This section contains graphs that, if a few basic parameters are known (such as median grain size, wave height, wave period, water depth, and current), a reasonable estimate of stress can be developed. The calculations for combined current/wave environments cannot be plotted easily. Under these conditions, the relationships become much more complex, and a detailed study is required to determine the bottom stresses and ultimate dispersive/nondispersive classification of the site.

The dashed lines in Figure 25 plot the critical value of the vertically averaged current velocity (u_{cr}) versus the median grain size (d_{50}) for various water depths. The expression for u_{cr}, as described by van Rijn (1993), is defined as a function of the water depth h and grain size distribution. This simplified equation, based on Shields curve for initiation of motion and assuming effective bed roughness can be estimated as $3d_{90}$ (where d_{90} is the 90th percentile grain size, i.e., 90 percent of the material is finer) and $d_{90} = 2d_{50}$ can be expressed as:

$$\bar{u}_{cr} = 0.19(d_{50})^{0.1}\log\left(\frac{12h}{3d_{90}}\right) \qquad \textit{for } 0.0001 \le d_{50} \le 0.0005\,m$$

$$\bar{u}_{cr} = 8.50(d_{50})^{0.6}\log\left(\frac{12h}{3d_{90}}\right) \qquad \textit{for } 0.0005 \le d_{50} \le 0.002\,m$$

As stated previously, the above equations calculate the approximate critical vertically averaged velocity value for the initiation of sediment movement. At these values, the particles will start to roll or move across the bottom in fairly regular jumps (saltation). There are also higher stress levels at which the particles will leave the turbulent bottom boundary layer and be brought into suspension. These values are called the critical velocities for initiation of suspension and are indicated by the solid lines in Figure 25. These values can be approximated, using the same assumptions as for u_{cr}, by:

$$\bar{u}_{cr,s} = 5.75\left[(s-1)gd_{50}\right]^{0.5}(\Theta_{cr,s})^{0.5}\log\left(\frac{12h}{3d_{90}}\right)$$

where s is the sediment specific gravity; g is acceleration of gravity; and $\Theta_{cr,s}$, the critical Shields parameter for suspension, is defined by:

$$\Theta_{cr,s} = \frac{16}{D^{*2}}\frac{w_s^2}{(s-1)gd_{50}} \qquad \textit{for } 1 < D^* \le 10$$

$$\Theta_{cr,s} = 0.16 \frac{w_s^2}{(s-1) g d_{50}} \qquad \textit{for } D^* > 10$$

w_s is the sediment settling speed (which can be estimated for a given grain size from charts or by Stokes law) and the dimensionless particle parameter, D^*, is defined by:

$$D^* = \left[\frac{(s-1) g}{\nu^2} \right]^{1/3} d_{50}$$

The value for the kinematic viscosity, *n*, is approximately 1×10^{-6} m^2/s.

For determining the stability of a specific site, Figure 25 can be used to indicate potential for site erosion when a distribution of the vertically averaged velocities, bed grain-size distribution, and water depth are known. If the velocities are frequently above u_{cr}, then there is a potential for some site erosion. There is a strong likelihood for severe erosion if the velocities frequently exceed $u_{cr,s}$. It should be emphasized that if there is any question concerning site stability, i.e., Figure 25 does not clearly indicate that erosion will not occur, more detailed data collection and modeling efforts should be undertaken to determine erosion potential.

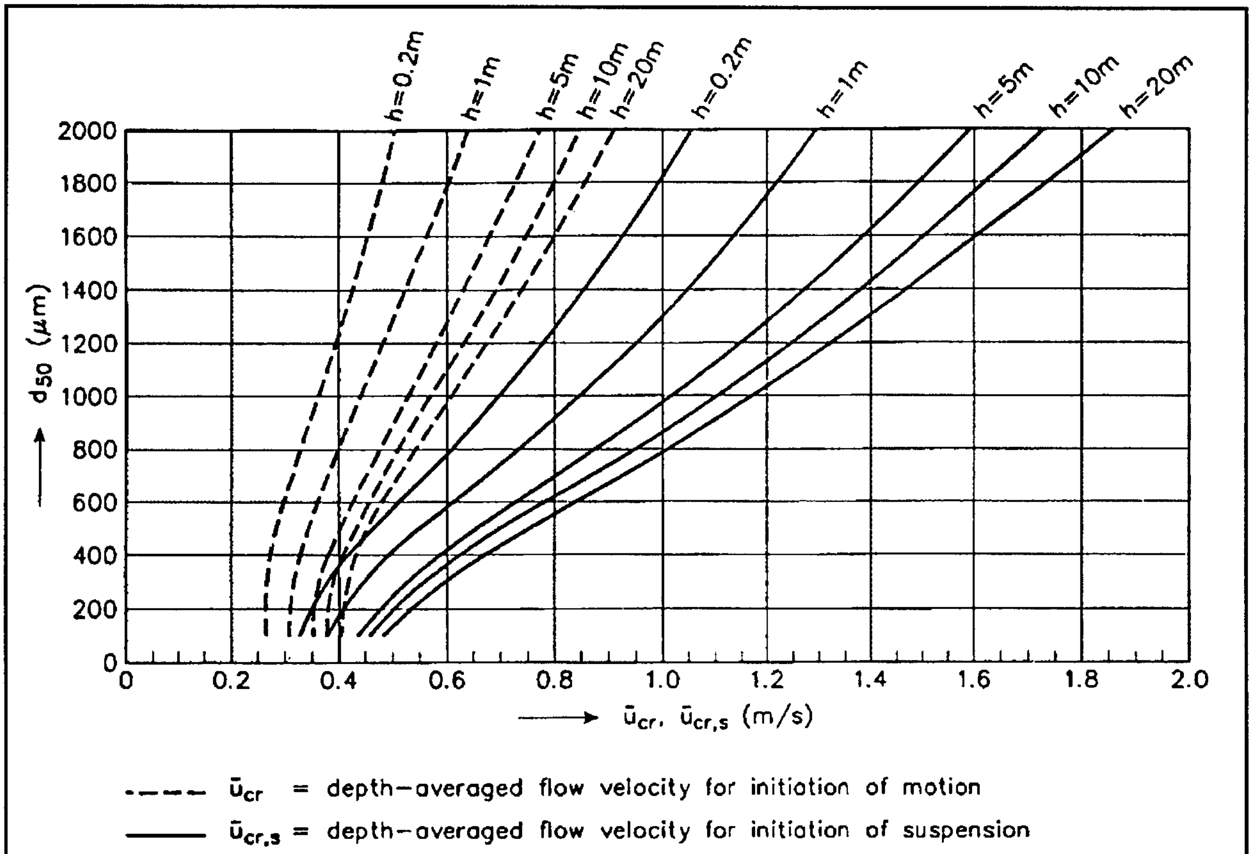


Figure 25. Critical vertically averaged velocities for a plane bed (from van Rijn 1993)

Under wave-dominated conditions, the orbital velocities produced by waves will be the primary force agitating the sediment bed surface and producing erosion. Because of the unsteady nature of the orbital velocities (compared with the relatively steady currents), a peak orbital velocity of similar magnitude to a current velocity will not result in similar shear stresses at the sediment-water interface. The current boundary layer is fully developed and much thicker than that for continually changing orbital velocities. Therefore, bottom shear stresses created by a similar magnitude orbital velocity will be much greater than that for current velocity and Figure 25 will not apply. Due to the complexity of wave/bottom stress complexities, there is no general agreement amongst researchers on a proper method for estimating bottom effects. However, it is possible, without a detailed analysis, to develop a first order magnitude estimate that will assist the engineer in determining site stability for a plane bed. The method described here was developed by van Rijn (1989), and a brief overview is presented in van Rijn (1993). Figure 26 plots wave period, T, versus the critical peak orbital velocity at the bed, $u_{\delta,cr}$. The solid lines are the experimentally determined values of the critical value for the initiation of motion. The average inaccuracy of the curves is 25 percent. The value of U_δ for conditions at a specific site can be evaluated by:

$$U_\delta = \frac{\pi H}{T \sinh(kh)}$$

where

H = significant wave height

T = wave period

k = wave number

The wave number k can be determined from the wave length L by the equation $k = 2p/L$. The wave length in turn is determined by iteration of the equation:

$$L = \frac{gT^2}{2\pi} \tanh(2\pi h/L)$$

The user can then compare the value of U_δ to the critical value, $U_{\delta,cr}$, for a known median grain size and wave period using Figure 26. If the values of U_δ is greater than $U_{\delta,cr}$, then the potential for erosion is significant. Even if the value is only slightly less than critical, given the margin of error in the estimates presented in Figure 26, the engineer should seek further detailed analysis to determine site stability. However, if the value is significantly less than critical, the site can be assumed stable.

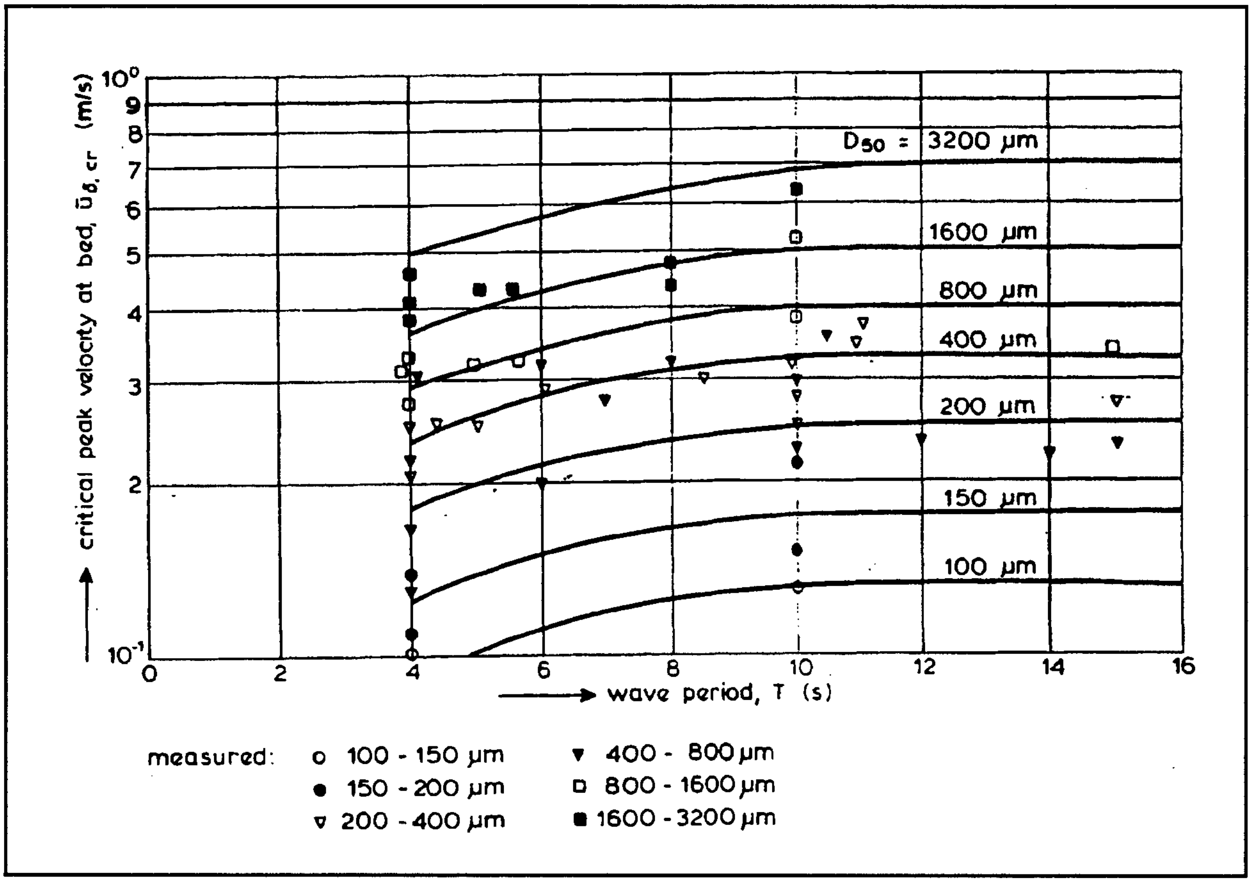


Figure 26. Initiation of motion for waves over a plane bed based on critical velocity (from van Rijn 1993)

***Example* 1, Current-dominated environment**: If the region of interest is in 10 m of water, the median grain size (d_{50}) is 500 mm, then the critical velocity for initiation of motion from Figure 25 is approximately 44 cm/s, and the critical velocity for initiation of suspension is 70 cm/s (these values can also be calculated from the equations in this section). If the vertically averaged velocity for a particular storm frequently exceeds 50 cm/s with peak velocities around 65 cm/s, then it can be assumed that the sediment bed will experience some erosion during the storm.

***Example* 2, Wave-dominated environment**: The water depth is 5 m, wave period is 7 s, wave height is 0.5 m, and d_{50} is 200 μm.

For these conditions, it is determined that L = 46 m and k = 0.14 m^{-1}. Using the supplied equation, U_δ = 0.30 m. From Figure 26, for a d_{50} of 200 mm and wave period of 7 s, $U_{\delta,cr}$ is approximately 0.24 m/s. Therefore, the bottom shear stresses generated by these conditions, represented by U_δ = 0.30 m, are greater than the critical value of 0.24 m/s, and erosion will occur under these conditions.

Predicting erosion magnitude and rate

Predicting erosion thicknesses, which consists of computing a resuspension rate (the volume or mass of material put into movement by the currents per unit of time and area), net transportation rate (how fast is the sediment mass or volume moved horizontally), net transportation gradient (is more sediment moving out of a given area than moving in), and the duration of the erosion, is a difficult task that requires a sophisticated numerical model to obtain reasonable results at an open-water site.

Erosion of fine-grained cohesive sediments is even more complicated than for cohesionless particles because of interparticle forces (i.e., cohesion), the fact that cohesive forces can vary with depth (i.e., become more erosion resistant), cohesive forces are time dependant (density and cohesion increase with time), and other factors (e.g., salinity). In contrast, cohesionless sediments are considerably simpler because the erosion resistance does not change with depth, time, or sediment chemistry. Thus, modeling erosion of cohesive sediments is much more difficult than for cohesionless sediments.

A model was developed as a part of the USACE Dredging Research Program (DRP) to evaluate the long-term fate of a mound, i.e., mound stability over periods ranging from months to years (Scheffner 1991a,b). This model is called the Long-Term FATE of dredge material (LTFATE) model (Scheffner et al. 1995). In LTFATE, hydrodynamic conditions at a site are considered using simulated databases of wave and current time series or actual wave and current data as driving forces. These boundary conditions are used to drive coupled hydrodynamic, sediment transport, and bathymetry change models that predict erosion of dredged material mounds (of specific dimensions, grain size, and water depth) over time. LTFATE uses empirically derived methods to estimate either noncohesive (Ackers and White 1973) or cohesive (Lavelle, Mofjeld, and Baker 1984) sediment resuspension, transport, and deposition. Results from this model indicate whether a given site is predominantly dispersive or nondispersive and predict potential erosion and migration of a mound for the given current and wave conditions, mound geometry, and sediment characteristics. Typical results from the model are shown in Figure 27. Appendix F describes the model in more detail by providing background, major assumptions and limitations, input requirements, and sample output.

The LTFATE model has recently been applied in hindcasting the stability of a capped mound located in the Mud Dump site, a designated ocean-disposal site in the New York Bight, during a severe storm that occurred in December 1992 (Richardson et al. 1993). In this application, wind and wave data from a directional wave buoy operated by the National Data Buoy Center of the National Weather Service, data on current and tidal fluctuation from a verified Bightwide numerical hydrodynamic model, and data on historical storm and surge effects in the area were used to develop bottom currents for a range of storm-induced conditions at the proposed capped mound location. The model was used to predict the magnitude of resulting cap material erosion. Long-term stability of the mound was also evaluated using empirical criteria from nearshore berms to determine the potential for significant movement of the overall capped feature using criteria from other monitored sites. This study provides a model for

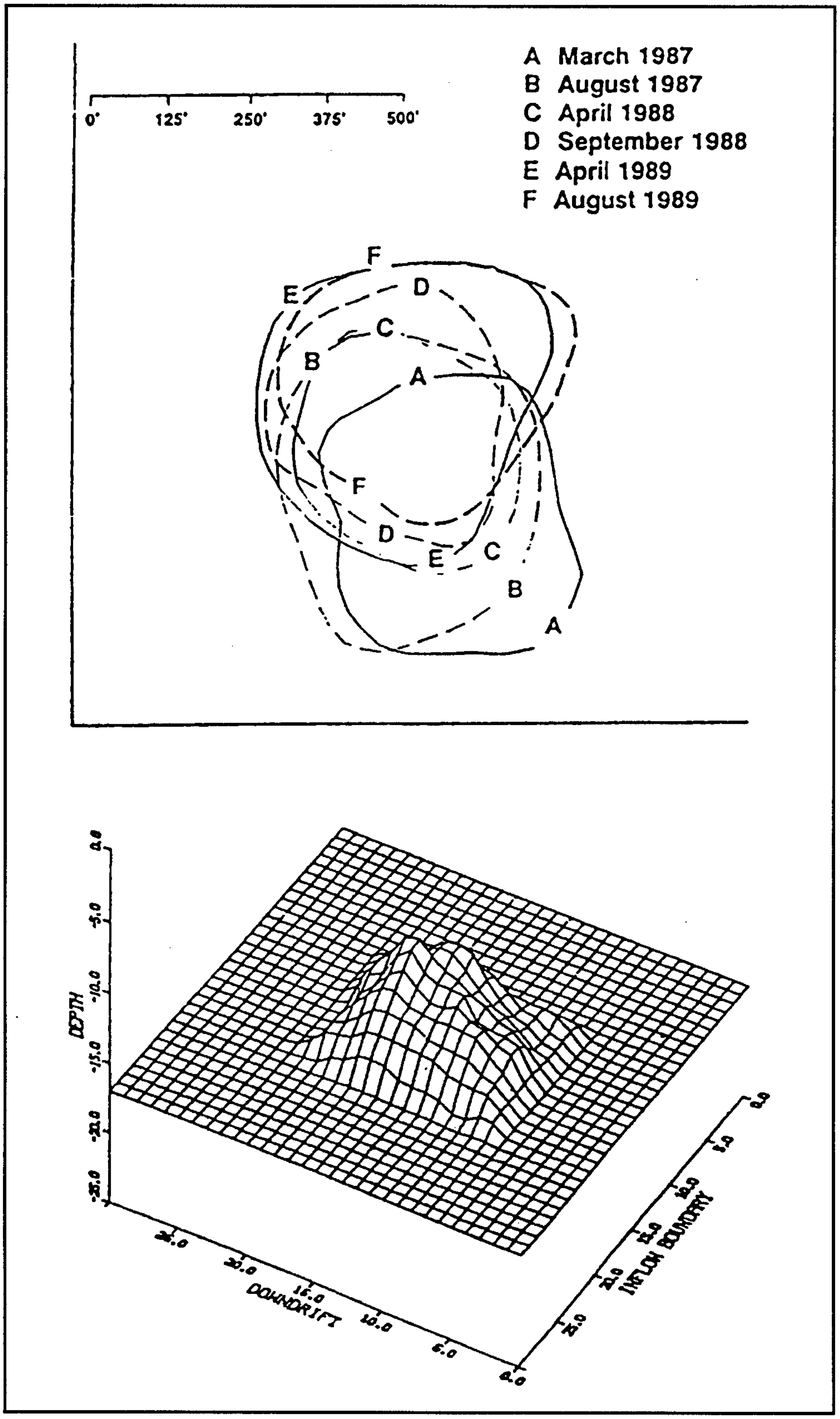


Figure 27. Typical LTFATE model results showing long-term changes to mound geometry

comprehensive evaluation of the potential mound stability from a single storm. A more comprehensive approach, however, is to evaluate the long-term physical stability by computing the frequency of occurrence of erosion over much longer periods. This procedure is described in the following section.

Frequency of erosion studies

While it is desirable to site capping projects in low-energy areas with little or no potential for erosion, these sites are not always available. At higher energy sites, the potential for erosion has to be estimated and taken into account when designing the cap. Stated simply, an additional layer is added to the overall cap thickness to account for expected erosion over a finite time period. Knowledge of the frequency of occurrence of vertical erosion (i.e., how often a given amount of vertical erosion will occur) is a critical component of a probabilistic cap design. Too thin an erosion layer may compromise the cap, potentially allowing the contaminants to be dispersed over the site and surrounding area. Conversely, too thick cap will have an unnecessarily high cost and also reduce the capacity of the site to contain additional dredged material. This section describes a rational method to determine the erosion layer thickness for sites where erosion is expected to be a problem. A detailed explanation of the frequency of erosion procedure and background information is provided in Appendix G.

The amount of expected erosion will be a function of the depth of the capped mound, mound geometry, the material used for the cap, and environmental forcing functions at the site, waves and currents, and their duration. The designer/project manager can influence the depth of the capped mound and the type of cap material. Therefore, most frequency of erosion studies of capped mounds require an investigation of a range of mound elevations (and thus water depths) and several different types of cap material, e.g., sand of various grain sizes and typical fine-grained (silt and clay) maintenance material.

Among existing procedures for computing frequency of erosion due to tropical and extratropical storms (e.g., worst case "design storms" or the joint probability method(JPM)), the empirical simulation technique (EST) is the best. EST is a statistical procedure for simulating nondeterministic multiparameter systems such as tropical and extratropical storms. The EST, which is an extension of the "bootstrap" statistical procedure (Efron 1982; Efron 1990), overcomes the JPM limitations by automatically incorporating the joint probability of the historical record. The bootstrap method on which EST is based incorporates resampling with replacement, interpolation based on a random walk nearest neighbor techniques with subsequent smoothing. More detailed descriptions of EST can be found in Scheffner, Borgman, and Mark (1993) and Borgman et al. (1992).

In EST, the various geometric and intensity parameters from storms are used to create a large artificial population (several centuries) of future storm activity (Borgman et al. 1992). The only assumption required for EST is that future storms will be statistically similar to past storms. Thus, the future storms generated during EST simulations resemble the past storms but possess sufficient variability to fill in the gaps in the historical data.

To perform the EST, historical storms impacting a site are broken down into the parameters that impact the engineering aspect of interest: storm track, maximum winds, radius to maximum, pressure deficit, etc. These variables are termed input vectors. The storm response of interest, in this case vertical erosion of the capped mound, is also calculated for each historical storm using an appropriate model (in this case LTFATE is used). The response of interest is referred to as a response vector. During EST simulations, N-repetitions (say 100 or more) of T-year responses (say 100 to 200 years) of the response vector of interest (vertical erosion for capping projects) are produced providing mean value frequency relationships with accompanying confidence limits such that probability of occurrence can be defined with error band estimates. In other words, the mean vertical erosion for a range of return intervals with confidence limits (based on the number of standard deviations) are produced by the EST procedure.

Application of the EST to a capping project involves a series of sequential steps to calculate the cap erosion thickness. A description of these specific steps are provided in Appendix G, using the Mud Dump study mentioned above as an example. The remainder of this section summarizes the required steps and concludes with specific recommendations on how to translate frequency of erosion values into a cap erosion layer thickness.

To define the required cap erosion layer thickness as a function of depth at a specific site, the following procedure was developed. It consists of a site-specific quantitative analysis approach. First, an appropriate set of storms, both tropical and extratropical for east coast sites, and tropical for Gulf coast sites, have to be selected. Next, the hydrodynamic inputs (the time series of storm surge levels and tide elevations, their resulting currents, and wave heights and periods) for the selected storms have to be developed for input to an erosion model such as the LTFATE model. These inputs are often developed using a 3-D ocean circulation model such as ADCIRC (Luettich, Westerink, and Scheffner 1992) or CH3D (Scheffner et al. 1994).

After the water level, current, and wave data for specific storms are available and in the proper format, LTFATE can be run to calculate the thickness of the layer eroded by each storm for a range of capped mound configurations (elevations and cap materials). These data are then input into the EST program, which makes 100 or more simulations of mound erosion over a long time period (100-200 years). The results can then be analyzed with standard statistical techniques to produce frequency of erosion estimates for the various mound configurations tested. Finally, the frequency of erosion estimates, including expected annual erosion and the longer return period erosion estimates, are converted into a design erosion layer thickness.

The following paragraphs discuss the results of such a study and how these can be used to compute erosion layer thickness.

Recommended procedure for computing erosion layer thickness and selecting a design cap erosion thickness

This section describes a recommended procedure for computing the erosion layer thickness for open-water capping sites. Also provided is a discussion on how the erosion thicknesses can be used to select the design erosion thickness for the cap.

One of the primary outputs of a frequency of erosion study will be a series of curves similar to the one shown in Figure 28. This figure shows the return period frequency of a given amount of vertical erosion for a year of extratropical storms acting on a mound in the Mud Dump site with a base depth of 73 ft and an 8-ft-high mound for a crest depth of 65 ft. The solid curve is the mean erosion predicted based on 100 simulations; error bars define plus or minus one standard deviation. Values from the curve can be translated into a tabular form. For northeast coast sites that experience both tropical and extratropical storms, the values from both types of storm are combined into a single return frequency table, such as the one as shown in Table 6 generated for the Mud Dump site.

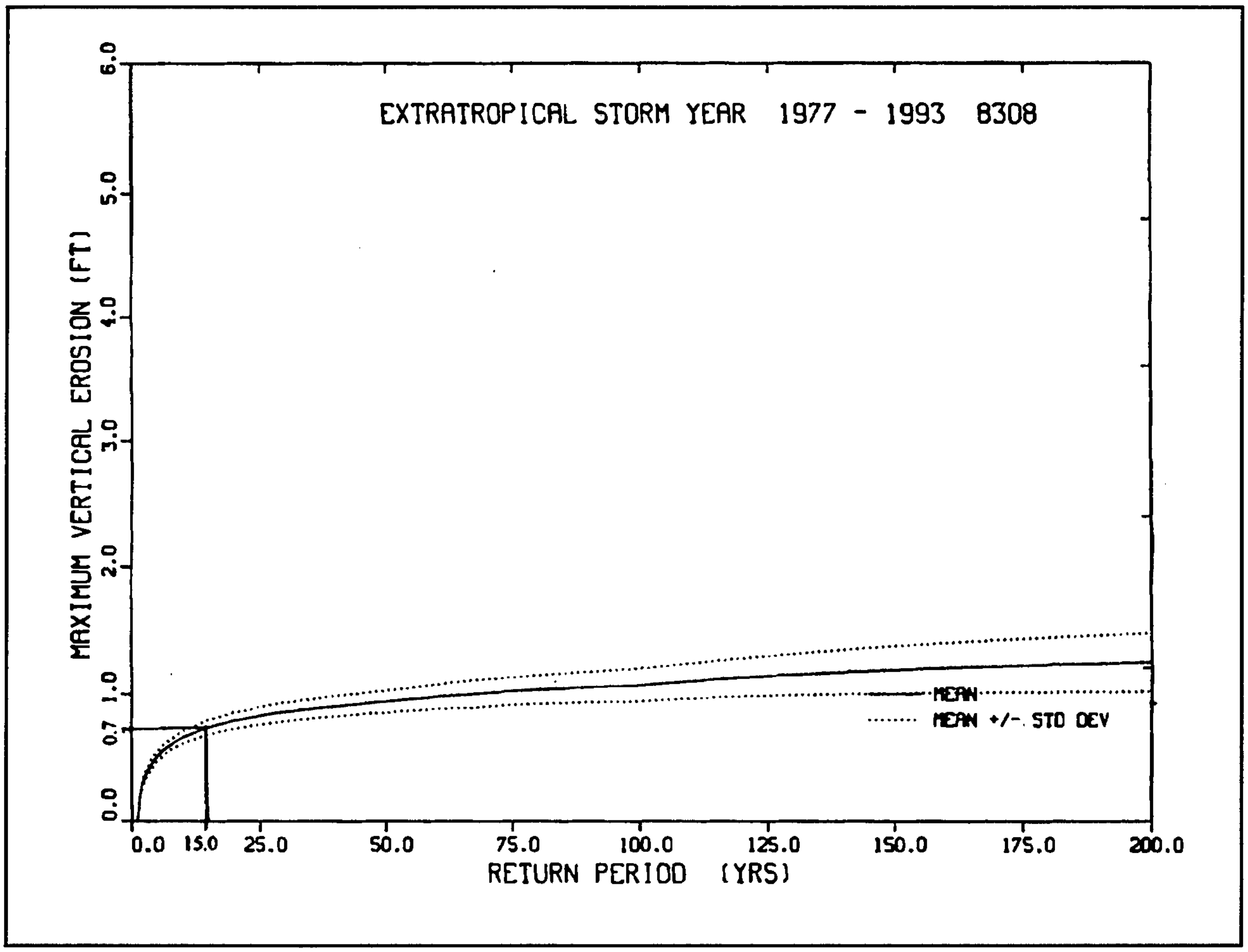


Figure 28. Frequency of vertical erosion from extratropical storms acting on a mound in Mud Dump site with a base depth of 73 ft and an 8-ft-high mound for a crest depth 65 ft

Table 6
Episodic Erosion Thickness Estimates for Mud Dump Site for 0.4-mm Sand Caps

Base Depth/ Mound Height/ Crest Depth, ft	Combined Hurrican/Northeaster Single-Year Erosion Frequency, ft			
	10 years	25 years	50 years	100 years
63/13/50	2.4	3.0	3.4	3.9
63/08/55	1.6	2.1	2.3	2.6
73/13/60	1.5	1.8	2.0	2.3
73/08/65	1.0	1.3	1.5	1.7
83/13/70	0.9	1.2	1.3	1.6
83/08/75	0.7	0.8	0.9	1.1

It is very important to note that the erosion values predicted by this curve and reported in the table are the maximum erosion experienced anywhere on the mound. Qualitatively, the maximum erosion is present over a very small portion of the mound, typically one corner on the seaward side (see Figure 29). Average erosion over the entire mound is expected to be much less, perhaps two-thirds of the maximum value, though this value will be a function of mound geometry, water depth, wave climate, and cap material and grain size.

In addition to maximum erosion expected from a severe storm year, the average-year cumulative erosion should be computed. To accurately compute average cumulative erosion, a time series of mound erosion resulting from typical storms (and nonstorm conditions if they are expected to produce erosion) over periods of between 5 and 10 years should be computed. During these model runs, the initial mound geometry would be impacted by a series of storms (or day-to-day conditions if warranted), with the resulting mound geometry from the previous storm becoming the input mound geometry for the following storm. Statistics on average and maximum erosion over the mound should be computed for time periods of say 1, 2, 5, and 10 years.

Using the above information on maximum episodic erosion thickness and cumulative annual erosion, the cap designers can then choose the return period erosion that provides the desired level of comfort or degree of risk. Factors that may influence the decision include the amount of uncertainty in the erosion prediction, the relative levels of annual versus episodic erosion, the level of contamination of the sediments being capped, whether or not additional material is expected to be placed on top of the project in the next few years, the difference in thickness required between a short and long return period, nearness of valuable resources/predicted consequences of the cap breeching, relative portion of the cap required for erosion compared with chemical isolation, bioturbation and consolidation, the unit/total cost of capping, difficulty in finding capping material and

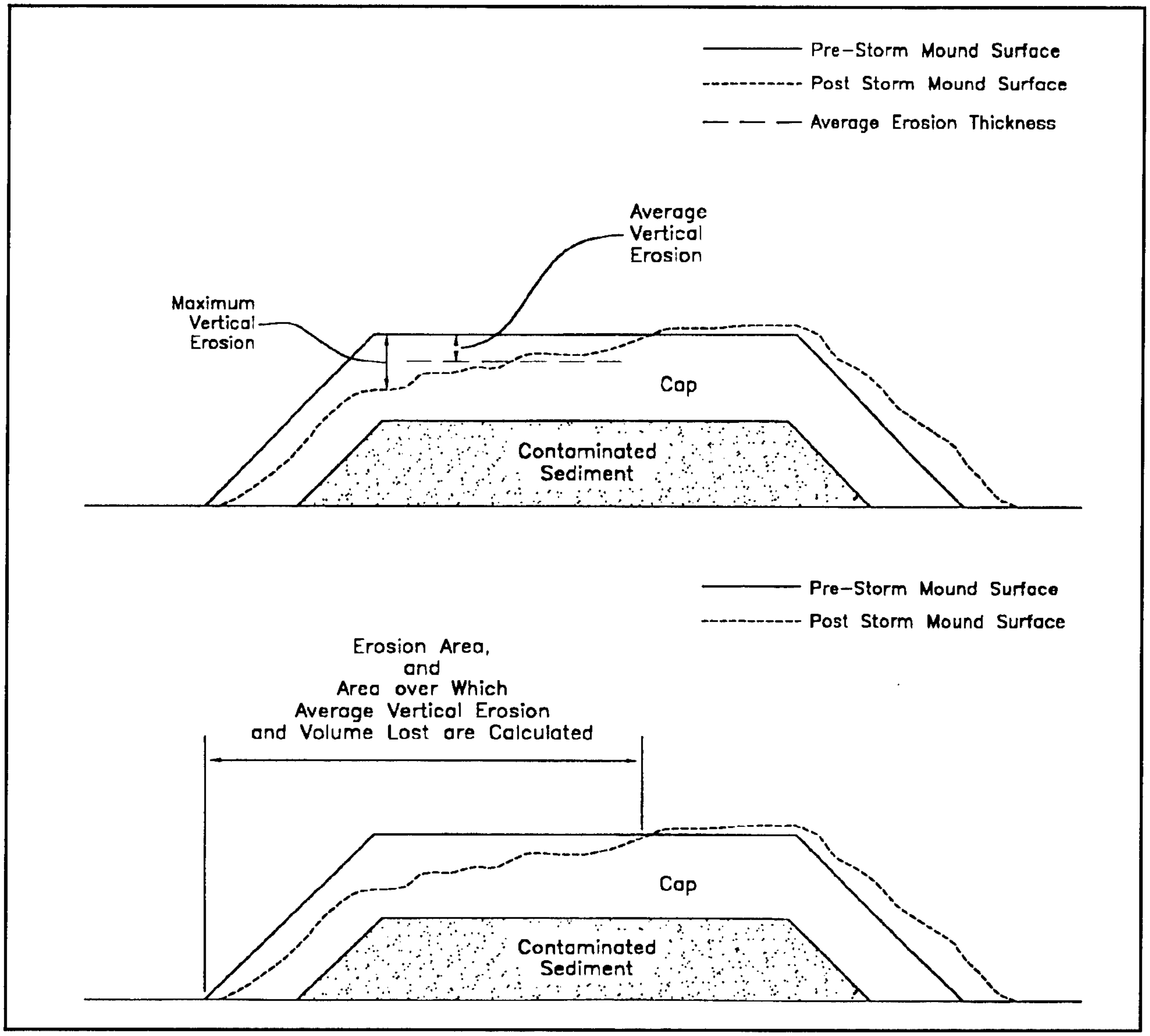


Figure 29. Idealized mound cross sections showing maximum and average vertical erosion and areas over which erosion volume is computed

gaining approval to cap, and other factors including political/social issues. Thicker erosion layers will reduce risk with a corresponding increase in cost.

The decision on the appropriate erosion layer thickness then will be site or region specific. For projects with minimally contaminated material where additional projects are expected in the next few years, a relatively short return period erosion thickness could be selected, say 10-20 years. Note that in Table 6, the erosion thickness for the 75-ft mound crest is 0.7 ft at a 10-year return period while the 100-year return period thickness in only 1.1 ft. For a mound at this depth, the designers may decide the extra protection provided by the additional 0.4 ft of cap is a good investment. However, for the 50-ft mound crest, the difference between the 10-year erosion thickness and 100-year erosion thickness is 1.5 ft (2.4 versus 3.9 ft), almost four times greater than at 75 ft. Therefore, if a short-term cap is needed for a 50-ft mound, the designers might find a 25-year erosion thickness; 3.0 ft provides a reasonable tradeoff between risk and cost.

Another critical factor in selecting a design erosion thickness may be the cost and difficulty in finding capping material. For example, assume the project is one where the desire is to place a cap that would ideally never have to be repaired, or one for which the renourishment interval would be on the order of decades because of the difficulty and cost in obtaining additional cap material. For such a project, a fairly long period erosion thickness, say 100 years, might be selected (perhaps adding some additional thickness for annual erosion if it is significant). However, if the cost of such a project becomes too high and capping sand is relatively available, then a shorter return period thickness, say 30 to 50 years (without adding annual erosion rates), might be more acceptable.

As a starting point, past practice in engineering structure design provides some guidance. Many Corps projects are designed with 50-year lives. However, because a capped project is, at least for now, assumed to require maintenance for a considerably longer time, a 100-year erosion thickness seems to be a reasonable starting point. First, because of our limited knowledge of historical storm data, it is difficult to predict with confidence storm conditions for return periods much greater than 100 to 200 years. Second, providing a cap thickness sufficient to resist storms with intervals greater than 100 to 200 years would probably be much too expensive. For projects where additional material is likely to be added in the near future, a 20-year return erosion thickness seems to be reasonable. The thickness of the erosion layer should also be capable of withstanding multiple years of annual erosion; a minimum of 10 years is suggested for caps designed for a long-term cap.

Additional cap should be placed when the average thickness of the cap has been reduced such that the design year return period erosion thickness would also remove some to all of the cap thickness that accounts for bioturbation. This is suggested because it is expected that a major storm that causes significant amounts of erosion will also remove any established biological community that is able to bioturbate a significant thickness of material (typically 10 to 20 cm). It is also assumed that the thickness of cap lost in a major storm will be repaired prior to recolonization by significant numbers of organisms that bioturbate to a substantial depth (greater than 1 year).

Potential control measures for erosion

If cap erosion is considered to be a problem, armoring with larger diameter material (coarse sand, gravel, riprap) or geotextiles may be considered as engineering approaches to overcome or protect against this problem. Procedures for design of caps composed of nonsediment components is available in the EPA guidance document for in situ capping projects (Palermo et al. 1996).

9 Monitoring Considerations for Capping

Need for Monitoring

Monitoring of capped disposal projects is required to ensure that capping acts as an effective control measure (Palermo, Fredette, and Randall 1992). Monitoring is therefore required before, during, and following placement of the contaminated and capping material to ensure that an effective cap has been constructed. (This activity also may be defined as construction monitoring.) Monitoring should also be required to ensure that the cap as constructed will be effective in isolating the contaminants and that long-term integrity of the cap is maintained (This activity also may be defined as long-term monitoring).

Since capping is a control measure for potential benthic effects, the monitoring discussed here does not focus on water column processes or the water column contaminant pathway during the placement of contaminated material prior to capping. Also, this chapter does not focus on those aspects of open-water site monitoring pertaining to site designation or on the direct physical effects of disposal. Any such monitoring would be considered in the context of the overall site selection process (Palermo 1991b).

Design of Monitoring Programs and Plans

The design of monitoring programs for any project should follow a logical sequence of steps. Several excellent publications containing general guidance for monitoring in marine environments and specific guidance on physical and biological monitoring at aquatic sites for purposes of site designation/specification and for permit compliance are available (Marine Board, National Research Council 1990; Fredette et al. 1990a; Fredette et al. 1990b; Pequegnat, Gallaway, and Wright 1990). These basic references should be consulted in developing appropriate monitoring plans for capping projects that suit the particular site and material conditions. A capping-specific monitoring plan has been developed for the DAMOS program in the New England Division (SAIC 1995a); it has been successful in evaluating capping success on over 20 capping projects to date (SAIC 1995a).

Fredette et al. (1990a) outlines five steps for developing a physical/biological monitoring program for open-water dredged material disposal. These steps as shown below should also be followed in developing a monitoring program for capping projects:

a. Designating site-specific monitoring objectives.

b. Identifying components of the monitoring plan.

c. Predicting responses and developing testable hypotheses.

d. Designating sampling design and methods (to include selection of equipment and techniques).

e. Designating management options.

Fredette et al. (1990a) recommend prospective monitoring that consists of observations or measurements that determine if site conditions conform to a predetermined standard. In addition, unacceptable adverse effects or unreasonable degradation are defined before sampling is begun. This is in contrast to retrospective programs in which the magnitudes, types, and areal extent of adverse impacts are not defined until after sampling is underway and data are interpreted. The physical and chemical thresholds that result in undesirable biological responses or effects must be determined and the potential impacts of the disposal predicted.

The monitoring program should be multitiered, as suggested by Fredette et al. (1986), Zeller and Wastler (1986), and Pearson (1987). Each tier has its own unacceptable environmental thresholds, null hypotheses, sampling design, and management options should the thresholds be exceeded. These are best determined by a multidisciplinary advisory group whose technical advice is sought in organizing and conducting the monitoring program. A sample tiered monitoring program pertaining to capping projects is outlined in Table 7. Each of the steps in developing a capping monitoring program is discussed in more detail in the following paragraphs. Note that not all the monitoring techniques would necessarily be used at every site.

Monitoring Objectives

Setting attainable and meaningful objectives is a necessary first step in the design of any monitoring program/plan. Appropriate objectives for a capping-monitoring program/plan may include the following:

a. Determine bathymetry, organisms, and sediment type at capping site.

b. Determine currents for evaluating erosion and dispersion potential.

c. Define areal extent and thickness of contaminated-material deposit to guide cap placement.

d. Define areal extent and thickness of the cap.

e. Determine that desired capping thickness is maintained.

f. Determine cap effectiveness in isolating contaminated material from benthic environment.

g. Determine extent of recolonization of biology and bioturbation potential.

Table 7
Sample Tiered Monitoring Program for a Capping Project

Monitoring Program	Monitoring Frequency	Threshold	Management (Threshold Not Exceeded)	Options (Threshold Exceeded)
Consult site designation surveys, technical advisory committee, and EIS for physical and chemical baseline conditions.				
TIER I *Bathymetry *Subbottom profiles *Side-scan sonar *Surface grab samples *Cores *Water samples	Pre, Post Placement, Annually	*Mound within 5 ft of nav. hazard. *Cap thickness decreased 0.5 ft. *Contaminant exceeds limit in sediment or water sample.	*Continued to monitor at same level. *Reduce monitoring level. *Stop monitoring.	*Go to next tier. *Stop use of site. *Increase cap thickness.
TIER II *Bathymetry *Subbottom profiles *Side-scan sonar *Sediment profile cam. *Cores *Water samples *Consolidation instru.	Quarterly to Semi-annually	*Cap thickness decreases 1 ft. *Contaminant exceeds limit in sediment or water sample.	*Continued to monitor at same level. *Reduce monitoring level.	*Go to next tier. *Replace cap material. *Increase cap thickness. *Stop use of site.
TIER III *Bathymetry *Subbottom profiles *Side-scan sonar *Sediment profile cam. *Surface grab samples *Cores *Water samples *Tissue samples	Monthly to Semi-annually	*Cap thickness decreases 1 ft. *Contaminant exceeds limit in sediment or water sample. *Contaminant exceeds limit in tissue.	*Continued to monitor at same level. *Reduce monitoring level.	*Replace cap material. *Increase cap thickness. *Stop use of site. *Change cap sediment. *Redredge and remove.

Components of the Monitoring Plan

The components of the monitoring plan must be directly tied to the objectives and should include physical, chemical, and biological components to address the processes of concern. In identification of components and processes, it should be noted that biological responses are a direct result of physical and chemical alterations due to the disposal operation. This fact provides a logical basis for establishing an appropriate tiered monitoring program that emphasizes physical monitoring in the lower tiers.

Physical processes of interest include the spreading and mounding behavior of the contaminated and capping layers during disposal operations, the potential erosion of these deposits due to currents and wave action, and the consolidation of the deposits and underlying sediment layers. Erosion and consolidation processes dictate the long-term thickness of the cap. The components of a monitoring plan needed to address these processes include periodic precision bathymetry, perhaps supplemented with SPC surveys, settlement plates, or other instrumentation.

Chemical processes of interest include potential mixing of contaminated material with the clean capping material during the construction phase, and perhaps in the long term due to bioturbation, and the potential migration of contaminants upward through the cap due to advection or diffusion. The components of the monitoring plan addressing these processes include sediment cores for chemical analysis of sediment or interstitial water to define the chemical profile of the contaminated and clean capping layers. Additional cores taken over time at the same stations would detect any upward migration of contaminants.

Biological processes of interest include type/quantity of organisms present and the potential for contaminant effects (i.e., toxicity and/or bioaccumulation) should contaminant migration occur or should the integrity of the cap be compromised. Components of monitoring that address these processes include sampling and analysis of benthic organisms that would colonize the site following completion of capping.

Developing Testable Hypotheses

Testable hypotheses must be established that are tied to critical threshold levels that, when exceeded, trigger a higher monitoring tier or implementation of a management action. Development of reasonable and testable hypotheses requires a prediction of the end result of the various processes that may occur at the site. A null hypothesis is developed (i.e., that there is no significant difference between predicted and observed conditions); if the threshold is exceeded, the null hypothesis is rejected. Tiers must be structured so that early warning of potential problems can be detected. Often physical monitoring may be the best tool in the lowest tier, but biological or chemical tools may have appropriate roles in the lowest tier as well. The key is to get relatively rapid, inexpensive, and interpretable results.

Construction Monitoring

Monitoring to ensure that placement occurs as designed may include baseline, postcontaminated material-placement, interim, and postcap material-placement surveys. Baseline surveys consist of determining the existing bathymetry of the site in order to determine changes in depth resulting from disposal. The postcontaminated material-placement monitoring determines where the contaminated sediments have been placed so that a final plan of cap-placement locations can be developed. Postcontaminated material-placement sampling is also needed as a baseline for cap-thickness determinations based on bathymetry. Interim surveys may be employed in large projects to determine where sufficient cap has been placed and where additional material should be placed. Finally, postcap material-placement monitoring is used to confirm the final cap thickness and to serve as a baseline for future monitoring efforts.

Monitoring for Long-Term Effectiveness

The principal long-term concerns for capped deposits are (a) whether the cap is remaining in place or whether erosion is occurring, and (b) whether the contaminants remaining within the contaminated layer are being transported to the sediment surface layer or to the water column. Erosion can occur either due to daily tidal currents, propeller wash, or as a result of storm-related surges or waves. Potential mechanisms for contaminant movement through the cap include pore water movement, diffusion, and biological mixing of the sediment (bioturbation).

Monitoring approaches for these concerns include sequential bathymetric surveys or diver-inspected settling plates to determine changes in deposit height, surface-sediment chemistry samples, sediment and pore water chemistry profiles from cores, sediment physical structure from cores, benthic community structure, and contaminant tissue concentrations of mound resident benthic species. These and other monitoring techniques discussed below can all be considered within the framework of a tiered monitoring plan and conducted on time intervals ranging from months to years.

After a severe storm, one with a 10- to 20-year return period, a modest monitoring program should be conducted to confirm the cap has not suffered any significant damage. Monitoring required after a severe storm should probably be limited to bathymetry, grab samples, and perhaps SPI and subbottom profiles.

Monitoring Techniques and Equipment

Selection of the types of samples or observations to be made, the equipment to be used, the number of samples or observations, etc., is highly project dependent. Fredette et al. (1990b) contains guidelines on available equipment and techniques. Monitoring programs may only consist of physical measurements that include bathymetry, cap thickness, sediment physical properties (e.g., grain-size distribution and density), wave and current conditions, etc. Depth sounders, side-scan sonar and subbottom profilers, sediment sampling and coring devices, sediment profiling cameras, and instruments for measuring engineering properties of the sediment are required to make these physical measurements.

Navigation and positioning equipment are needed to accurately locate sampling stations or survey tracks in the disposal-site area. The accuracy requirements for monitoring are similar to those for placing the contaminated material and cap. See the discussion on navigation and positioning in Chapter 5.

Precision bathymetric surveys are perhaps the most critical monitoring tool for capping projects. Such surveys allow determination of the location, size, and thickness of the contaminated material mound or deposit and cap. A series of surveys should be taken before placement of contaminated material, immediately following (and perhaps during) placement of the contaminated material, and immediately following placement of the cap. The differences in bathymetry as measured by the consecutive surveys yield the location and thickness of the deposits. Because relatively small changes in mound elevation are of prime interest, highly accurate bathymetric surveys are required. Lillycrop et al. (1991) discuss interdependence of tidal elevations or bathymetry measurements and equipment capabilities and their effect on measurements. Acoustic instruments such as depth sounders (bottom elevations accurate to ± 0.6 ft under favorable conditions), side-scan sonar (mapping of areal extent of sediment and bedforms), and subbottom profilers (measures internal mound and sea-floor structure) are used for these physical measurements. Survey track spacing can be 50 to 200 ft depending on the areal coverage of the mound.

The attainable accuracy of bathymetric surveys limits the area and thickness of the deposit that can be detected. Limits of accuracy are governed by a variety of factors, which include accuracy of positioning systems, water depth, wave climate, etc. Engineer Manual (EM) 1110-2-1003 contains detailed information on hydrographic survey equipment and techniques and should be consulted in estimating the accuracy limitations of surveys. Other monitoring tools such as side-scan sonar, settlement plates, or SPCs must be employed to detect thinner deposits of contaminated and capping material.

Most methods for monitoring ocean-bottom depths from the ocean surface (air/water interface) are not accurate to within 20 cm. Waves bobbing the ship on which measurement equipment is attached, inaccuracy in local tidal elevation, and inaccuracy in latitude/longitude location add to the natural error of the instruments in measuring the bottom depth. In addition, the sediment/water interface is not clearly defined. During relatively quiescent periods, during which most measurements must be made, there is often a nephloid layer that blurs the sediment water interface. This layer can be classified as bottom sediment with a high water content or water with a high sediment content. This layer often creates "noise" on instruments measuring the bottom depths. Therefore, in addition to monitoring the mound from above, periodically, core samples should be extracted from different locations on the sediment mound to determine the thickness of remaining cap material. These cores should be extracted from those locations on the mound from which it is determined (by experience, surface measurements, and models) that most erosion occurs.

Bathymetric monitoring of deposits to determine sediment losses needs to be coupled with an understanding of consolidation processes. Consolidation that occurs in the cap, contaminated sediment, and the original base material within 6 to 12 months of disposal can result in substantial reductions in mound height (Silva et al. 1994; Poindexter-Rollings 1990) that could mistakenly be considered as erosion. Therefore, settlement plates are very useful.

The SPC is a tool that can be used to detect thin layering within sediment profiles. The SPC is an instrument that is lowered to the bottom and is activated to obtain an image of sediment layering and benthic activity by penetrating to a depth of 15 to 20 cm. As with bathymetric surveys, the SPC approach also has limits in its ability to detect the extent and thickness of deposits. The limiting depth of penetration limits the thickness that can be detected. However, SPC can be used in conjunction with bathymetric surveys to define the full range and extent of deposit thicknesses. The SPC is extremely effective for mapping the extent of the flanks of contaminated sediment around the central portion of the mound. Knowing their extent is critical to successful capping since these flanks can account for an area several times larger than that of the central mound and can include 20 to 40 percent of the sediment mass.

Sediment samples can be taken using grab samplers or coring devices to determine both physical and chemical parameters. In general, a core is required to sample the full thickness of a cap layer and the underlying contaminated material. Conventional boring techniques, vibracore samplers, and a variety of gravity coring devices may be suitable. However, site-specific factors such as the layering of the deposit (e.g., sand cap over relatively soft material), the material properties, and the capability of a coring technique to collect samples from such deposits should be considered when selecting a coring technique.

A variety of other instruments and approaches may be considered to gain needed information regarding the physical condition and processes occurring at capping sites. These include settlement plates (which must be monitored by divers), use of remotely operated instruments, or divers with photography and video cameras to obtain data on site conditions.

Biological monitoring may include sampling of fish and benthic organisms. Fish and many shellfish are mobile; therefore, data using these organisms are more difficult to relate to cause and effect. Sampling design using such mobile species needs to carefully consider effects of scale and migration dynamics. Most often, disposal mounds or sites are inconsequential with respect to the ranges of such species, and linking any observed changes in a species to disposal activities may be exceedingly difficult.

Benthic organisms are usually sedentary and often are considered good indicators of the effects of physical and chemical alterations of the environment. Benthic sampling devices include trawls, drags, box corers, and grab samplers. Trawls and drags are qualitative samplers that collect samples at the bottom interface, and therefore are good for collecting epifauna and shallow infauna (top few centimeters). Quantitative samples are usually obtained with box corers and grab samplers. Generally these samplers collect material representing 0.02 to 0.5 m^2 of surface area and sediment depths of 5 to 100 cm.

Detection of chemical gradients or changes in the distribution of contaminants within the mound can be monitored, but requires an understanding of the baseline heterogeneity of contaminants within both the contaminated deposit and the cap. For example, the contaminant concentrations within the contaminated deposit can be expected to range from hot spots to values that are similar to or even below the concentrations within the cap. This is reflective of typical heterogeneity within the original deposit and cleaner underlying layers of the channel or harbor. Thus, while it may be possible to detect large transitions, gradients may be much more difficult to observe, particularly if surface contamination existed within the channel prior to dredging.

Sampling of tissues of marine biota that colonize the mound also needs to be carefully considered. Typically, the chemical analyses require about 15 to 30 g (wet weight) of tissue per replicate. Unless the particular region has large-bodied resident species that are easily collected, it may take a day or more of field collection per station to obtain the necessary sample requirement. Tissue sampling is also complicated by the natural variation of benthic populations in both space and time. In some years, the target species may be very abundant, while in other years the species can be rare. These factors can result in large monitoring costs or produce data that are of limited value.

Designating Management Actions

When any acceptable threshold values are exceeded, some types of management actions are required. The appropriate management actions should be determined/defined early in the disposal planning process; they should not be determined after the threshold values have been exceeded.

Management options in early tiers could include increasing the level of monitoring to the next tier, the addition of more sediment to form a thicker cap, or stopping use of the site. Management options in later tiers could include stopping use of the site, changing the cap material, or the addition of a less porous material in cases where contaminant transport due to biological or physical processes is occurring. For caps that are experiencing erosion, additional cap can also be added, although it may be advisable to choose a coarser material (coarse sand or gravel) to provide armoring. In cases where extreme problems are encountered, removal of the contaminated material and placement at another site could be considered.

10 Case Studies

Subaqueous capping of contaminated dredged material in open-water sites began in the late 1970s, and a number of capping operations under a variety of disposal conditions have been accomplished. The Corps has conducted over 20 capping projects, with the majority conducted by the USACE New England Division (NED). An overview of the field experiences related to capping of contaminated dredged material is found in T able 8. Projects have included sites in Central Long Island Sound, New York Bight area at the mouth of the Hudson River, Puget Sound, and Rotterdam Harbor, the Netherlands. Data on capping projects vary widely in their availability. The projects listed in Table 8 are not intended to be all inclusive, but are representative of a range of site and operational conditions. Brief descriptions of most of these projects and others are given in the following paragraphs.

Long Island Sound

Capping is an alternative frequently used by the NED for disposal of material dredged from numerous industrialized harbors in New England. NED has documented the operations and monitoring programs in the Central Long Island Sound (CLIS) disposal site and other sites as a part of the Disposal Area Monitoring System (DAMOS). The DAMOS program was initiated in 1977, and the experience gained from 15 years (1979-94) of DAMOS capping experience is described in a series of DAMOS technical reports, many of which describe operations involving capping. The capping experience gained by NED in the CLIS disposal area has recently been summarized in a monograph (SAIC 1995) from which some of the information presented here is taken. Other capping experience gained by NED in the New London disposal site can be found in DAMOS reports and SAIC reports.

Over 15 years of disposal site monitoring of capped mounds in New England have provided an important data set of sufficient duration to allow evaluation of the long-term effects of capping contaminated dredged material. The data set includes a broad spectrum of characteristics including physical, chemical, and biological components. Future capping projects can benefit from the lessons learned in these pioneering projects.

Table 8
Summary of Selected Capping Projects

Project		Contaminated Material			Capping Material				
Location (Date)	Site Name and Characteristics	Volume $yd^3 \times 10^3$	Dredging Material	Placement Method	Volume $yd^3 \times 10^3$	Cap Thickness ft	Placement Method	Positioning Method	Literature Source
Duwamish Waterway Seattle (1984)	Existing subaqueous depression 70 ft deep	1.1	Clamshell	Scow (sand)	3.6	1-3	Sprinkling from scow	Surveying instruments	Truitt 1986b Sumeri 1984
Rotterdam Harbor Netherlands (1981-1983)	Phase I Botlek Harbor excav to 98 ft deep	1,200	Trailing suction hopper	Pump-out submerged diffuser	— (clay)	2-3	Scow, then leveled over site	Surveying instruments	d'Angremond, de Jong, and de Waard 1986
	Phase II 1st Petro. Harbor excav to 80 ft deep	620	Matchbox suction	Pipeline submerged diffuser	— (clay	2-3	Scow, then leveled over site	Automated dredge/suction head positioning equipment	d'Angremond, de Jong, and de Waard 1986
Hiroshima Bay, Japan (1979-1980)	Contaminated bottom sediment overlaid in situ with capping material 70 ft deep	N/A	N/A	N/A	— (sand with shell)	1.6	Conveyor to gravity-fed submerged tremie suction pump-out thru submerged spreader bar	Surveyed grid and winch/ anchor wires	Kikegawa 1983 Togashi 1983
New York Bight (1980)	Generally flat bottom 80-90 ft deep	860 (mounded to 6 ft thick)	Clamshell	Scows	1,800 (majority fine sand)	avg: 3-4 max: 5-9	Scow, hopper dredge	Buoy, real-time navigation electronics	Freeland 1983, Mansky 1984, O'Connor and O'Connor 1983, Suszkowski 1983
Central Long Island Sound Disposal Area (CLIS) (1979)	Stamford-New Haven North, flat bottom 65 ft deep	34 (mounded to 3-6 ft thick)	Clamshell	Scows	65.4 (sand)	7-10	Hopper dredge	Buoy, LORAN-C coupled positioning system	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1979)	Stamford-New Haven South, flat bottom 70 ft deep	50 (mounded to 4-6 ft thick	Clamshell	Scows	100 (cohesive)	13	Scow	Buoy, LORAN-C coupled positioning system	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983

(Continued)

Table 8 (Concluded)

Project		Contaminated Material			Capping Material				
Location (Date)	Site Name and Characteristics	Volume $yd^3 \times 10^3$	Dredging Material	Placement Method	Volume $yd^3 \times 10^3$	Cap Thickness ft	Placement Method	Positioning Method	Literature Source
CLIS (1981)	Norwalk, generally flat bottom 65 ft deep	92 (multiple mounds 8-12 ft thick)	Clamshell	Scows	370 (silt and sand)	6-7	Scow	Buoy	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1982-1983)	Mill-Quinnipiac flat bottom 65 ft deep	40	Clamshell	Scows	1,300 (silt)	Multiple broad area placement estimated final avg 6-10	Scow	Buoy	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1983)	Cap Site No. 1 generally flat 60 ft depth	33 (mounded 3 ft thick)	Clamshell	Scows	78 (silt)	Incomplete coverage	Scows	Buoy	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1983)	Cap Site No. 2 generally flat 56 ft deep	40 (low mound 2 ft thick)	Clamshell	Scows	40 (sand)	Irregular maximum 4.5	Scows	Buoy, LORAN-C	Morton, Parker, and Richmond 1984; O'Connor and O'Connor 1983
CLIS (1989-1990)	S-90-1 Harbor Village/Branford River generally flat 60 ft deep	37.6			102.7	Incomplete coverage; several distinct capped mounds 0.6 to 2.0 ft thick	Scows	Buoy	SAIC 1995b
CLIS (1993-1994)	CLIS-NHAV 93 New Haven Harbor generally flat 60 ft deep	561.5	Clamshell		665.2		Scows	Taut-wire buoy	NED files
New London Disposal Site (1988-1989)	Generally flat 54 ft deep	17.4 (2.3 ft thick)		Scows	77.8-scow 28.3—hydro surveys	0.3 to 2.6 ft thick			SAIC 1990
Portland Disposal Site (1991-1992)		17.4			70.3				SAIC 1996

Four LBC projects are the focus of the SAIC (1995a) report, and they all were conducted in the CLIS disposal site. The four NED projects (Stamford-New Haven, Mill-Quinnipiac River, Norwalk, and Cap Sites 1 and 2) are located within the boundaries of the CLIS disposal site, which is an area of 2 nm^2 located approximately 6.2-miles south-southeast of New Haven, CT, in water depths between 56 and 82 ft (Figure 30). Baseline data sets had previously been collected and were available for use in the capping projects as described in SAIC (1995a). Two other recent capping projects not discussed in SAIC (1995a), Harbor Village-Branford River (CS 90-1) and New Haven (CLIS-NHAV 93), have also been conducted in CLIS.

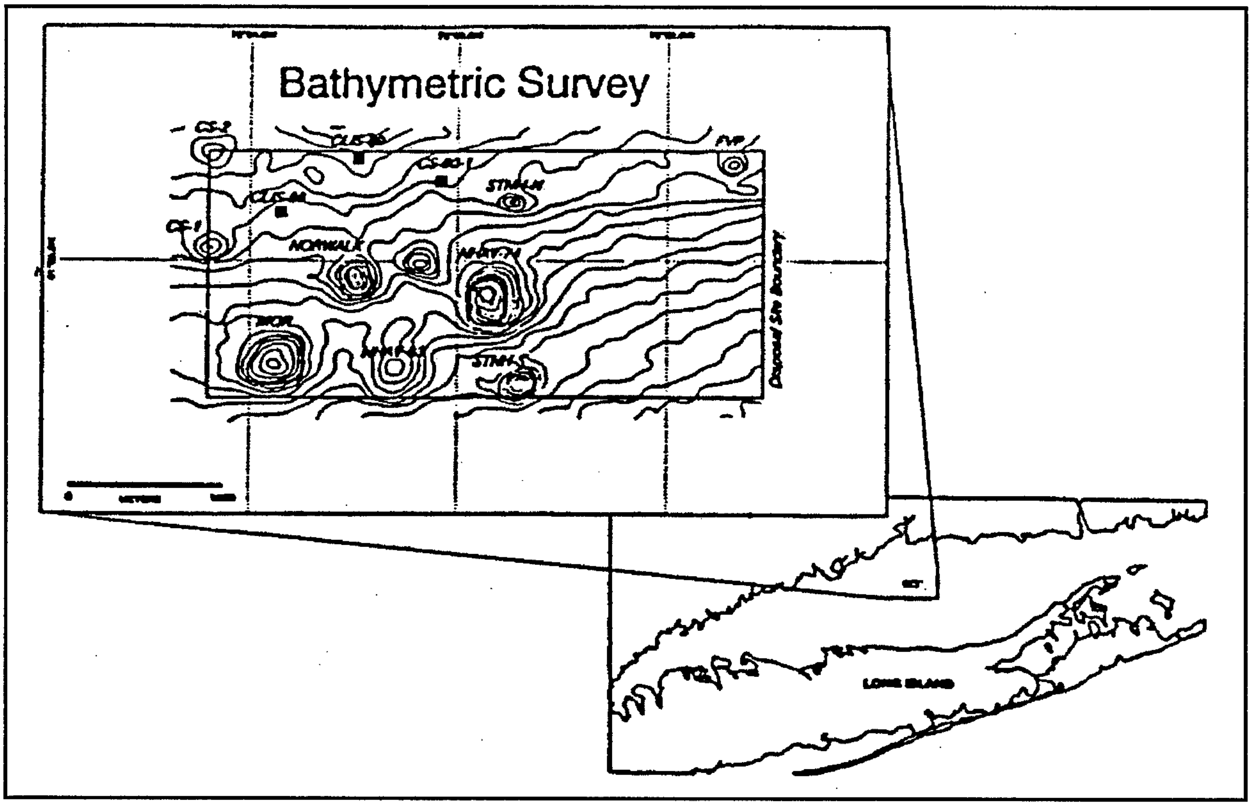


Figure 30. Central Long Island Sound disposal site (SAIC 1995a)

The Stamford-New Haven project was the first planned capping project at a subaqueous site in United States coastal waters. This project involved disposal of contaminated material from Stamford Harbor followed by capping with slightly less contaminated material from New Haven Harbor at two sites within CLIS. The success of the 1979 Stamford-New Haven project led to increased use of capping in New England under the DAMOS program.

The Stamford-New Haven North and South (STNH-N and STNH-S) and the experimental Cap Site 2 (CS-2) were the most successful of the early capped mounds. Bathymetry and SPC data showed that the contaminated material was thickly covered with capping material from the center to the outside radii. Point dumping of mound material and subsequent placement of the cap material over the mound accomplished with the aid of a taut-wired buoy and accurate navigational controls proved to be successful. The stability of these mounds has been tested by 11 years of monitoring and the passage of Hurricane David in 1979, although the hurricane's passage was coincident with the predicted exponential compaction phase of the mound, and Hurricane Gloria (Fredette et al. 1989). It is desirable for the mound/cap formation to occur well before any storm windows in order that natural settlement and compaction has time to occur. All three mounds showed normal biological recolonization rates in subsequent monitoring. Sediment chemistry data show the surface sediment remained at or below background concentrations of the contaminants measured. Coring data show a clear visual and chemical boundary in many of the cores.

The historical record of the successful capping of the STNH mounds and CS-2 provided comparative insight as to why other capping projects were not as successful. For example, accurate placement of dredged sediments is less reliable without the use of both a buoy and an accurate navigation system, and their lack of use was attributed to the offset of the cap and mound at CS-1. The Mill-Quinnipiac River mound (MQR) demonstrated the importance of controlling operational factors and maintaining vigilant monitoring. Biological monitoring at the MQR showed subnormal recolonization rates relative to the other CLIS mounds. The disposal operations that included the Mill-Quinnipiac River and Black Rock and New Haven harbors were not conducted as distinct mound and cap depositional phases. The overlapping cap/mound deposition may have affected the recolonization rate at MQR. Similarly, the Norwalk mound was not formed in distinct cap and mound operations. The contaminant concentrations for both the mound and cap at Norwalk were well below those of Black Rock and MQR, and there was no evidence of adverse effects due to disposal operations at Norwalk in subsequent monitoring. Sediment chemistry results from MQR show that the surface chemistry of the mound was not similar to Black Rock sediments; instead, concentrations were at the high end of the range of most constituents analyzed in New Haven sediments. However, these monitoring results have allowed NED to detect and take corrective management actions.

During a 1993 NED capping project, maintenance sediments from New Haven Harbor and private terminals were placed in the CLIS. A total of approximately 500,000 yd^3 of contaminated material was dredged from New Haven Harbor and private terminals followed by capping with about 660,000 yd^3 of cap materials. Placement of the contaminated sediments was controlled with a taut-wire buoy, while a total of 18 separate placement points (using LORAN-C) were specified for the cap placement. Throughout the cap placement process, continuous monitoring allowed for adjustment of disposal points to optimize cap coverage and avoid point dumping.

The unique aspect of this project was that the mounds created from five previously placed projects were used to make a bowl in which to place the 500,000 yd^3 of New Haven sediments (Fredette 1994). At the center of the bowl, the depth was 62 ft, while the surrounding depths were generally 0.6 to 10 ft shallower. Surveys showed that the planned depression was successful in reducing the spread of the contaminated sediments and thereby significantly reduced the volume of capping sediments required.

The CLIS experience has provided insight on the procedures that historically are recommended for a successful capping project. In the preproject planning, it is recommended to (a) completely characterize the sediments to be disposed including sediment chemistry, bioassay, or bioaccumulation data and classify sediments using most recent information; (b) estimate volumes of material to be disposed; (c) conduct site surveys and choose a disposal area that is not vulnerable to natural or anthropogenic erosion; (d) schedule dredging and disposal operations ideally to complete mound and cap well before a storm season to allow for consolidation and surface stabilization; and (e) dispose the cap materials as soon as possible after contaminated material. For the disposal operations, it is recommended to (a) employ both accurate navigational techniques and a taut-wired buoy to locate the designated disposal mound; (b) point dump mound materials by directing the barge to unload as near to the buoy as possible; (c) dispose approximately one-third of the cap sediments along the radius of the contaminated mound; (d) maintain the preproject plan for mound deposition followed by cap deposition; and (e) keep good records of all disposal operations.

New York Bight

Experimental Mud Dump (EMD) mound

An evaluation of the 1980 LBC project at the Experimental Mud Dump (EMD) site at the New York Bight apex (Figure 31) was reported by O'Connor and O'Connor (1983), and excerpts from their report are used to summarize this capping project. Contaminated dredged material from the Hudson Estuary, Newark Bay, and contiguous waters were capped initially with fine sediments from the Bronx River and Westchester Creek and followed with sand from the Ambrose Channel. The resulting cap was a 1-m-thick layer of sand overlaying contaminated sediment. Biological, chemical, and physical investigations were completed to evaluate the ability of the cap to remain intact and reduce the loss of organic and inorganic toxicants from the contaminated material to the surrounding water.

Results showed the cap was successfully placed at the experimental dump site, and it remained intact after 16 months. Erosion of the cap was minor, and predictions of cap life were in excess of 20 years under normal environmental conditions. However, it was predicted that major storm events were capable of causing cap erosion and exposing the contaminated material. The contaminated material volume decreased by 4 percent over the 16-month study due partly to consolidation and partly to losses during the disposal operation. Contaminant levels in the sand cap as measured by chemical analysis were shown to be lower than those in contaminated sediments. Bioaccumulation investigations indicated that contaminant uptake was less than at uncapped dredged material sites. Therefore, it was concluded that the New York Bight EMD capping project was successful

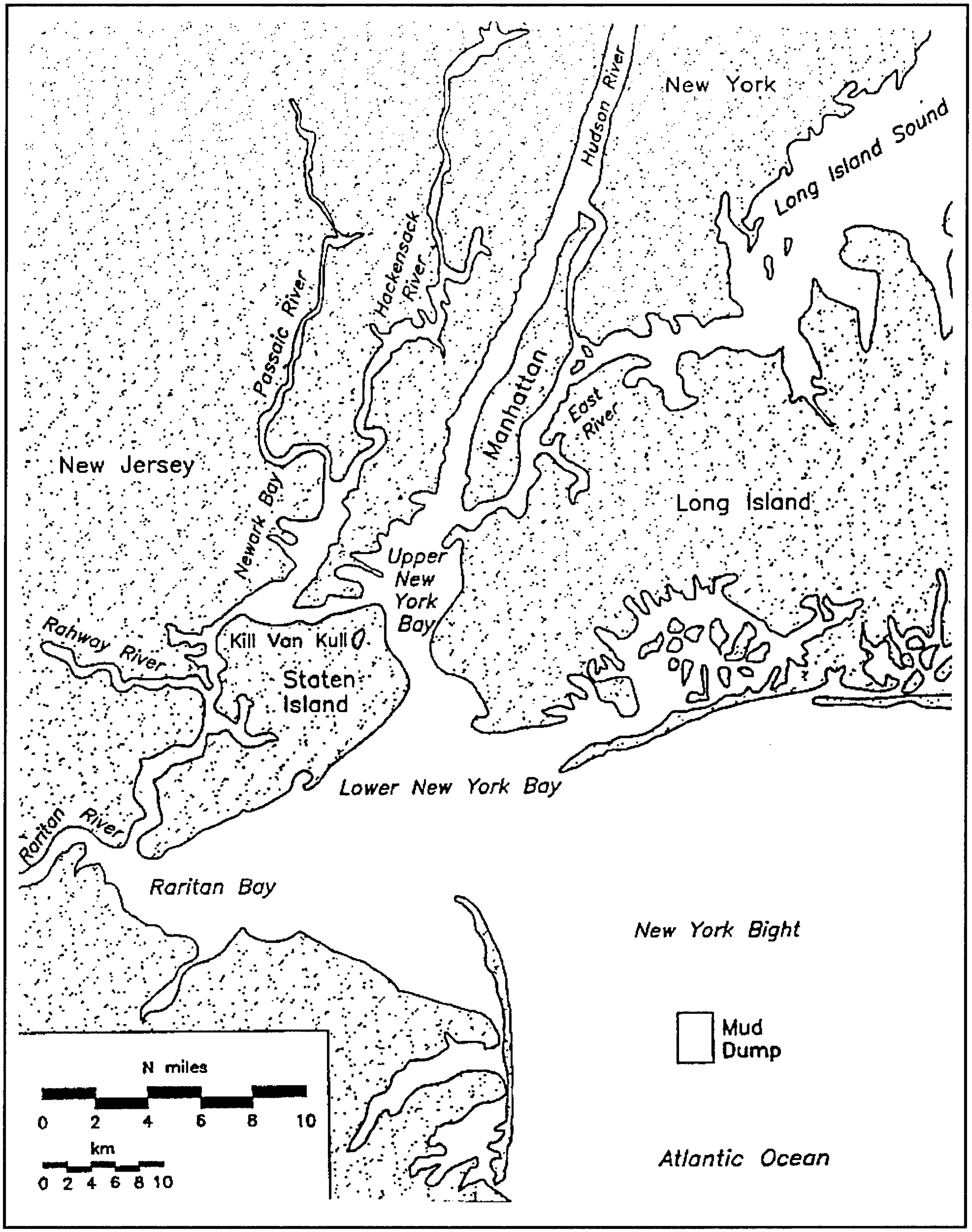


Figure 31. Mud Dump site in New York Bight (O'Connor and O'Connor 1983)

and capping can serve as an alternative to the control of contaminants in dredged material. The thickness and stability of the cap reduced the losses of contaminants to the surrounding water. It was recommended that capping be integrated with routine disposal operations to efficiently cover and isolate contaminated material at designated disposal sites.

In 1986 a detailed survey of the EMD mound was conducted to evaluate long-term stability of the mound (Parker and Valente 1988). Results of the survey, which included precision bathymetry, subbottom profiling, and SPI imagery, indicated the sand cap has not experienced significant erosion.

Port Newark/Elizabeth project

In June and early July 1993, 450,000 m^3 of maintenance sediments contaminated with low levels of dioxin from the Port Newark/Elizabeth complex (part of the larger Port of New York-New Jersey), and last dredged in 1990, were dredged and placed in the Mud Dump site (MDS) (Figure 31). The maintenance material was subsequently capped (July 1993-February 1994) with 1,900,000 m^3 of sand from Ambrose Channel. This project was preceded by several years of controversy due to the dioxin contamination (May, Pabst, and McDowell 1994; McDowell, May, and Pabst 1994; Greges 1994). Concerns about cap stability were based on erosion within the MDS that occurred after a severe northeaster in December 1992 (McDowell, May, and Pabst 1994). Erosion thicknesses greater than 1 m occurred from portions of the flanks of recently placed fine-grained maintenance material. These concerns led to a study (Richardson et al. 1993) that concluded that a mound with a 0.4-mm sand cap with an upper crest limit at a depth of 23 m (75 ft) should be stable (i.e., experience minimal erosion) during a storm comparable with the December 1992 storm.

The upper cap elevation limit of 23 m combined with the large volume of material and limited space available resulted in the design of a triangular-shaped mound as shown in Figure 32. Water depths at the site of the planned disposal ranged from 24 to 25.3 m. A design requirement to provide a 1-m cap over the mound restricted the planned elevation of the contaminated mounds to approximately 1.5 m.

Readily available geotechnical data on the contaminated sediments were limited to percent sand, silt, clay, and percent moisture (average values were 6, 58, 35, and 52 percent, respectively).

The contaminated material was removed using mechanical dredges; no overflow was allowed. Dredged material was placed in bottom-dump scows ranging in capacity from 1,900 to 4,600 m^3 and transported to the MDS. A total of 149 loads were placed over a 5-week period. The permit required the barge operators to place material within the 150-m-wide by 350- to 450-m-long disposal lanes on a rotating basis (Figure 32). To assist the contractor in siting the placements, the apex's of the triangle had taut-moored buoys. To reduce the chance of placing material outside the lanes, the contractor was directed to dispose of all material within 60 m of an imaginary line connecting the apex buoys. Calibrated LORAN-C positions for the tugs with offsets to correct for the location of the center of

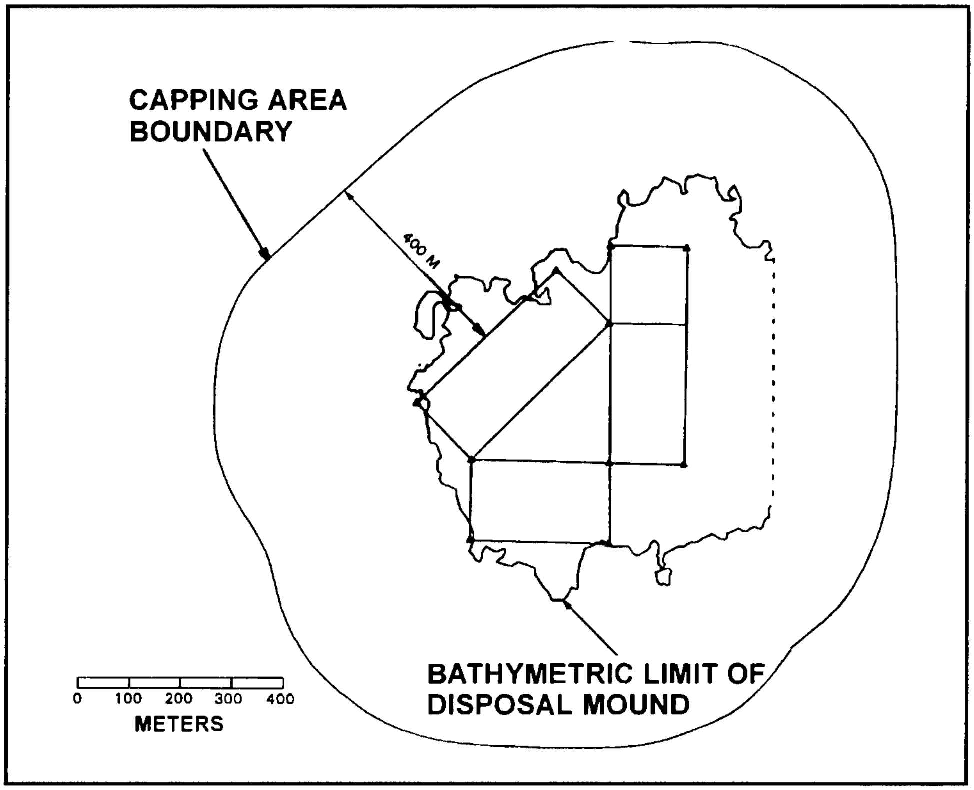


Figure 32. Port Newark/Elizabeth mound limits

the barges were recorded. Barge speed during placement was 0.5 to 1.5 m/sec. To help prevent mounding at the point of release, the barge operators were directed to crack the hull part way resulting in a disposal time of 30 sec to 1 min, and were also directed to enter the disposal lanes from opposite ends on alternate placements.

Apex buoys were installed using calibrated LORAN-C so they could be quickly reset. LORAN-C was calibrated with short-range microwave readings at known points within the harbors.

A bathymetric survey conducted during mound construction indicated the contaminated material mound was exceeding the desired 1.5-m height limitation in some locations. This combined with the Port's request to increase the amount of material dredged altered the disposal lane pattern to include additional placement in the center of the triangle and the addition of a 150- by 150-m square area at the north end of lane AB (Figure 32).

The final postcontaminated mound bathymetry survey showed that a roughly triangular mound had been formed as designed. As might be expected, individual mound peaks were evident (generally located at the ends of the lanes), which projected above the average mound thickness over the area of about 1.3 m. The peaks ranged in elevation from 1.5 to 2.4 m. Average side slopes (from the edge of the mound crest down to the 0.2-m contour) on the outer sides of the mounds were about 1:45.

The final overall dimensions of the contaminated sediment mound, as defined by the 0.3-m contour, were approximately 630 m in the north/south direction and 645 m in the east/west direction. If the 0.15-m contour is defined as the edge of the main mound, then the mound dimensions increase to approximately 745 m in each direction as shown in Figure 32. SPI surveys of the contaminated sediment apron showed the apron extended out approximately 400 m in each direction beyond the outer edge of the disposal lanes, creating a roughly circular area to be capped with an average diameter of 1,370 m (4,500 ft) (Figure 32).

Based on nine SPC transects with three to six stations per transect that contacted the apron, the average thickness was about 3 to 5 cm. On some transects, the thickness decreased regularly out from the mound, while on others the variation was more random. The native bottom was visually distinct, allowing a visual resolution of a minimum thickness of contaminated sediments of 1 to 2 cm. Thus, the edge of the apron was defined as areas with less than 1- to 2-cm thickness of dredged material.

Prior to the start of the capping operation, New York District and EPA Region II staff decided to cap the contaminated mound including the apron with 1 m of sand. This required what was initially estimated as 1,500,000 m^3 of sand to cap the area shown in Figure 32. On 11 July 1994, hopper dredges began placing cap material, 0.4 mm sand from Ambrose Channel, over the contaminated sediments. At least two intermediate surveys and additional capping were required before capping was completed in February 1994, when an estimated total of 1,870,000 m^3 of sand had been placed covering the entire contaminated footprint with close to a meter or more of sand. The additional 370,000 m^3 (480,000 yd^3) over the original estimate (a 25-percent increase) was due to the requirement to provide a 1-m cap everywhere as opposed to an average of 1 m. Capping the contaminated main mound as defined by the 0.15-m contour with 1 m of sand would have required an estimated volume of approximately 450,000 m^3. If instead of the 1-m cap placed over the apron, a 0.30-m cap had been placed over the apron, it would have required an estimated 308,000 m^3, for a total cap volume of 758,000 m^3. Increasing that total by 25 percent to provide a minimum 1-m cap over the main mound and a 30-cm cap over the apron would have brought the total to 940,000 m^3, or approximately half the amount actually placed.

Due to concerns about the possible adverse effects of contaminated sediment resuspension during the cap placement, EPA Region II required that the initial 15 cm of cap placed impact the bottom with as little downward velocity as possible (i.e., sprinkled at the individual particle settling velocity). This required modification of previous capping procedures routinely used where barge or hopper dredges perform conventional bottom dumping operations. Randall, Clausner, and Johnson (1994) discuss modifications made to the STFATE model (and now incorporated into the MDFATE model), based on experiments using planar laser-induced fluorescence (Roberts, Ferrier, and Johnson 1994), used to model cap placement.

The capping procedure consisted of using the spit-hull hopper dredges Dodge Island and Manhattan Island and the hopper barge Long Island discharging over predetermined lanes to cover the contaminated mound. The split-hull dredges "sprinkled" their average 2,000-m^3 loads over a period of 25 to 30 min while moving at an average speed of 3.0 to 3.7 km/hr with the hull cracked open 0.3 m. The Long Island pumped out its average 9,200-m^3 load through over-the-side pipes with the slurry directed forward over a period of 2 to 3 hr while moving at 1.9 to 5.6 km/hr.

To uniformly place the material, the dredges followed a series of lanes 30 m wide that covered the contaminated sediment mound and apron. Turning requirements typically caused the hopper barge to move over four lanes after reaching the end of a lane. A series of straight-lane segments around the perimeter were also used to cover the outer edges of the project. Disposal-lane orientation varied over the duration of the project. Initially, the lanes started north-south; at later stages they were a series of straight sections around the roughly octagon-shaped perimeter of the project (Figure 33). Microwave positioning (with three shore stations) with an estimated accuracy of 3 m or better was used for navigation and positioning of the hopper dredges.

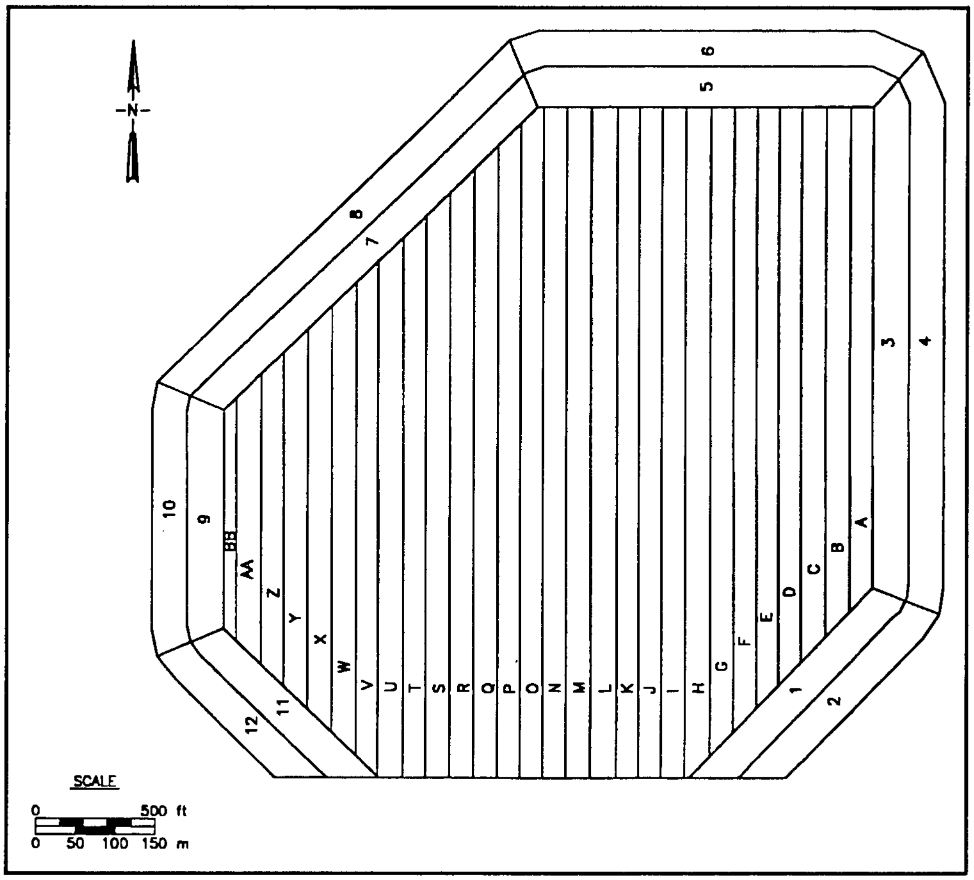


Figure 33. Disposal lanes used for placing cap material in Port Newark/ Elizabeth project

Initial cap placement involved sailing long straight lines, 600 to 900 m long (with a turn at the end of each line). Cleanup operations, i.e., filling in small areas that have less than the required thickness, generally involved areas only about 100 m across. Placing sand in these small areas was much less efficient due to two factors. For the Long Island, maneuvering is very difficult, with 20 to 25 min required to turn the vessel around and place it on an exact location at a specific heading. For the split-hull hopper dredges, problems associated with cleanup were due to the fact that once the hull is split, disposal of material continues until the hopper is empty, i.e., the spilt hull cannot be closed until the hopper is empty. Thus during cleanup, considerable amounts of sand end up being placed on areas adjacent to the cleanup locations that already have sufficient thickness.

After completing the project, the hopper dredges were found to have problems with sealing of the hoppers, possibly as a result of structural deformations due to long hours of sailing with the hull cracked.

Duwamish River Demonstration

The first CAD project in Puget Sound in the northwestern United States was in the Duwamish Waterway (Figure 34) as reported by Sumeri (1989). A shoal that limited navigation through the waterway was found to contain contaminated sediments that eliminated the possibility of unconfined open-water disposal. Thus, the Seattle District initiated a demonstration project to dispose of 840 m^3 of contaminated material in a subaqueous depression in the West Waterway and to cap it with 3,220 m^3 of clean maintenance dredged material from the upper Duwamish River (Sumeri 1984). The fine-grained contaminated sediment exited the bottom-dump barge as a slurry and descended rapidly to the bottom as a cohesive mass (convective descent). Three barges using survey positioning systems were used to place the sand cap by "sprinkling" sand at an average rate of 21 m^3/min from incrementally opened split-hull barges. The resulting average cap thickness was 61 cm. The sprinkling procedure using conventional equipment minimized displacement of the contaminated sediment and hastened the consolidation process. Since the capping material was released slowly, it tended to settle to the bottom as individual grains and not as a contiguous mass. Vibracore sediment samples taken up to 5 years following capping showed the interface between the contaminated and cap sediments was sharp throughout the entire monitoring program. Measured contaminant concentrations were either absent or present in low concentrations in the cap material.

One Tree Island Marina

A CAD project involving direct mechanical placement of material was conducted in 1987 for the expansion of the One Tree Island Marina at Olympia, WA (Figure 34). The operation involved dredging of 2,980 m^3 of contaminated material by clamshell with disposal in a deep conical pit dredged on the project site and capping with 2,980 m^3 of clean material.

The dredging operation was conducted in somewhat crowded conditions with the project dimensions of 48.8 by 91.5 m situated between two other marinas (Figure 35). First, the contaminated layer overlying the location

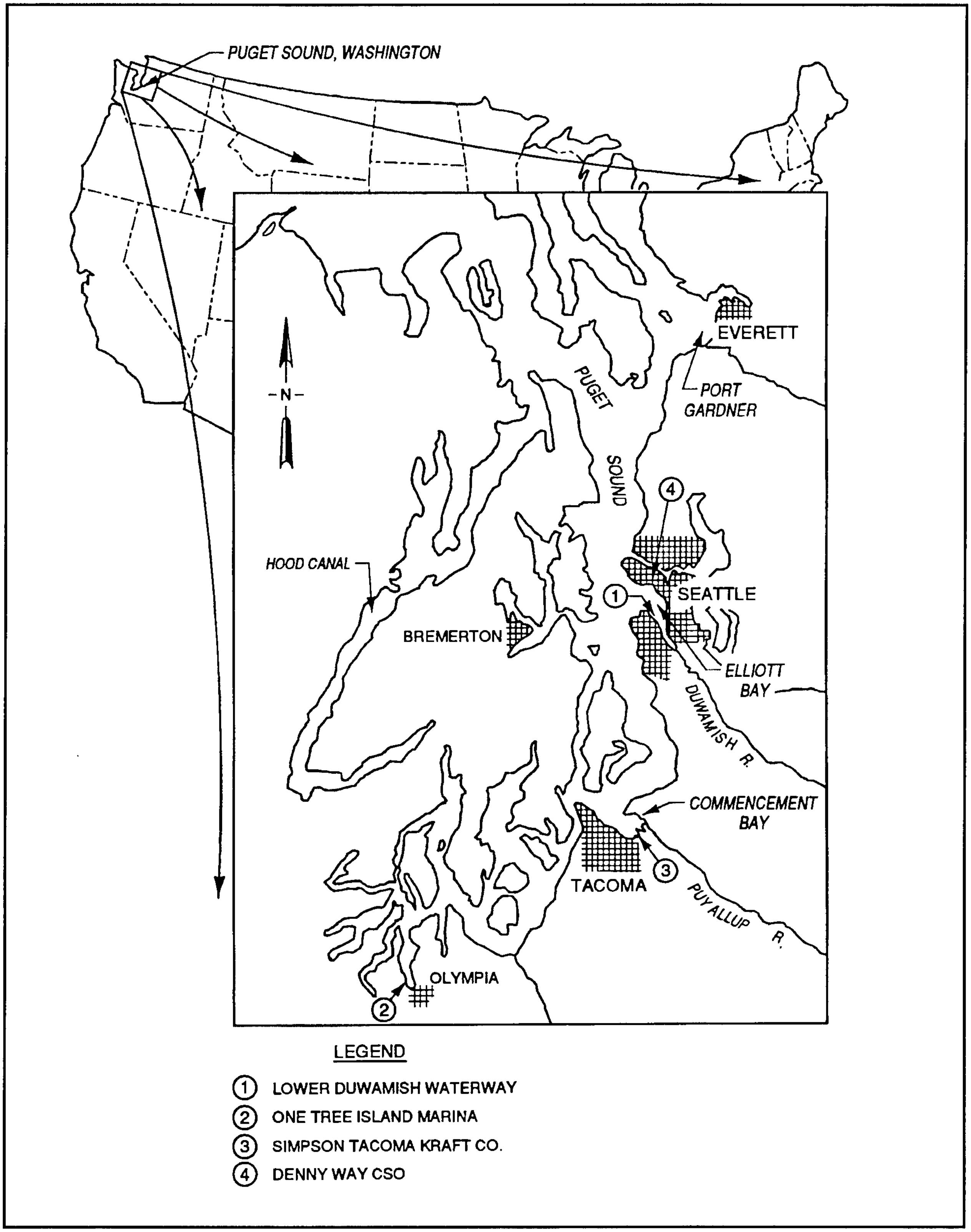


Figure 34. Puget Sound capping projects

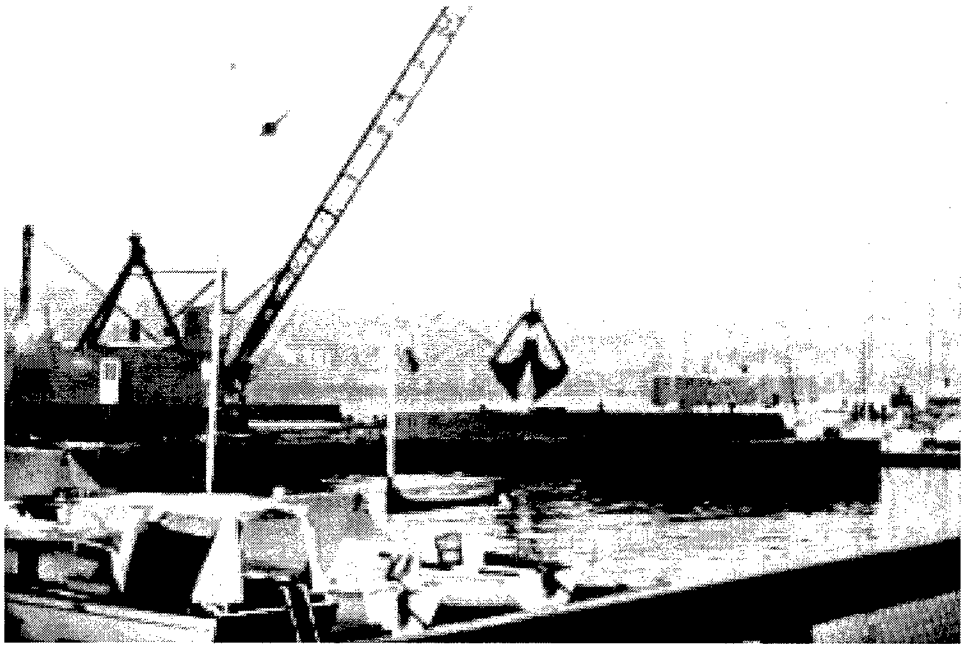


Figure 35. One Tree Island Marina project

of the pit was dredged by clamshell into three barges. Next, the clean conical pit and additional clean material were dredged into an additional split-hulled barge and disposed at another deep-water site. The pit capacity was confirmed, and then the three barge loads of contaminated material were placed in the pit. Finally, more clean material was dredged by clamshell directly into the pit to provide the 1.2-m minimum cap over the contaminated sediment. During dredging, a 45-m dilution zone extending radially from the point of dredging was specified, and outside this area, local water quality standards were maintained. A monitoring program was conducted to evaluate the effectiveness of the cap.

Simpson Tacoma Kraft

In 1988, the Simpson Tacoma Kraft Company capped approximately 17 acres of in situ contaminated nearshore bottom area with 0.6 to 3.7 m of sand hydraulically dredged from the Puyallup River (Sumeri 1989). The contaminated bottom sediments were the result of 37 years of discharging untreated mill wastewater, log storage and chipping operations, and stormwater discharges. The site was a designated EPA Superfund site.

The Puyallup River material was predominantly medium sand with some clay and small fractions of fine and coarse sand and traces of gravel. This material was determined to be relatively clean by chemical and bioassay testing and suitable for capping. Twelve- and ten-inch (30.5- and 25.4-cm) hydraulic dredges were used to dredge approximately 152,910 m^3 of capping material. This material was transported approximately 1 km through floating and submerged pipeline to a spud barge for distribution over the contaminated sediment area. A 2.4- by 4.3-m plywood diffuser box with baffles and 15-cm side boards containing holes throughout was used to distribute the sand slurry over a wide area. This device essentially sprinkled the sand over the contaminated fine-grained sediment on the bottom. The spud barge and boom extension were swung about the spud and controlled by anchor lines. The cap was placed by swinging the plywood box ("sand box" as shown in Figure 7) back and forth until manual leadline soundings indicated the desired cap thickness was attained. Acoustic depth sounders were ineffective due to high sand load and entrained air in the water column. The barge was moved ahead 3.1 m providing a one-third overlap, and the swinging procedure was repeated. Subsequent movements of the spud barge and spreading of the cap material were made until the contaminated area was completely capped. Physical, chemical, and biological monitoring were initiated to determine cap effectiveness during the first 5 years following cap placement.

Denny Way

The Denny Way Combined Sewer Overflow (CSO) is located in the lower Duwamish River in Puget Sound (Sumeri 1989). It discharges both untreated sanitary sewage and stormwater runoff and acts as a relief point during peak storm events each year. The bottom sediments in the area off the Denny Way CSO (Figure 34) were found to be contaminated. Subsequently, a CSO control plan and source control activities were instituted to reduce the toxicant loading.

The in situ contaminated sediments at Denny Way were capped with sand using a similar procedure as used in the Duwamish capping project. For this project, sand placement needed to be more accurate. Clean sands were obtained from a maintenance dredging project and transported to the site by a bottom-dump barge. Placement of the cap was completed by pushing the barge sideways and sprinkling a 39-m-wide sand blanket. Barge displacement was measured with two pressure transducers installed in stilling wells at each end of the barge, and these displacement signals were telemetered to the microprocessor onboard the attending tug. The navigational position of the barge was tracked by a laser positioning system, which also telemetered the tugboat and monitored position and sand-sprinkling rate. A cap of 0.6 to 0.9 m was placed at the Denny Way CSO site, and monitoring of the cap effectiveness was instituted.

Port of Los Angeles/Marina del Ray

A large CAD project has recently been completed in the Port of Los Angeles (LA), and this project is the first to be implemented in California. The CAD site is constructed inside and adjacent to the main breakwater in LA Harbor and is known as the Permanent Shallow Water Habitat (PSWH) site. Materials placed in the site include contaminated materials from channel deepening within LA Harbor and contaminated materials from the Marina del Ray Project. Subaqueous dikes were first constructed using suitable quarry run materials from Catalina Island. Contaminated sediments from the harbor were placed by surface release at the site. Materials from the Marina del Ray Project were placed at the site using geotextile bags, the first demonstration of this technology as an application for placement of contaminated dredged material.

The PSWH site was originally designed by the Port of Los Angeles as an environmental mitigation measure for the Pier 400 harbor development project. Site design called for filling the 190-acre area to raise the natural bottom from 40- to 45-ft depths to depths less than 20 ft, creating a shallow-water foraging area for the endangered California least tern. Quarried stone from Catalina Island was used for construction of the subaqueous berm (see Figure 36). Approximately 543,000 cu yd of contaminated material from the harbor were placed within the site. These sediments had elevated levels of contaminants and were considered unsuitable for open-water disposal and were also undesirable from the standpoint of placement in the Pier 400 engineered landfill.

The contaminated sediment was placed in the center of the 94-acre portion of the overall 190-acre site. The 94-acre area was laterally separated from the outer boundaries of the site by buffer zones ranging from 200 to 650 ft, all of which were slated for capping with clean material. The widest (650-ft) buffer was located on the breakwater side to ensure the contaminated sediments would remain isolated in the event of a rare catastrophic storm that might breach the breakwater. Approximately 4 million cu yd of clean material from the harbor, which was physically unsuitable for landfill construction, comprised the lower (thickest) layer of the cap. Clean sand was used for the final 2 ft of cap to resist erosion and provide suitable substrate for the tern habitat. Together, this resulted in a cap thickness generally exceeding 15 ft. Such a cap thickness is far in excess of that required for effective capping from the standpoint of containment and was dictated in part by site geometry and dredging volumes.

The sequence of material placement was also driven in part by the dredging requirements for the overall Pier 400 project. The placement of initial portions of contaminated material was by clamshell dredge. This material was placed in the "central area" of the PSWH, while other initial elements were mechanically placed in the "perimeter area." The initial capping material was placed over the "central area" using a hopper dredge. The subsequent capping layers were placed by pipeline dredge.

Placement of a sand cover was completed after a waiting period of 11 months to allow for consolidating the fine-grained capping material and minimizing the mixing of sand with the fine material.

Prior to initiation of the Pier 400 project, the PSWH site was selected for placement of additional contaminated material from the Marina del Ray project located 35 miles from LA Harbor. This project involved approximately 55,000 cu yd of sandy contaminated sediments, which also contained potentially floatable debris. The initial scheduling of operations at Marina del Ray would have required placement of this material at the PSWH site prior to construction of the subaqueous berms. To avoid dispersion during placement and spreading of contaminated material in absence of the berms, the permit required use of geotextile bags for the

Marina del Ray material (Mesa 1995). Actual placement was initiated following completion of the berms, so the geotextile bags were not actually required as a control measure; but the project proved to be a valuable field demonstration of this innovative concept.

The sediments were dredged using a clamshell and placed in a split-hull scow lined with two layers of geotextile (a nonwoven inner liner and a woven outer shell) forming a container. Following completion of filling of a barge, the geotextile material was brought over the top of the barge, and the edges were sewn closed to form the completed container. Modifications were made to the scow bulkheads to reduce the width and length of the filled volume to allow easier release of the filled bags.

The first geocontainer was filled with approximately 1,900 cu yd of material. Because of drainage of the sandy sediment during transport and subsequent bridging action, the first container failed to fall completely from the barge. Water jets were finally employed to fluidize the material and release the bag. Subsequent bags were only filled with approximately 1,300 cu yd, and additional fabric was used in forming the containers, providing more "slack" in the containers to help with release. A total of 44 containers were placed (Figure 36).

All contaminated materials were successfully placed within the subaqueous dikes, and the dikes have performed as intended. Bathymetric and sediment profiling image camera monitoring confirmed that approximately 98 percent of the contaminated material was retained behind the subaqueous dike, and that the thickest deposits immediately outside the dike were generally less than 5 cm (the regulatory limit set for the project in advance).

Rotterdam Harbor

As a consequence of local effluent discharge from chemical industries sited around the 1st Petroleum Harbor in the Port of Rotterdam, the harbor basin contained heavily contaminated material. Several options (upland, open water, dredged pits, and confined behind a sheet-piled dam) were considered for disposing of the contaminated material as described by Kleinbloesam and van der Weijde (1983). The alternative finally selected was a CAD project that consisted of excavating pits in the 1st Petroleum Harbor, dredging the contaminated material, disposing of it in the pits, and capping and lining the pit with clean material (Figure 37). The plan, called the Putten Plan, had to be executed so that dispersion of pollutants into the surface water and groundwater was very low, but acceptable. Special dredging equipment was used for the disposal operation, and studies were conducted to determine the dispersion of the contaminants.

The first dredge pit was 550 by 120 m at the bottom and was 15 m deep with a capacity of 1.4 million m^3. The silt from the pit dredging was disposed at sea, and the sand was used at various landfill projects. Two additional pits were dredged; the contaminated dredged material was taken to the first pit, and the clean material was used or discharged at sea. A third

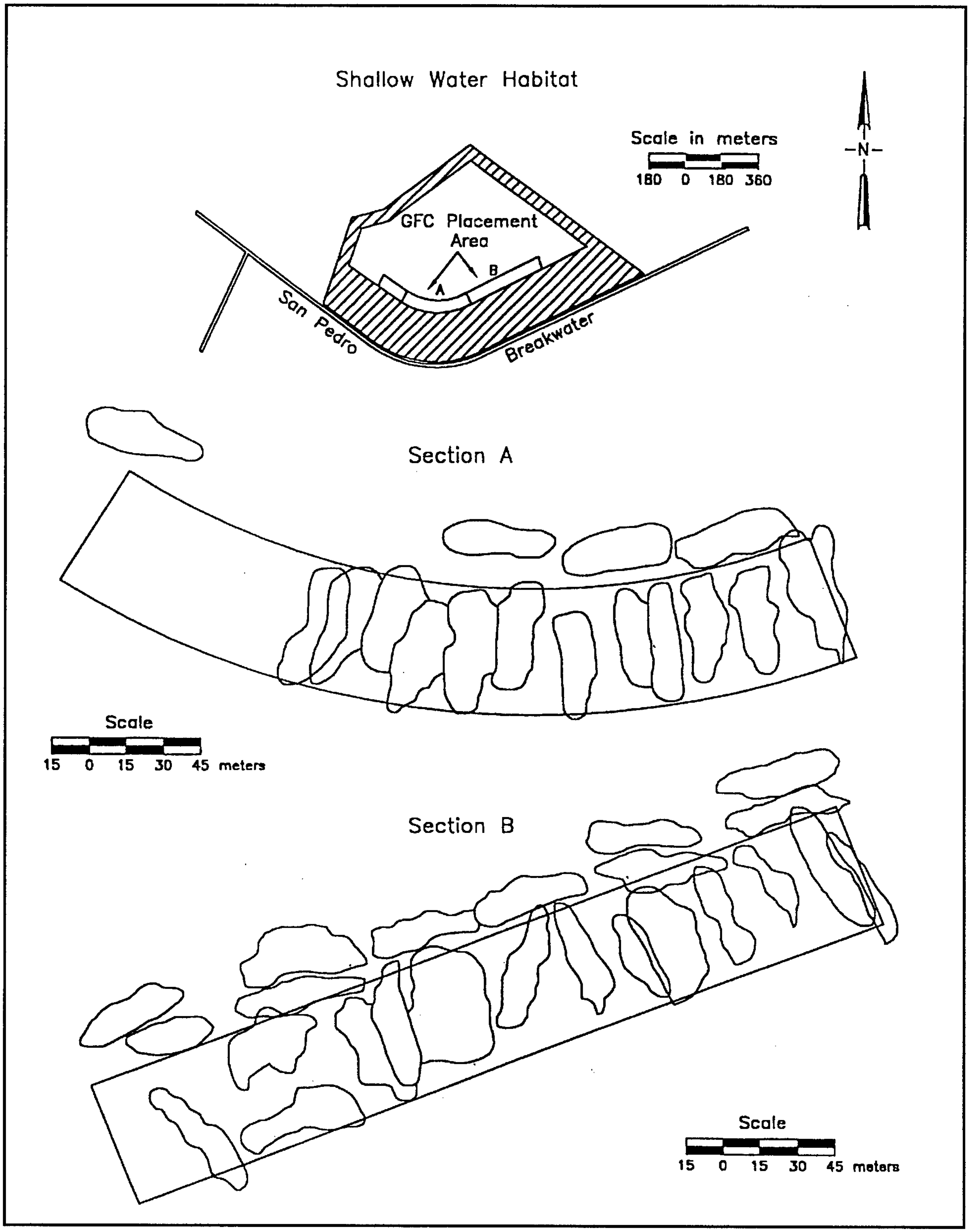


Figure 36. Marina del Ray project plan showing location of berms and geotextile bags

pit was needed to compete the disposal of all expected contaminated material. This procedure (Figure 37) was to be completed only once, and subsequent maintenance would be completed using normal methods.

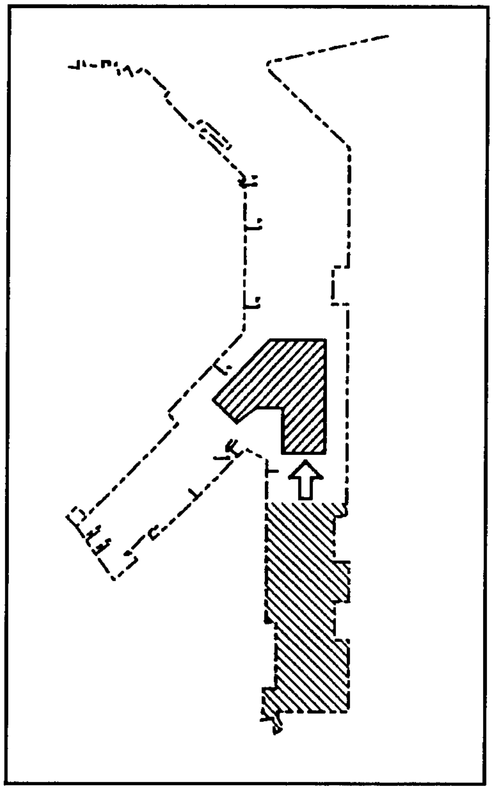


Figure 37. Rotterdam Harbor CAD project

A suction dredge was converted to act as the discharge vessel with the suction pipe used as the discharge pipe. Conditions on the suction dredge operation were (a) no overflow, (b) no water jets in suction process, (c) lower working speed, (d) must use onboard pumping systems for contaminated sediment discharge, (e) contaminated water from silt and degassification must not be discharged overboard, and (f) contaminated mixtures cannot be pumped overboard. The discharge pipe was extendable to 30 m and was equipped with a modified discharge opening (diffuser). The diffuser directed the discharge radially and reduced the exit velocity to between 0.3 and 0.4 m/sec. The dredge was also equipped with a degassification system. Contaminated material was dredged with a modified stationary suction dredge. Its suction mouth was equipped such that only the upper layer of the dredged material was touched, and the suction intake had no moving parts or waterjets. The objective was to maintain the in situ density of the dredged contaminated material throughout the dredging, transporting, and discharging operations. Pollution of the groundwater through the bottom of the dredge pit was also of concern. After researching this problem, it was decided to place a layer of clay as a liner in the bottom of the dredge pit.

Hiroshima Bay

Hiroshima Bay in the Inland Sea of Japan was the site of bottom-sediment improvement testing using a special barge unloader sand spreader (Kikegawa 1983). The investigation demonstrated that the sand-overlaying process was successful using a barge unloader sand spreader (Figure 10), and the sand layer had only minor irregularities in thickness with a mean thickness of 0.5 m. Coarse particle size (0.1 to 10 mm) containing shells with silt content of 0.1 to 0.3 percent was used as the overlaying material. The discharge sand quantity during the spreading operation was estimated using the pump suction pressure. Bottom sediment resuspension during discharge was measured with a portable turbidity instrument, which showed the resuspension of the bottom sediment was up to 1.5 m above the seafloor. The depth of spreading did not cause any noticeable differences in the spreading capability. The sand spreading did result in turbulence in the bottom sediment, but contamination of the surrounding water did not occur. The success of the sand-spreading demonstration was above expectations, but it was concluded that a new type of sand spreader would be needed for larger scale operations.

A conveyor barge (Figure 11) with 18 hopper bins was used in Hiroshima Bay for another sand-spreading test (Togashi 1983). The barge could discharge 2,000 m^3 in 1 hr. A telescopic tremie tube was installed, and the length of the tube was adjusted so that the sand discharged would not disturb the spread of the sludge as it contacted the seafloor. The sea sand had a average specific gravity of 2.62 and silt content of 0.6 to 1.5 percent. The design thickness was 0.5 m. Results of the field tests showed the average 0.5-m thickness was obtained using a volume equivalent of 0.25 m of overlay placed twice from a height of 10 to 12 m above the bottom. The sand thickness was stable; the impact on the bottom sediment was diminished at this height, and turbidity and resettling were minimized. This conveyor barge method was considered to be an efficient and mobile technique for sand overlaying and is applicable in a wide range of areas.

11 Summary and Recommendations

Summary

This report presents technical guidance for subaqueous dredged material capping. The guidance is summarized as follows:

a. Capping is the controlled accurate placement of contaminated material at an open-water disposal site, followed by a covering or cap of clean isolating material. Within the context of capping, the term "contaminated" refers to material that needs isolation from the benthic environment, while the term "clean" refers to material found to be suitable for open-water disposal.

b. A capping operation must be treated as an engineered project with carefully considered design, construction, and monitoring to ensure that the design is adequate.

c. There is a strong interdependence between all components of the design for a capping project. By following an efficient sequence of activities for design, unnecessary data collection and evaluations can be avoided, and a fully integrated design is obtained.

d. The basic criterion for a successful capping operation is simply that the cap thickness required to isolate the contaminated material from the environment can be successfully placed and maintained.

e. The contaminated sediment must be characterized from physical, chemical, and biological standpoints. Physical characteristics are of importance in determining the behavior of the material during and following placement at a capping site. Chemical and biological characterization data for the contaminated material to be capped are useful in determining potential water column effects during placement and acceptable exposure times before placement of the cap begins.

f. The capping sediment must also be characterized from the physical, chemical, and biological standpoints. Physical characteristics determine the behavior during placement of the cap and long-term consolidation and stability against erosion. Chemical and biological characterization should determine if the capping sediment is acceptable for unrestricted open-water disposal (i.e., a "clean" sediment).

g. The selection of an appropriate site is a critical requirement for any capping operation. The general considerations for selection of any nondispersive open-water site also apply to selection of a site for capping, but a capping site requires special consideration of bathymetry, currents, water depths, bottom-sediment characteristics, and operational requirements. In general, capping sites should be located in relatively low-energy environments with little potential for erosion of the cap.

h. A number of different equipment types and placement techniques can be considered for capping operations. Conventional discharge of mechanically dredged material from barges and hydraulically dredged material from hopper dredges or pipelines can be considered if the anticipated bottom spread and water column dispersion are acceptable. If water column dispersion must be reduced or if additional control in placement is required, use of diffusers, tremies, and other equipment needed for submerged discharge can be considered. Controlled discharge and movement of barges and use of spreader plates or boxes with hydraulic pipelines can be considered for spreading a capping layer over a larger area. Compatibility between equipment and placement technique for contaminated and capping material is essential for any capping operation.

i. Accurate navigation to the disposal site and precise positioning during material placement are required for capping operations. State-of-the-art equipment and techniques must be employed to ensure accurate placement to the extent deemed necessary. Diligent inspection of operations to ensure compliance with specifications is essential.

j. Scheduling of the contaminated-material placement and capping operation must consider both exposure of the contaminated material to the environment and engineering and operational constraints.

k. Evaluation of potential water column effects due to placement of contaminated material must be performed. If water column release is unacceptable, control measures must be considered to reduce the potential for water column effects, or other dredging equipment and placement techniques or use of another capping site can be considered.

l. The cap must be designed to chemically and biologically isolate the contaminated material from the aquatic environment. The determination of the minimum required cap thickness is dependent on the physical and chemical properties of the contaminated and capping sediments, the potential for bioturbation of the cap by aquatic organisms, and the potential for consolidation and erosion of the cap material.

m. The spread and mounding behavior of contaminated material during placement must be evaluated to predict the geometry of the deposit and resulting cap material requirements. The capping material behavior must be similarly evaluated to determine if the design of the cap and volume of capping material available are adequate. The smaller the "footprint" of the contaminated material as placed, the less volume of capping material will be required to achieve a given cap thickness.

n. An evaluation of the consolidation and long-term potential for erosion of the mound or deposit must be conducted to ensure that the required cap thickness can be maintained. The design-cap thickness must be adjusted to account for potential erosion and consolidation. The cap can also be armored with coarser material to minimize erosion.

o. Monitoring of capped sites is required during and following placement of the contaminated and capping material to ensure that an effective cap has been constructed and to ensure that the cap as constructed is effective in isolating the contaminants and that long-term integrity of the cap is maintained. Design of monitoring programs must be logically developed, prospective in nature, and tiered with each tier having its own thresholds, null hypotheses, sampling design, and management responses based on exceedance of predetermined thresholds.

p. Capping of contaminated material in open-water sites began in the late 1970s, and a number of capping operations under a variety of disposal conditions have been accomplished. Field experience with these projects has shown that the capping concept is technically and operationally feasible.

q. The cost of capping is generally lower than alternatives involving confined (diked) disposal facilities. The geochemical environment for subaqueous capping favors long-term stability of contaminants as compared with the upland environment where geochemical changes may favor increased mobility of contaminants. Capping is therefore an attractive alternative for disposal of contaminated sediments from both economic and environmental standpoints.

Recommendations

As more designs are completed and additional field experience is gained, the technical guidelines in this report should be refined and expanded. Additional research is also recommended to develop improved tools for capping evaluations. Specific recommendations for further research are summarized as follows:

a. More clearly define impacts associated with capping at water depths exceeding 100 ft. PSSDA monitoring has shown material dispersion can be predicted in 300- to 400-ft water depth in Puget Sound.

b. Refine and verify models for short-term fate of dredged material to allow for predictions within the full range of conditions expected at capping sites.

c. Refine and verify models that predict subaqueous mound development due to multiple discharges from barges or hopper dredges or long-term discharge from pipelines. Approaches should included both water column and spread behavior of the discharges and the geotechnical considerations associated with mound-slope stability, density flows, and resistance to bearing failure. Such tools will have application for general open-water site management as well as specific application to capping scenarios.

d. Refine and verify models that predict long-term erosion from dredged material mounds. Additional emphasis should be placed on mounds covered with fine-grained material. Such tools will have application for general open-water site management as well as specific application to capping scenarios.

e. Refine existing estimates of resuspension of contaminated material during cap placement. This work will assist in determining the costs versus benefits of "sprinkling" cap material versus conventional bottom dumping of cap material.

f. Develop engineering guidance on acceptable rates and methods of application of capping material over contaminated material of varying density and shear strength. These techniques should consider the geotechnical behavior related to displacement and mixing of contaminated and capping sediments and resistance of the sediments to bearing failure. Extend the investigation to include penetration of dense (e.g., rock) cap material into contaminated material mounds.

g. Refine existing models for prediction of capped-mound consolidation. This effort will likely require developing or refining instrumentation for in situ geotechnical measurements.

h. The effect of pore water pressure fluctuations within the mound caused by the surface wave climate should be studied to determine possibility of contaminant release and reduced mound stability.

i. Develop predictive tools for evaluation of long-term cap integrity, considering chemical migration via consolidation, bioturbation, and diffusion. Both analytical and modeling approaches should be considered. Refinements to sediment-water interface models for this purpose are ongoing under the Disposal Operations Technical Support Program.

j. Conduct laboratory and field verification studies of long-term cap integrity. Laboratory approaches should include refinement of existing cap-effectiveness tests using columns. Additional laboratory verification of consolidation effects on contaminant migration should be conducted using large geotechnical centrifuges. Field studies should include periodic monitoring and sampling of capped sites to include analysis of core samples.

References

Ackers, P., and White, R. W. (1973). "Sediment transport: New approach and analysis," *Journal of the Hydraulics Division* 99 (HY11), 2041-60.

Adamec, S. A., Jr., Johnson, B. H., and Trawle, M. J. (1988). "Numerical modeling of material from Everett, Washington, Naval Port disposed in Puget Sound," Draft Report, U.S. Army Engineer Waterways Experiment Station, Vicksburg Mississippi.

Allard, R., Farrar, P., Mark, D., Martin, J., Shapiro, B., Lowe, S., and Ko, D. S. (1996). "Creating a 4-D integrated scenario near Camp Pendelton, CA." *Proceedings of the Conference on Coastal Oceanic and Atmospheric Prediction,* Am. Meteorological Soc., Boston, MA.

Allen, J. R. L. (1970). "The avalanching of granular solids on dune and similar slopes," *Journal of Geology* 78 (3), 326-51.

American Public Health Association (APHA). (1986). *Standard methods for the examination of water and wastewater.* 15th ed., Washington, DC.

Ariathurai, R., and Krone, R. B. (1976). "Finite element model for cohesive sediment transport," *Journal of the Hydraulics Division* 102(HY3), 323-38.

Ariathurai, R., MacArthur, R. C., and Krone, R. B. (1977). "Mathematical model of estuarial sediment transport," Technical Report D-77-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Averett, D. E., and Palermo, M. R., Otis, M. J., and Rubinoff, P. B. (1989). "New Bedford Harbor Superfund Project, Acushnet River estuary engineering feasibility study of dredging and dredged material disposal alternatives; Report 11, Evaluation of conceptual dredging and disposal alternatives," Technical Report EL-88-15, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bain, C. C., Westerink, J. J., Luettich, R. A., Jr., Scheffner, N. W. (1994). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuaries; Report 4, Hurricane storm surge modeling using large domains," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1995). "Influence of domain size and grid structure on the response characteristics of a hurricane storm surge model," Technical Report DRP-95-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ballinger, D. C. (1979). "Methods for chemical analysis of water and wastes," EPA 600/4-79-020, U.S. Environmental Protection Agency, Cincinnati, OH.

Barnard, W. D. (1978). "Prediction and control of dredged material dispersion around dredging and open-water pipeline disposal operations," Technical Report DS-78-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bijker, E. W. 1971. "Longshore transport computations," *Journal of the Waterways, Harbors, and Coastal Engineering Division* (WW4), 687-701.

Bohlen, W. F., Gee, A., and Germano, J. D. "Sediment capping of subaqueous dredged material disposal mounds: An overview of the New England experience," Report in preparation by Science Applications International Corporation for U.S. Army Engineer Division, New England.

Bokuniewicz, H. (1989). "Behavior of sand caps on subaqueous dredged material disposal sites," *Oceanic processes in marine pollution, Vol 4, Scientific monitoring strategies for ocean waste disposal.* D. Hood, A. Schoener, and P. K. Parks, ed., Krieger Publishing Co., Malabar, FL.

Bokuniewicz, H. J., Gerbert, J., Gordon, R. B., Higgins, J. L., Kaminsky, P., Pilbeam, C. C., Reed, M., and Tuttle, C. (1978). "Field study of the mechanics of the placement of dredged material at open-water disposal sites," Technical Report D-78-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Borgman, L. E., Miller, M. C., Butler, H. L., and Reinhard, R. D. (1992). "Empirical simulation of future hurricane storm histories as a tool in engineering and economic analysis," *Proceedings of Civil Engineering in the Oceans* V, ASCE, New York.

Borgman, L. E. and Scheffner, N. W. (1991). "The simulation of time sequences of wave height, period, and direction," Technical Report DRP-91-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bosworth, W. S. and Thibodeaux, L. J. (1990). "Bioturbation: A facilitator of contaminant transport in bed sediment," *Environmental Progress* 9(4).

Bowers, G. W., and Goldenblatt, M. K. (1978). "Calibration of a predictive model for instantaneously discharged dredged material," EPA-600/3-78-089, U.S. Environmental Protection Agency, Corvallis, OR.

Boyer et al. (1994). "Recovery, a mathematical model to predict the temporal response of surface water to contaminated sediments," Technical Report W-94-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brandes, H., Silva, A., and Fredette, T. J. (1991). "Settlement of offshore mounds of capped dredged materials," *Maritimes.*

Brandsma, M. G. and Divoky, D. J. (1976). "Development of models for prediction of short-term fate of dredged material discharged in the estuarine environment," Contract Report D-76-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brannon, J. M., et al. (1985). "Effectiveness of capping in isolating contaminated dredged material from biota and the overlying water," Technical Report D-85-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1986) "Effectiveness of capping in isolating dutch kill sediment from biota and the overlying water," Miscellaneous Paper D-86-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Brannon, J., and Poindexter-Rollings, M. E. (1990). "Consolidation and contaminant migration in a capped dredged material deposit," *The Science of the Total Environment* 91, 115-26.

Bray, R. N., Bates, A. D., and Land, J. M. (1997). *Dredging, a handbook for Engineers.* 2d ed., John Wiley and Sons, New York.

Brooks, N. H. (1973). "Dispersion in hydrologic and coastal environments," Pacific Northwest Water Quality Laboratory, Northwest Region, U.S. Environment Protection Agency, Corvalis, OR.

Cargill, K. W. (1982). "Consolidation of soft layers by finite strain theory," Miscellaneous Paper GL-82-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cargill, K. W. (1985). "Mathematical model of the consolidation/desiccation process in dredged material," Technical Report D-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Chow, V. T. (1959). *Open channel hydraulics.* McGraw-Hill Book Company, New York.

Christoffersen, J. B., and Jonsson, I. G. (1985). "Bed friction and dissipation in a combined current and wave motion," *Ocean Engineering* 12(5), 387-423.

Clausner, J. E., Palermo, M. R., Banks, D., and Palmerton, J. (1996). "Potential application of geosynthetic fabric containers for open water placement of contaminated dredged material," Environmental Effects of Dredging Technical Note EEDP-01-39, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Clausner, J. E., Scheffner, N. W., and Allison, M. C. (1995). "Assessment of remaining capacity of the Mud Dump site," Letter Report for New York District, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Corson, W. D., Resio, D. T., and Vincent, C. L. (1980). "Wave information study of U.S. coastlines; Report 1, Surface pressure field reconstruction for wave hindcasting purposes," Technical Report HL-80-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cox, J. M., Maresca, P., and Jarvela, A. (1995). "Silent inspector user's manual," Instruction Report DRP-95-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

d'Angremond, K., de Jong, A. J., and de Waard, C.-P. (1986). "Dredging of polluted sediment in the 1st Petroleum Harbor, Rotterdam." *Proceedings of the Third United States/The Netherlands Meeting on Dredging and Related Technology.* Prepared for the U.S. Army Corps of Engineers Water Resources Support Center by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Di Toro, D. M., Jeris, J. S., and Clarcia, D. (1985). "Diffusion and partitioning of hexachlorobiphenyl in sediments," *Environ. Sci. Technol.* 19(12), 1169-75.

Dortch, M. S., Hales, L. Z., Letter, J. V., and McAnally, W. H., Jr. (1990). "Methods of determining the long-term fate of dredged material for aquatic disposal sites," Technical Report D-90-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Duarte, F., Joseph, J., Satterlee, G. (1995). "Construction of geocontainer and geobag contraction dikes to eliminate dredging at Red Eye Crossing." *Proceedings of Ports* '95, ASCE, New York.

Earhart, G., Clarke, D., and Shipley, J. (1988). "Beneficial uses of dredged material in shallow coastal waters; Chesapeake Bay demonstration," Information Exchange Bulletin D-88-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Efron, B. (1982). "The jackknife, the bootstrap and other resampling plans," Society for Industrial and Applied Mathematics, Philadelphia, PA.

__________. (1990). "More efficient bootstrap computations," *Journal of the American Statistical Association* 85(409), 79-89.

Elliot, D. O. (1932). "The improvement of the Lower Mississippi River for flood control and navigation," Vol. II, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Environmental Laboratory. (1987). "Disposal alternatives for PCB-contaminated sediments from Indiana Harbor, Indiana," Miscellaneous Paper EL-87-9, 2 Vols, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Environmental Protection Agency (EPA). (1986). "U.S. Environmental Protection Agency, ocean dumping site designation delegation handbook," Office of Marine and Estuarine Protection, Washington, DC.

EPA/U.S. Army Corps of Engineers (USACE). (1991). "Evaluation of dredged material proposed for ocean disposal (testing manual)," EPA-503/8-91/001, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

__________. (1998). "Evaluation of dredged material proposed for discharge in inland and near-coastal waters - Testing manual," EPA-823-B-98-004, U.S. Environmental Protection Agency, Washington, DC.

Farrar, P. D., Borgman, L. E., Glover, L. B., and Reinhard, R. D., Pope, J., Swain, A., and Ebersole, B. (1994). "Storm impact assessment for beaches at Panama City, Florida," Technical Report CERC-94-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Francingues, N. R., Palermo, M. R., Lee, C. R., and Peddicord, R. K. (1985). "Management strategy for disposal of dredged material: Contaminant testing and controls," Miscellaneous Paper D-85-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fredette, T. J. (1994). "Disposal site capping management: New Haven Harbor." *Proceedings of Dredging '94*, ASCE, New York.

Fredette, T. J., Anderson, G., Payne, B. S. and Lunz, J. D. (1986). "Biological monitoring of open-water dredged material disposal sites." *IEEE Oceans '86 Conference Proceedings, Washington, DC.*

Fredette, T. J., Bohlen, W. F., Rhoads, D. C., and Morton, R. W. (1988). "Erosion and resuspension effects of Hurricane Gloria at Long Island Sound dredged material disposal site." *U.S. Army Corps of Engineers Seventh Annual Water Quality Seminar Proceedings, Charleston, SC.*

__________. (1989). "Erosion and resuspension effects of Hurricane Gloria at Long Island Sound dredged material disposal sites," Environmental Effects of Dredging Information Exchange Bulletin, Vol D-89-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fredette, T. J., Germano, J. D., Carey, D. A., Murray, P. M., and Kullberg, P. G. (1992). "Chemical stability of capped dredged material disposal mounds in Long Island Sound, USA," *Chemistry and Ecology* 7, 173-94.

Fredette, T. J., Germano, J. D., Kullberg, P. G., Carey, D. A., and Murray, P. "Chemical stability of capped dredged material disposal mounds in Long Island Sound, USA." *1st International Ocean Pollution Symposium, Mayaguez, Puerto Rico. Chemistry and Ecology.* In preparation.

Fredette, T. J., Nelson, D. A., Clausner, J. E., and Anders, F. J. (1990a). "Guidelines for physical and biological monitoring of aquatic dredged material disposal sites," Technical Report D-90-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Fredette, T. J., Nelson, D. A., Miller-Way, T., Adair, J. A., Sotler, V. A., Clausner, J. E., Hands, E. B., and Anders, F. J. (1990b). "Selected tools and techniques for physical and biological monitoring of aquatic dredged material disposal sites," Technical Report D-90-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Freeland, G. L., et al. (1983). "Sediment cap stability study of New York dredged material dumpsite," Support Agreement No. NYD 80-124CC, by Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, FL, for U.S. Army Engineer District, New York.

Gibson, R. E., England, G. L., Hussey, M. J. L. (1967). "The theory of one-dimensional consolidation of saturated clays; I, Finite nonlinear consolidation of thin homogeneous layers," *Geotechnique* 17(3), 261-73.

Gibson, R. E., Schiffman, R. L., and Cargill, K. W. (1981). "The theory of one-dimensional consolidation of saturated clays, II, fine non-linear consolidation of thick homogeneous layers," *Canadian Geotechnical Journal* 18, 289-93.

Gordan, R. (1974). "Dispersion of dredged spoil dumped in near-shore waters," *Estuarine and Coastal Marine Science* 2, 349-58.

Greges, M. (1994). "Ocean disposal with capping of dioxin contaminated sediment: New York case history #1." *Proceedings of Dredging* '94, American Society of Civil Engineers, New York, 1278-84.

Gunnison, D., et al. (1987a). "Appendix F: Evaluation of the effectiveness of capping in isolating contaminated Indiana Harbor dredged material from biota and the overlying water," Miscellaneous Paper EL-87-9, Vol II, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1987b). "Development of a simplified column test for evaluation of thickness of capping material required to isolate contaminated dredged material," Miscellaneous Paper D-87-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hales. (1995). "Accomplishments of the Corps of Engineers Dredging Research Program," *Journal of Coastal Research* 11(1), 68-88.

Hands, E. B., and Allison, M. C. (1991). "Mound migration in deeper water and methods of categorizing active and stable berms." *Proceedings of Coastal Sediments '91*, ASCE, 1985-99.

Hayes, D. F., McLellan, T. N., and Truitt, C. L. (1988). "Demonstrations of innovative and conventional dredging equipment at Calumet Harbor, Illinois," Miscellaneous Paper EL-88-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Headland, R. E., Lesnik, J. R., McNeilan, T. W., and Hooper, J. R. (1995). "Feasibility study of sediment restoration alternatives for the southern California natural resource damage assessment; Appendix G: Hydrodynamics and geotechnical assessment of the in-situ capping alternative," Moffatt and Nichols Engineers, Baltimore, MD.

Headquarters, U.S. Army Corps of Engineers (HQUSACE). (1983). "Dredging and dredged material disposal," Engineer Manual 1110-2-5025, 25 March 1983, Washington DC.

__________. (1984). "Shore Protection Manual," Washington, DC.

Hench, J. L., Luettich, R. A., Jr., Westerink, J. J., and Scheffner, N. W. (1994). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuaries; Report 6, Development of a tidal constituent database for the eastern North Pacific," Technical Report

DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Herbich, J. B. (1992). *Handbook of dredging engineering.* McGraw-Hill, Inc., New York.

Ho, F. P., Su, J. C., Hanevich, K. L., Smith, R. J., and Richards, F. P. (1987). "Hurricane climatology for the Atlantic and Gulf Coasts," Technical Report NWS 38, National Weather Service, NOAA, Silver Spring, MD.

Hubertz, J. M., Brooks, R. M., Brandon, W. A., and Tracy, B. A., (1993). "Hindcast wave information for the U.S. Atlantic Coast," WIS Report 30, Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Ippen, A. T., ed. (1966). *Estuary and coastline hydrodynamics.* McGraw-Hill Book Co., Inc., New York.

Jarvinen, B. R., Neumann, C. J., and Davis, M. A. S. (1988). "A tropical cyclone data tape for the North Atlantic Basin, 1886-1983: Contents, limitations, and uses," NOAA Technical Memorandum NWS NHC 22.

JBF Scientific Corporation. (1975). "Dredging technology study, San Francisco Bay and Estuary," U.S. Army Engineer District, San Francisco, CA.

Jensen, R. E., Hubertz, J. M., Thompson, E. F., Reinhard, R. D., Bishop, B. J., Brandon, W. A., Payne, J. B., Brooks, R. M., and McAneny, D. S. (1992). "Southern California hindcast wave information," WIS Report 20, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johanson, E. E., Bowen, S. P., and Henry, G. (1976). "State-of-the-art survey and evaluation of open-water dredged material placement methodology," Contract Report D-76-3, prepared by JBF Scientific Corporation for U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H. (1978). "Application of the instantaneous dump dredged material disposal model to the disposal of Stamford and New Haven Harbor material from a scow in the Long Island Sound," Internal Working Document prepared for New England Division, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1979). "Application of the instantaneous dump dredged material disposal model to the disposal of San Diego Harbor material at the 45 and 100 fathom disposal sites," Internal Working Document, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1990). "User's guide for models of dredged material disposal in open water," Technical Report D-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H. (1992). "Numerical disposal modeling." Technical Note DRP-1-02, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H., and Fong, M. T. (1995). "Development and verification of numerical models for predicting the initial fate of dredged material disposed in open water; Report 2, Theoretical developments and verification results," Technical Report DRP-93-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H., and Holliday, B. W. (1977). "Numerical model results of dredged material disposal at ten proposed ocean disposal sites in the Hawaiian Islands," Miscellaneous Paper H-77-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1978). "Evaluation and calibration of the Tetra Tech dredged material disposal models based on field data," Technical Report D-78-47, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H., McComas, D. N., McVan, D. C., and Trawle, M. J. (1993). "Development and verification of numerical models for predicting the initial fate of dredged material disposed in open water; Report 1, Physical model tests of dredged material disposal from a split-hull barge and a multiple bin vessel," Technical Report DRP-93-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Jonsson, I. G. (1966). "Wave boundary layers and friction factors." *Proc., Coast. Engrg. Conf., 10th, Tokyo, Japan.*

Kikegawa, K. (1983). "Sand overlying for bottom sediment improvement by sand spreader." *Management of bottom sediments containing toxic substances: Proceedings of the 7th U.S./Japan Experts Meeting.* Prepared for the U.S. Army Corps of Engineers Water Resources Support Center by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 79-103.

Kleinboesam, W. C. H., and van der Weijde, R. W. (1983). "A special way of dredging and disposing of heavily polluted silt in Rotterdam," World Dredging Congress 1983, Paper M2, Singapore, 509-25.

Koh, R. C. Y., and Chang, Y. C. (1973). "Mathematical model for barged ocean disposal of waste," Environmental Protection Technology Series EPA 660/2-73-029, U.S. Environmental Protection Agency, Washington, DC.

Kraus, N. C., and Larson, M. (1988). "Beach profile change measured in the tank for large waves, 1956-1957 and 1962," Technical Report CERC-86-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Larson, M., and Kraus, N. C. (1989). "SBEACH: Numerical model for simulating storm induced beach change; Report 1, Theory and model foundation," Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lavelle, J. W., Mofjeld, H. O., and Baker, E. T. (1984). "An in situ erosion rate for a fine-grained marine sediment," *J. Geophys. Res.* 89(C4), 6543-552.

Lermans, A. (1979). *Geochemical processes water and sediment environments*. John Wiley and Sons, New York.

Lillycrop, W. J., Garcia, A. W., Howell, G. L., and Grogg, W. E. (1991). "Automated real-time tidal elevation system for offshore dredging operations." Chapter 42. *Tidal hydrodynamics*. B. B. Parker, ed., John Wiley and Sons, Inc., New York, 829-37.

Ling, H. I., Leshchinsky, D., Gilbert, P. A., and Palermo, M. R. (1996). "In-situ capping of contaminated submarine sediments: Geotechnical considerations." *Environmental geotechnics*. A. A. Masashi Kamon, ed., Balkem, Rotterdam, The Netherlands, 575-580.

Luettich, R. A., Jr., Westerink, J. J., and Scheffner, N. W. (1992). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries; Report 1, Theory and methodology of ADCIRC-2DDI and ADCIRC-3DL," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Mansky, J. M. (1984). "Underwater capping of contaminated dredged material in New York Bight Apex," Environment Effects of Dredging, Information Exchange Bulletin, Vol D-84-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Marine Board, National Research Council. (1990). *Managing troubled waters - The role of marine environmental monitoring*. National Academy Press, Washington, DC.

Mark, D. J., and Scheffner, N. W. (1993). "Validation of a continental-scale storm surge model for the cost of Delaware." *3rd International Conference on Estuarine and Coastal Modeling, Chicago, Il.*

Matisoff, G. "Mathematical models of bioturbation." *Animal-sediment relations*. P. L. McCall and M. J. Tevesz, ed., Plenum Press, New York, 289-331.

May, B., Pabst, D., and McDowell, S. L(1994). "Dioxin capping management and monitoring program: Design and implementation." *Proceedings of Dredging "94.* American Society of Civil Engineers, New York, 1027-36.

McAneny, D. "The coastal engineering data retrieval system (CEDRS)," Miscellaneous Paper in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

McDowell, S. (1993). "Comparison of baseline bathymetric surveys: New York Mud Dump site," Report by Science Applications International Corporation, submitted to USAE District, New York, New York.

McDowell, S., May, B., and Pabst, D. (1994). "The December 1992 storm at the New York Mud Dump site." *Proceedings of Dredging*'94, ASCE, New York.

McFarland, V. A. "A bioaccumulation study testing the effectiveness of varying cap apron thicknesses for isolation of dioxin," Report in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

McLellan, T. N., and Truitt, C. L. (1986). "Demonstration of a submerged diffuser for dredged material disposal." *Proceedings of the Conference Oceans '86, Washington, DC.*

McNeil, J., Taylor, C., and Lick, W. "Measurements of the erosion of undisturbed bottom sediments with depth," accepted for publication to *Journal of Hydraulic Engineering.*

Mehta, A. J., Hayter, E. J., Parker, W. R., Krone, R. B., and Teeter, A. M. (1989). "Cohesive sediment transport - I: Process description," *Journal of Hydraulic Engineering,* ASCE, 115(3), 1076-93.

Mesa, C. L. (1995). "Containerization of contaminated dredge sediments - the Marina Del Rey experience." *Proceedings of the 25th Texas A&M Annual Dredging Seminar, TAMU Center for Dredging Studies, College Station, TX.*

Moritz, H. R. (1994). "User's guide for the multiple dump fate model, final report," Contract Report DACW39-94-M-1304, Prepared for the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1997). "Management of ocean dredged material disposal sites at the mouth of the Columbia River." *Proceedings of the Western Dredging Association Eighteenth Technical Conference and Thirtieth Annual Texas A&M Dredging Seminar.* Center for Dredging Studies, Texas A&M University, College Station, TX, 119-139.

Moritz, H. R., and Randall, R. E. (1992). "User guide for the open water disposal area management simulation," Final Report by Texas A&M Research Foundation to U.S. Army Engineer Waterways Experiment Station, Contract Number DACW39-90-K-0015, Vicksburg, MS.

Moritz, H. R., and Randall, R. E. 1995. "Simulating dredged material placement at open water disposal sites," *Journal of Waterway, Port, Coastal, and Ocean Engineering,* ASCE, 121(1).

Morton, R. W. (1980a). "Capping procedures as an alternative technique to isolate contaminated dredged material in the marine environment," Report to USACE, New England Division, Newport, RI, Science Applications, Inc.

__________. (1980b). "The management and monitoring of dredge spoil disposal and capping procedures in central Long Island Sound." *Second annual ocean dumping symposium, Woods Hole, MA.* DAMOS Contribution No. 8, U.S. Army Corps of Engineers, New England, Waltham, MA.

__________. (1983a). "Precision bathymetric study of dredged material capping experiment in Long Island Sound." *Wastes in the ocean, Volume II. Dredged material disposal.* D. R. Kester, I. W. Duedall, B. H. Ketchum, and P. K. Parks, ed., John Wiley and Sons, Inc., New York, 99-121.

__________. (1983b). "Capping procedures as an alternative technique to isolate contaminated dredged material in the marine environment." *Proceedings of the 7th US/Japan Experts Meeting.* U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 108-133.

__________. (1987). "Recent studies concerning the capping contaminated dredged material." *Proceedings of the United States/Japan Experts Meeting on management of bottom sediments containing toxic substances, November 3-6, 1987, Baltimore, MD.*

__________. (1989). "Monitoring the effectiveness of capping for isolating contaminated sediments." *Symposium/workshop on contaminated marine sediments, Tampa, FL.* Nat. Acad. Press, Washington, DC, 262-279.

Morton, R. W., Parker, J. H., and Richmond, W. H., ed. (1984). "Disposal area monitoring system: Summary of program results 1981-1984," DAMOS Contribution #46, Science Applications International Corporation of U.S. Army Engineer Division, New England, Waltham, MA.

Mudrock, A., and MacKnight, S. D. (1991). *Handbook of techniques for aquatic sediment sampling.* CRC Press, Boca Raton, FL.

Myers, A. C. (1979). "Summer and winter burrows of a Mantis shrimp, *Squilla empusa,* in Narragansett Bay, Rhode Island (USA)," Estuarine Coastal Marine Science 8, 87-98.

Myers, T. E., Averett, D. E., Olin, T. J., Palermo, M. R., Reible, D. D., Martin, J. L., and McCutcheon, S. C. (1996). "Estimating contaminant losses from components of remediation alternatives for contaminated sediments," EPA 905-R96-001, March 1996, Assessment and Remediation of Contaminated Sediments (ARCS) Program, U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

Myers, V. A. (1975). "Storm tide frequencies on the South Carolina coast," Technical Report NWS-16, National Weather Service, NOAA, Silver Spring, MD.

Neal, R. W., Henry, G., and Greene, S. H. (1978). "Evaluation of the submerged discharge of dredged material slurry during pipeline dredged operations," Technical Report D-78-44, by JBF Scientific Corp. for U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Nelson, E. E., Vanderheiden, A. L., and Schuldt, D. A. (1994). "Eagle Harbor Superfund Project." *Proceedings of Dredging '94,* American Society of Civil Engineers, New York, 1122-1131.

New York District. (1994). "New York Harbor dredged material management plan: Draft Phase I assessment."

Nichols, M. N., Thompson, G. S., and Faas, R. W. (1978). "A field study of fluid mud dredged material: Its physical nature and dispersal," Technical Report D-78-40, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

O'Connor, J. M., and O'Connor, S. G. (1983). "Evaluation of the 1980 capping operations at the experimental Mud Dump site, New York Bight Apex," Technical Report D-83-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R. (1989). "Capping contaminated dredged material in deep water." *Proceedings of the Specialty Conference Ports 89,* American Society of Civil Engineers, Boston, MA.

__________. (1991a). "Design requirements for capping," Dredging Research Technical Note DRP-5-03, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1991b). "Site selection considerations for capping," Technical Note DRP-5-04, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_________. (1991c). "Equipment and placement techniques for capping," Technical Note DRP-5-05, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R. (1994). "Placement techniques for capping contaminated sediments." *Proceedings of Dredging '94, The Second International Conference and Exhibition on Dredging and Dredged Material Placement.* American Society of Civil Engineers, Lake Buena Vista, FL.

_________. "Diffuser for submerged discharge of dredge material," Environmental Effects of Dredging Programs Technical Note in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R., et al. (1989). "Evaluation of dredged material disposal alternatives for U.S. Navy Homeport at Everett, Washington," Technical Report EL-89-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R., Fredette, T. J., and Randall, R. E. (1992). "Monitoring considerations for capping," Dredging Research Technical Notes, DRP-5-07, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R., Maynord, S., Miller, J., and Reible, D. D. (1996). "Guidance for in-situ subaqueous capping of contaminated sediments," Environmental Protection Agency, EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Parker, J. H., and Valente, R. (1988). "Long-term sand cap stability: New York dredged material disposal site," Contract Report CERC-88-2, performed by Science Applications International Corporation under contract to U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Parry, R. (1994). "Constructing beneficial use dredged material projects." *Proceedings of Dredging '94,* ASCE, New York, 547-554.

Parthenaides, E. (1965). "Erosion and deposition of cohesive soils," *Journal of Hydraulics,* Div. Am Soc. Civ. Eng., 91(HY1), 105-138,

Pearson, T. H. (1987). "Benthic ecology in an accumulating sludge-disposal site." *Oceanic processes and marine pollution; Vol. 1, Biological processes and wastes in the ocean.* J. M. Capuzzo and D. R. Kester, ed., Krieger Publishing, Malabar, FL, 195-200.

Pequegnat, W. E., Gallaway, B. J., and Wright, T. D. (1990). "Revised procedural guide for designation surveys of ocean dredged material disposal sites," Technical Report D-90-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Poindexter, M. E. (1989). "Monitoring dredged material consolidation and settlement at aquatic disposal sites," Environmental Effects of Dredging Program Technical Note EEDP-01-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Poindexter-Rollings, M. E. (1990). "Methodology for analysis of subaqueous sediment mounds," Technical Report D-90-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Prater, M. D., Hardy, T. A., Butler, H. L., and Borgman, L. E. (1985). "Estimating error of coastal stage frequency curves." *Proceedings of the 19th International Conference on Coastal Engineering.* ASCE, New York.

Randall, R. E. (1986). "Synthesis procedures for evaluating site capacity for open-water disposal of dredged material," Miscellaneous Paper in review, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Randall, R. E., Clausner, J. E., and Johnson, B. H. (1994). "Modeling cap placement at New York Mud Dump site." *Proceedings of Dredging '94*, American Society of Civil Engineers, New York, 1295-1304.

Resio, D. T., and Hands, E. B. (1994). "Understanding and interpreting seabed drifter (SBD) data," Technical Report DRP-94-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Richardson, T. W., ed. (1993). "Summary of results assessments for proposed capping project New York Bight mud dump dredged material disposal site," Letter report to New York District by the Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Rhoads, D. C., and Boyer, L. F. (1982). "The effects of marine benthos on physical properties of sediments: A successional perspective." *Animal-sediment relations.* P. L. McCall and M. Tevesz, ed., Phenum Press, New York.

Rhoads, D. C., and Germano, J. D. (1982). "Characterization of organism-sediment relations using sediment profile imaging: An efficient method of remote monitoring of the sea floor (REMOTS©), *Marine Ecology Progress Series* 8, 115-128.

Roberts, P. J. W., Ferrier, A., and Johnson, B. H. (1994). "New techniques for experimental studies of dredged material dispersion." *Proceedings of Dredging '94,* American Society of Civil Engineers, New York, 1192-1200.

Rollings, M. P. (1994). "Geotechnical considerations in dredged material management." *Proceedings, First International Congress on Environmental Geotechnics, International Society for Soil Mechanics and Foundation Engineering and Canadian Geotechnical Society, Edmonton, Alberta.*

Rollings, M. P. (1997). "Dredged material consolidation models: Evaluation and comparison of predictive capabilities," DOER Technical Note in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sanderson, W. H., and McKnight, A. L. (1986). "Survey of equipment and construction techniques for capping dredged material," Miscellaneous Paper D-86-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W. (1989). "Disposal site evaluation for the New York Bight," Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_________. (1991a). "A generalized approach to site classification - Dispersive or non-dispersive," Dredging Research Information Exchange Bulletin, Vol. DRP-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_________. (1991b). "A systematic analysis of disposal site stability." *Proceedings of Coastal Sediments '91.* ASCE, 2012-26.

_________. (1992). "Dispersion analysis of Humboldt Bay, California, interim offshore disposal site," Miscellaneous Paper DRP-92-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

_________. (1994). "Tidal constituent data base - East Coast, Gulf of Mexico, and Caribbean Sea," DRP Technical Note DRP-1-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., Borgman, L. E., and Mark, D. J. (1993). "Applications of large domain hydrodynamic models to generate frequency of occurrence relationships." *Proceedings 3rd International Conference on Estuarine and Coastal Modeling, Chicago, IL.*

Scheffner, N. W., and Borgman, L. E. (1992). "A stochastic time series representation of wave data," *Journal of Waterways, Ports, Coastal, and Ocean Engineering* 118(4).

Scheffner, N. W., Mark, D. J., Blain, C. A., Westerink, J. J., and Luettich, R. A., Jr. (1994). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuaries; Report 5, A tropical storm database for the east and Gulf of Mexico Coasts of the United States," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., and Tallent, J. R. (1994). "Dispersion analysis of the Charleston, South Carolina, ocean dredged material disposal site," Miscellaneous Paper DRP-94-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., Thevenot, M. M., Tallent, J. R., and Mason, J. M. (1995). "LTFATE: A model to investigate the long-term fate and stability of dredged material disposal sites; User's guide," Instruction Report DRP-95-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, P. R., and Palermo, M. R. (1990). "The automated dredging and disposal alternatives management system (ADDAMS)," Technical Note EEDP-06-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Science Applications International Corporation (SAIC). (1990). "Capping survey, New London disposal site, Feb. 3, 1989," DAMOS Contribution Number 71, U.S. Army Corps of Engineers, New England Division.

__________. (1995a). "Sediment capping of subaqueous dredged material disposal mounds: An overview of the New England experience, 1979-1993," DAMOS Contribution #95. SAIC Report No. SAIC-90/7573&c84 prepared for the U.S. Army Engineer Division, New England, Waltham, MA.

__________. (1995b). "Monitoring cruise at the central Long Island Sound disposal site, July 1990," DAMOS Contribution #94, U.S. Army Engineer Division, New England, Waltham, MA.

__________. (1996). "Monitoring cruise at the Portland Disposal Site, July 1992," DAMOS Contribution Number 108, U.S. Army Corps of Engineers, New England Division.

Scott et al. (1987). "Impact of open-water disposal of Black Rock Harbor dredged material on benthic recolonization at the FVP site," Technical Report D-87-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sea Surveyor, Inc. (1994). "Queens Gate dredging geotechnical and chemical investigation," Report prepared for the Port of Long Beach, Benicia, CA.

Shields, F. D., and Montgomery, R. L. (1984). "Fundamentals of capping contaminated dredged material." *Proceedings of the Conference Dredging '84,* American Society of Civil Engineers, 1, 446-460.

Silva, A. J., Brandes, H. G. Uchytil, C. J., Fredette, T. J., and Carey, D. (1994). "Geotechnical analysis of capped dredged material mounds." *Proceedings of Dredging '94,* ASCE, New York, 410-419.

Stark, T. D. (1991). "Program documentation user's guide: PSDDF89, primary consolidation and desiccation of dredged fill," Instruction Report D-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Stark, T. D. "Program documentation and user's guide: PSDDF, secondary consolidation and desiccation of dredged fill," Report in preparation, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sturgis, T., and Gunnison, D. (1988). "A procedure for determining cap thickness for capping subaqueous dredged material deposits," Technical Note EEDP-01-09, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sumeri, A. (1984). "Capped in-water disposal of contaminated dredged material." *Proceedings of the Conference Dredging '84,* American Society of Civil Engineers, 2, 644-653.

_________. (1989). "Confined aquatic disposal and capping of contaminated bottom sediments in Puget Sound." *Proceedings of the WODCON XII, Dredging: Technology, Environmental, Mining, World Dredging Congress, Orlando, FL, 2-5 May 1989.*

_________. (1995). "Dredged material is not a spoil: A status on the use of dredged material in Puget Sound to isolate contaminated sediments." *Proceedings of the 14th World Dredging Congress, World Organization of Dredging Associations, Amsterdam, The Netherlands.*

Sumeri, A., Fredette, T. J., Kullberg, P. G., Germano, J. D., Carey, D. A. (1991). "Sediment chemistry profiles of capped in-situ dredged sediment deposits: Results from three U.S. Army Corps of Engineers offices." *WEDA XII Western Dredging Association and Twenty-fourth Annual Dredging Seminar.*

Sumeri, A., Fredette, T. J., Kullberg, P. G., Germano, J. D., Carey, D. A., and Pechko, P. (1994). "Sediment chemistry profiles of capped dredged material deposits taken 3 to 11 years after capping," Dredging Research Technical Note DRP-5-09, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Sustar, J. F., and Ecker, R. M. (1972). "Monitoring dredge disposal on San Francisco Bay," OTC Paper #1660, Offshore Technology Conference, May 1972, II405-II412.

Suszowski, D. J. (1983). "Studies on capping of contaminated dredged material by the New York District, Corps of Engineers." *Management of Bottom Sediments Containing Toxic Substances: Proceedings of the 7th US/Japan Experts Meeting.* Prepared for the U.S. Army Corps of Engineers Water Resources Support Center by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 134-145.

Swart, D. H. (1976). "Predictive equations regarding coastal transports." *Proceedings of the 15th Coastal Engineering Conference.* ASCE, 1113-32.

Tavolaro, J. F. (1984). "A sediment budget study of clamshell dredging and ocean disposal activities in the New York Bight," *Environmental Geology and Water Science* 6(3), 133-140.

Teeter, A. M. (1988). "New Bedford Harbor Superfund project, Acushnet River estuary engineering feasibility study of dredging and dredged material disposal alternatives; Report 2, Sediment and contaminant hydraulic transport investigations," Technical Report EL-88-15, Report 2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Teeter, A. M., and Pankow, W. (1989). "Schematic numerical modeling of harbor deepening effects on sedimentation, Charleston, SC," Miscellaneous Paper HL-89-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thoma et al. (1993). "Efficiency of capping contaminated sediments in situ. 2. Mathematics of diffusion - absorption in the capping layer," *Environmental Science and Technology* 27(12).

Togashi, H. (1983). "Sand overlaying for sea bottom sediment improvement by conveyor barge." *Management of bottom sediments containing toxic substances: Proceedings of the 7th US/Japan Experts meeting.* Prepared for the U.S. Army Corps of Engineers Waters Resources Support Center by the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 59-78.

Trawle, M. J., and Johnson, B. H. (1986). "Alcatraz disposal site investigation," Miscellaneous Paper HL-86-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Truitt, C. L. (1986a). "Fate of dredged material during open water disposal," Environmental Effects of Dredging Programs Technical Note EEDP-01-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1986b). The Duwamish Waterway capping demonstration project: Engineering analysis and results of physical monitoring," Technical Report D-86-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Truitt, C. L. (1987a). "Engineering considerations for capping subaqueous dredged material deposits—Background and preliminary planning," Technical Note EEDP-01-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1987b). "Engineering considerations for capping subaqueous dredged material deposits—Design concepts and placement techniques," Environmental Effects of Dredging Technical Note EEDP-01-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Truitt, C. L., Clausner, J. E., and McLellan, T. N. (1989). "Considerations for capping subaqueous dredged material deposits," *Journal of Waterway, Port, Coastal, and Ocean Engineering* 115(6).

U.S. Army Corps of Engineers (USACE). 1970. "Laboratory soils testing," Engineer Manual 1110-2-1906, Washington, DC.

__________. (1987). "Confined disposal of dredged material," Engineer Manual 1110-2-5027, Washington, DC.

__________. (1990). "New Bedford Harbor Superfund pilot study, evaluation of dredging and dredged material disposal," U.S. Army Engineer Division, New England, Waltham, MA.

__________. (1991). "Hydrographic surveying," Engineer Manual 1110-2-1003, Washington, DC.

U.S. Army Corps of Engineers/Environmental Protection Agency (USACE/EPA). (1984). "General approach to designation studies of ocean dredged material disposal sites," U.S. Army Engineer Water Resources Support Center, Fort Belvoir, VA.

__________. (1992). "Evaluating environmental effects of dredged material management alternatives - A technical framework," EPA842-B-92-008, Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, DC.

U.S. Department of Transportation. (1984). "Code of Federal regulations," Office of the Federal Register, National Archives and Records Services, General Services Administration, Washington, DC.

Van De Graff, J., and Van Overeem, J. (1979). "Evaluation of sediment transport formulae in coastal engineering practice," *Coast. Engrg.*, Amsterdam, 3, 1-32.

Van Rijn, L. C. (1989). "Handbook of sediment transport by currents and waves," Report H461, Delft Hydraulics Laboratory, Delft, The Netherlands.

Van Rijn, L. C. (1993). *Principles of sediment transport in rivers, estuaries and coastal seas.* Aqua Publications, Amsterdam, The Netherlands.

Van Wijck, J., and Smits, J. (1991). "Underwater disposal of dredged material: A viable solution for the maintenance of dredging works in the River Scheldt," Bulletin No. 73, Permanent International Association of Navigation Congresses.

Wang, X. Q., Thibodeaux, L. J., Valsaraj, K. T., and Reible, D. D. (1991). "Efficiency of capping contaminated bed sediments in situ. 1. Laboratory-scale experiments on diffusion-adsorption in the capping layer," *Environmental Science and Technology* 25(9).

Westerink, J. J., Bain, C. C., Luettich, R. A., Jr., and Scheffner, N. W. (1994). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuarines; Report 2, User's manual for ADCIRC-2DDI," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Westerink, J. J., Luettich, R. A., and Scheffner, N. W. (1993). "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts and estuaries; Report 3, Development of a tidal constituent data base for the western North Atlantic and Gulf of Mexico," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

White, P. (1972). "Sediment transport in channels: A general function," Report Int 104, Hydraulics Research Station, Wallingford, England.

Wiley, M. B. (1994). "DAMOS capping model verification," DAMOS Contribution #89, Contract report written by Science Applications International Corporation for U.S. Army Engineer District, New England, Waltham, MA.

__________. (1995). "Deep water capping," DAMOS Contribution #98, Contract report written by Science Applications International Corporation for U.S. Army Engineer District, New England, Waltham, MA.

Williams, D. T. (1983). "Tampa Bay dredged material disposal site analysis," Miscellaneous Paper HL-83-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Wong, K. S., and Duncan, J. M. (1984). "CONSOL: A computer program for 1-D consolidation analysis of layered soil masses," Report No. UCB/GT/84-06, Department of Civil Engineering, University of California, Berkeley, CA.

Zeller, R. W., and Wastler, T. A. (1986). "Tiered ocean disposal monitoring will minimize data requirements," *Oceans '86*, Marine Technology Society, Washington, DC, 3, 1004-1009.

Zeman, A. J. (1993). "Subaqueous capping of very soft contaminated sediments." *Fourth Canadian Conference on Marine Geotechnical Engineering, St. John's, Newfoundland.*

Appendix A
Glossary of Terms

Aquatic environment - The geochemical environment in which dredged material is submerged underwater and remains water saturated after disposal is completed.

Aquatic ecosystem - Bodies of water, including wetlands, that serve as the habitat for interrelated and interacting communities and populations of plants and animals.

Baseline - Belt of the seas measured from the line of ordinary low water along that portion of the coast that is in direct contact with the open sea and the line marking the seaward limit of inland waters.

Bioaccumulation - The accumulation of contaminants in the tissues of organisms through any route, including respiration, ingestion, or direct contact with contaminated water, sediment, or dredged material.

Capping - The controlled, accurate placement of contaminated material at an open-water site, followed by a covering or cap of clean isolating material.

Coastal zone - Includes coastal waters and the adjacent shorelands designated by a State as being included within its approved coastal zone management program. The coastal zone may include open waters, estuaries, bays, inlets, lagoons, marshes, swamps, mangroves, beaches, dunes, bluffs, and coastal uplands. Coastal-zone uses can include housing, recreation, wildlife habitat, resource extraction, fishing, aquaculture, transportation, energy generation, commercial development, and waste disposal.

Confined disposal - Placement of dredged material within diked nearshore or upland confined disposal facilities (CDFs) that enclose the disposal area above any adjacent water surface, isolating the dredged material from adjacent waters during placement. Confined disposal does not refer to subaqueous capping or contained aquatic disposal.

Confined disposal facility (CDF) - An engineered structure for containment of dredged material consisting of dikes or other structures that enclose a disposal area above any adjacent water surface, isolating the dredged material from adjacent waters during placement. Other terms used for CDFs that appear in the literature include “confined disposal area,” “confined disposal site,” and “dredged material containment area.”

Contained aquatic disposal (CAD) - A form of capping that includes the added provision of some form of lateral containment (for example, placement of the contaminated and capping materials in bottom depressions or behind subaqueous berms) to minimize spread of the materials on the bottom.

Contaminant - A chemical or biological substance in a form that can be incorporated into or onto, or be ingested by, and that harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.

Contaminated sediment or contaminated dredged material - Contaminated sediments or contaminated dredged materials are defined as those that contain sufficient contaminants to warrant isolation from the benthic environment.

Disposal site or area - A precise geographical area within which disposal of dredged material occurs.

Dredged material - Material excavated from waters of the United States or ocean waters. The term dredged material refers to material that has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

Dredged material discharge - The term dredged material discharge as used in this document means any addition of dredged material into waters of the United States or ocean waters. The term includes open-water discharges; discharges resulting from unconfined disposal operations (such as beach nourishment or other beneficial uses); discharges from confined disposal facilities that enter waters of the United States (such as effluent, surface runoff, or leachate); and overflow from dredge hoppers, scows, or other transport vessels.

Effluent - Water that is discharged from a confined disposal facility during and as a result of the filling or placement of dredge material.

Habitat - The specific area or environment in which a particular type of plant or animal lives. An organism's habitat provides all of the basic requirements for the maintenance of life. Typical coastal habitats include beaches, marshes, rocky shores, bottom sediments, mudflats, and the water itself.

Leachate - Water or any other liquid that may contain dissolved (leached) soluble materials, such as organic salts and mineral salts, derived from a solid material. For example, rainwater that percolates through a confined disposal facility and picks up dissolved contaminants is considered leachate.

Level bottom capping (LBC) - A form of capping in which the contaminated material is placed on the bottom in a mounded configuration.

Open-water disposal - Placement of dredged material in rivers, lakes, estuaries, or oceans via pipeline or surface release from hopper dredges or barges.

Sediment - Material, such as sand, silt, or clay, suspended in or settled on the bottom of a water body. Sediment input to a body of water comes from natural sources, such as erosion of soils and weathering of rock, or as the result of anthropogenic activities, such as forest or agricultural practices, or construction activities. The term dredged material refers to material that has been dredged from a water body, while the term sediment refers to material in a water body prior to the dredging process.

Suspended solids - Organic or inorganic particles that are suspended in water. The term includes sand, silt, and clay particles as well as other solids, such as biological material, suspended in the water column.

Territorial sea - The strip of water immediately adjacent to the coast of a nation measured from the baseline as determined in accordance with the Convention on the territorial sea and the contiguous zone (15 UST 1606; TIAS 5639) and extending a distance of 3 nmi from the baseline.

Toxicity - Level of mortality or other end point demonstrated by a group of organisms that have been affected by the properties of a substance, such as contaminated water, sediment, or dredged material.

Toxic pollutant - Pollutants, or combinations of pollutants, including disease-causing agents, that after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator of the U.S. Environmental Protection Agency, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations in such organisms or their offspring.

Turbidity - An optical measure of the amount of material suspended in the water. Increasing the turbidity of the water decreases the amount of light that penetrates the water column. High levels of turbidity can be harmful to aquatic life.

Appendix B Model for Chemical Containment by a Cap

by Dr. Danny D. Reible, Louisiana State University[1]

Introduction

This appendix describes a model for evaluation of chemical flux through a cap. Through use of this model, the effectiveness of chemical containment of a cap can be assessed. This model should be applied once remediation objectives are determined, a specific capping material has been selected and characterized, and a minimum cap thickness has been determined based on components for isolation, bioturbation, and consolidation. If the objective of the cap is attainment of a given contaminant flux, the model can be used to estimate the required cap thickness.

This model assumes that the cap is armored such that erosion of the cap does not provide the primary means of contaminant migration. Instead, the contaminants contained within the pore water of the sediment are available to migrate into the cap and subsequently into the overlying water. The pore water concentration, C_{pw}, is always assumed in a state of local equilibrium that is related to the sediment contaminant loading, ω_{sed}, milligrams contaminant per kilogram dry sediment, through an observed partition coefficient, K_d^{obs}, as

$$\omega_{sed} = K_d^{obs} \, C_{pw} \tag{B1}$$

Thus the initial pore water concentration in the sediment, C_0, is given by

$$C_0 = C_{pw} = \frac{\omega_{sed}}{K_d^{obs}} \tag{B2}$$

[1] This appendix is identical to Appendix B of the report entitled "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments" (Palermo et al. 1996).

The difference between this concentration and the concentration in the overlying water defines the driving force for contaminant release to that water. In addition, it is normally this concentration that defines the sediment quality criteria because it is this concentration that defines the contaminant levels to which benthic organisms are exposed. Benthic organisms are generally the most sensitive organisms in the sediment environment, and any contaminants that they may accumulate may be transferred higher in the food chain. Isolation of contaminants from these benthic organisms is one of the most important motivations for placement of a cap. The objective is to place a cap of sufficient thickness to realize this isolation.

Relationship Between Sediment and Pore Water Concentrations

Equation B1 defines an observed partition coefficient between the sediment and the adjacent pore water. Use of a measured partition coefficient does not require linearity or reversibility of the sorption isotherm, nor does it require specification of the form of the contaminant in the pore water (e.g., dissolved or bound to particles). For a compound that sorbs to soil with an observed partition coefficient of K_d^{obs} (liters/kilogram), the ratio of the total concentration in the soil to that in the pore water is given by the retardation factor, R_f,

$$R_f = \epsilon + \rho_b K_d^{obs} \tag{B3}$$

The retardation factor is so named because contaminant migration in the pore water is slowed by the sorption onto the immobile sediment phase.

The value of K_d^{obs} for either the sediment or the cap should be determined directly by evaluating the ratio of sediment or cap loading to pore water concentration. In the absence of direct measurement of pore water concentrations, however, the value of K_d^{obs} can be estimated for hydrophobic organic compounds that tend to sorb reversibly and nonselectively upon organic matter in the sediment or pore water. For these compounds, the observed partition coefficient can be normalized by the amount of organic carbon present in the sediment or pore water to define a "universal" partition coefficient, K_{oc}, that should be constant for a particular compound. Given such a contaminant at concentration ω_{sed} in the sediment, the concentration dissolved in the pore water is given by

$$C_{diss} = \frac{\omega_{sed}}{K_{oc}\, f_{oc}} \tag{B4}$$

Here f_{oc} is the fraction organic carbon in the sediment in mass organic carbon per mass dry sediment. The same relation applies to the capping material if the concentrations and properties are characteristic of the cap rather than the underlying sediment.

In addition, the water in the pores contains contaminant sorbed to organic carbon (dissolved or particulate organic carbon present at concentration ρ_{oc}, e.g., in milligrams/liter). To a first approximation, the partitioning to this suspended organic matter is also governed by the organic carbon based partition coefficient, K_{oc}, and thus the total pore water concentration for that compound is given by

$$\begin{aligned} C_{pw} &= C_{diss}\,(1 + \rho_{oc}K_{oc}) \\ &= \frac{\omega_{sed}}{K_{oc}f_{oc}}\,(1 + \rho_{oc}K_{oc}) \end{aligned} \tag{B5}$$

Note, however, that the truly dissolved concentration can never exceed the solubility of the contaminant in water, C_w^*, and therefore the pore water concentration is bounded by

$$C_{pw} \leq C_w^*\,(1 + \rho_{oc}K_{oc}) \tag{B6}$$

As a result of this limit, there exists a critical sediment loading, ω_{crit}, above which the contaminant concentration in the pore water is independent of the sediment loading. The dissolved concentration is always given by the water solubility under these conditions, and the total pore water concentration is given by the equality in Equation B5.

$$\begin{aligned} &\omega_{crit} = K_{oc}\,f_{oc}\,C_W^* \\ &For\ \omega_{sed} > \omega_{crit} \qquad C_{pw} = C_w^*\,(1 + \rho_{oc}K_{oc}) \end{aligned} \tag{B7}$$

Thus the observed sediment-water partition coefficient for a hydrophobic organic compound is given by

$$\begin{aligned} K_d^{obs} &= \frac{\omega_{sed}}{C_0} && \textit{if measurements are available} \\ &= \frac{K_{oc}\,f_{oc}}{(1 + \rho_{oc}K_{oc})} && \textit{estimate if } \omega_{sed} \leq \omega_{crit} \\ &= \frac{\omega_{sed}}{C_w^*\,(1 + \rho_{oc}K_{oc})} && \textit{estimate if } \omega_{sed} \geq \omega_{crit} \end{aligned} \tag{B8}$$

Effective Thickness of a Cap

The effective thickness, L_{eff}, of a cap is reduced by consolidation of the cap, ΔL_{cap}, consolidation in the underlying sediment, ΔL_{sed}, and by bioturbation over a depth, L_{bio}. Bioturbation, the normal life-cycle activities of benthic organisms, leads to mixing and redistribution of contaminants and sediments in the upper layer. The chemical migration rate within the bioturbated zone is typically much faster than in other portions of a cap. In addition, consolidation typically occurs on a time scale that is rapid compared with the design lifetime of a cap. Consolidation of the cap directly reduces the thickness of a cap and the separation between contaminants and the overlying water or benthic organisms while consolidation of the underlying sediment results in the expression of potentially contaminated pore water. Using $\Delta L_{sed,A}$ to represent the thickness of a cap compromised by a contaminant A during consolidation of the underlying sediment, the effective cap thickness remaining for chemical containment is given by

$$L_{eff} = L_0 - L_{bio} - \Delta L_{cap} - \Delta L_{sed,A} \tag{B9}$$

where L_0 is the initial thickness of the cap immediately after placement.

The depth of bioturbation can be assessed through an evaluation of the capping material and recognition of the type, size, and density of organisms expected to populate this material. Because of the uncertainty in this evaluation, the bioturbed zone is generally chosen conservatively, that is, considered to be as large as the deepest penetrating organism likely to be present. Due to the action of bioturbating organisms, this layer is also generally assumed to pose no resistance to mass transfer between the contaminated sediment layer and the overlying water.

The consolidation of a cap can be estimated through use of standard consolidation models; for example, the Corps of Engineers' Primary Consolidation and Dessication of Dredged Fill (PCDDF) model (Stark 1991). Note, however, that in addition to reducing the thickness of a cap, consolidation serves to reduce both the porosity and permeability of a cap causing reductions in chemical migration rates by both advection and diffusion.

The consolidation of the underlying contaminated sediment can also be estimated through consolidation models. These models do not predict the resulting movement of the chemical, however, and a model is described below. The effective cap thickness estimated by Equation B9 is subject to chemical migration by advection and diffusion processes. The long-term chemical flux to the water via these processes can be modeled.

The complete model of chemical movement through the cap must be composed of two components:

- An advective component considering the short-term consolidation of the contaminated sediment underlying the cap.

- A diffusive or advective-dispersive component considering contaminant movement as a result of pore water movement after the cap has fully consolidated.

The first component is operative for all caps but only for a short period of time. The first component allows determination of the effective cap thickness through Equation B9. The resulting effective cap thickness can then be used to assess long-term losses through the cap by advective and/or diffusive processes.

For simplicity and conservatism, the sediment underlying a cap may be assumed to remain uniformly contaminated at the concentration levels prior to cap placement. In reality, migration of contaminants into the cap reduce the sediment concentration and the long-term flux to the overlying water. The consideration of this situation, however, complicates the analysis and the models used to describe contaminant flux. Analytical models are presented for the case of constant concentration in the underlying sediment. The results of a numerical model that incorporates the depletion of the underlying sediment concentrations are referenced for comparison.

Model for Short-Term Cap Losses—Advection During Cap Consolidation

After placement of capping materials, consolidation of both the cap and the underlying sediment occurs. Consolidation of the cap results in no contaminant release since the cap is initially free of contamination. Furthermore, the consolidation of the cap serves to reduce the permeability and, to a lesser extent, the porosity of a cap. Both serve to reduce contaminant migration through the cap by both diffusive and advective processes.

Consolidation of the underlying sediment due to the weight of the capping material, however, tends to result in expression of pore water and the contaminants associated with that water. The ultimate amount of consolidation may be estimated using standard methods; for example, the previously referenced PCD model. The consolidation of the underlying sediment is likely to occur over a short period (e.g., months) compared with the lifetime of the cap. It is appropriate, therefore, to assume that the consolidation occurs essentially instantaneously and estimate the resulting contaminant migration solely on the basis of the total depth of consolidation and the pore water expressed. For a nonsorbing contaminant, the penetration depth of the chemical is identical to that of the expressed pore water. For a sorbing contaminant, the penetration depth is less as a result of the accumulation of chemical on the sediment.

Mathematically, if ΔL_{sed} represents the ultimate depth of consolidation of the underlying contaminated sediment due to cap placement, the depth of cap affected by this pore water (or nonsorbing contaminant), $\Delta L_{sed,pw}$, is given by

$$\Delta L_{sed,pw} \approx \frac{\Delta L_{sed}}{\epsilon} \tag{B10}$$

where ϵ is the porosity of the cap materials. The division by the cap porosity recognizes that the expressed pore water moves only through the void volume formed by the spaces between the grains of the capping material. Equation B10 assumes that the capping material is spatially uniform and that pore water is not preferentially forced through a small fraction of the total cap area.

Although the depth of cap affected by the expressed pore water is given by Equation B10, the migration distance of a sorbing contaminant is less due to accumulation in the cap. The quantity of contaminant that can be rapidly adsorbed by the cap material, ω_{cap} (milligrams/kilogram dry cap material), is generally assumed to be proportional to the concentration in the pore water (C_{pw}, milligrams/liter),

$$\omega_{cap} = K_{d,cap}^{obs} C_{pw} \tag{B11}$$

where the constant of proportionality is the observed sediment-water partition coefficient in the cap. Note that the observed partition coefficient is measured during sorption onto clean cap material since this is the conditions that occur after placement of a clean cap onto contaminated sediment. The maximum quantity that can be sorbed by the cap is given by the product of the observed partition coefficient and the initial pore water concentration of the contaminant in the underlying sediment, C_0.

As a result of sorption onto the immobile sediment, the distance that the contaminant migrates in the cap during consolidation of the underlying sediment by a distance ΔL_{sed} is given by

$$\Delta L_{sed,A} \approx \frac{\Delta L_{sed}}{R_f} \approx \frac{\Delta L_{sed}}{\epsilon + \rho_b K_{d,cap}^{obs}} \tag{B12}$$

This distance must be subtracted from the actual cap thickness to estimate effective cap thickness. Note that this model suggests that the more sorbing a cap, the less important is consolidation in the underlying sediment. Sorption for hydrophobic organics such as polyaromatic hydrocarbons and polychlorinated biphenyls is strongly correlated with the organic carbon content of the sediments. $K_{d,cap}^{obs}$ is typically of the order of hundreds or thousands for these compounds; if a cap contains 0.5-percent organic carbon or more, the loss of effective cap thickness due to penetration of the contaminant is a small fraction of the sediment consolidation distance. Metals also tend to be strongly associated with the solid fraction, again reducing the migration of contaminant out of the sediment as a result of consolidation.

Estimation of Long-Term Losses

Mechanisms and driving force

The effective cap thickness defined by Equation B9 is subject to advection or diffusion or a combination of both throughout the lifetime of the cap. The long-term contaminant release or loss requires estimation of the contaminant flux by these processes. Diffusion is always present, while advection only occurs if there exists a significant hydraulic gradient in the underlying sediments. The relative magnitude of diffusion to advection in the cap of effective thickness, L_{eff}, can be estimated by the Peclet number.

$$Pe = \frac{U_{pw} L_{eff}}{D_{eff}} \tag{B13}$$

where

U_{pw} = advective velocity (Darcy or superficial velocity) in the sediment

D_{eff} = effective diffusion/dispersion coefficient

If the magnitude or absolute value of the Peclet number is much greater than one, advection dominates over diffusion/dispersion, while the opposite is true for absolute values much less than one. Advection directed out of the cap will speed contaminant release, while advection directed into the sediment will effectively lengthen the cap.

The average groundwater flow velocity is estimated from the sediment conductivity (K, centimeters/second) or permeability (K, square centimeters) and the local hydraulic gradient.

$$U_{pw} = -K \frac{\partial h}{\partial z} = -\frac{k \rho g}{\mu} \frac{\partial h}{\partial z} \tag{B14}$$

where

ρ = density of water (~1 g/cm^3)

g = acceleration of gravity (980 cm·sec^{-2})

μ = viscosity of water (~0.01 g·cm^{-1}·sec^{-1})

$\frac{\partial h}{\partial z}$ = local gradient in hydraulic head with distance into sediment

The minus sign recognizes that the groundwater flow is to regions of lesser hydraulic head. The average groundwater flow is the volumetric seepage rate (volume/time) divided by the sediment-water interfacial area. Thus, lakes with large sediment-water interfacial areas tend to exhibit less potential for advective influences than small streams. Estuarine systems subject to significant tidal fluctuations may also exhibit significant advective transport. Losing streams, in which the advective transport is into the sediment, may exhibit advection but may not be important since the direction of transport is away from the sediment-water interface and long travel distances may be required to impact groundwater of significance. Similarly, advection may be less important in wetlands subject to frequent cycles of flooding followed by infiltration due to the downward vector of advection. The presence of a cap will tend to reduce any advective transport by preferentially channeling flow to uncapped sediment. The permeability of the cap materials may also be selected or modified to minimize advection.

The effect of advection includes both transport by the pore water flow and that by diffusion and dispersion. Dispersion is the additional "diffusion-like" mixing relative to the average pore water velocity that occurs as a result of heterogeneities in the sediments. Thus the description of advection is more complicated than diffusion, and the model for long-term cap losses will be subdivided into models appropriate only when diffusion dominates and models when both advection and diffusion/dispersion are important.

Both processes are operative only for that portion of the contaminant present in the pore water as measured by the concentration C_0. This might include contaminant dissolved in the pore water as well as contaminant sorbed to fine particulate or colloidal matter suspended in the pore water. The best measure of this concentration is through direct pore water measurements. In the absence of pore water measurements, however, linear reversible sorption can be assumed and Equations B5 or B7 apply,

$$C_0 = \begin{cases} \dfrac{\omega_{sed}}{K_{oc}\, f_{oc}} \left(1 + \rho_{oc} K_{oc}\right) & \textit{if } \omega_{sed} \leq \omega_{crit} \\ C_w^{*} \left(1 + \rho_{oc} K_{oc}\right) & \textit{if } \omega_{sed} \geq \omega_{crit} \end{cases} \tag{B15}$$

where

C_w^{*} = equilibrium solubility of chemical in water

ω_{sed} = sediment loading (milligrams chemical/kilogram (dry) sediment)

Equation B15 indicates that the pore water concentration increases linearly with the sediment loading until the water is saturated, that is, until the solubility limit is reached. This limit is the normal water solubility adjusted for the sorption onto organic matter in the pore water.

Degradation of contaminants over the long time of expected confinement is a significant benefit of capping that should be incorporated into the design of a cap. Polyaromatic hydrocarbons as well as chlorinated aliphatic and aromatic compounds all exhibit slow but finite rates of degradation or transformation in the generally anaerobic environment beneath a cap. If simple first order degradation kinetics is employed, the sediment loading changes with time according to

$$\omega_{sed} = \omega_{sed}^{0}\, e^{-k_r t} \tag{B16}$$

where

ω_{sed}^{0} = sediment loading at time of cap placement

k_r = exponential time constant given by $0.693/t_{0.5}$

$t_{0.5}$ = chemical half life in sediment

In the absence of dependable data on rates of degradation or transformation, the conservative assumption of no contaminant depletion is generally assumed.

In the subsequent sections, the movement of contaminants from the sediments through the cap by both diffusion and advection are evaluated. The focus is on the development of simple analytical models that can be expressed in algebraic form. This generally limits the conditions evaluated to uniform sediment and cap physical and chemical properties and an initial contaminant concentration that is both uniform in the sediment and constant. Depletion of contaminant in the sediment by either chemical degradation or mass depletion as a result of the release of material through the cap is not considered. The models are thus conservative indicators of contaminant release from the sediment (that is, they overestimate the concentration in the sediment or the flux of contaminant to the overlying water column).

Diffusion

Diffusion is a process that occurs at significant rates only within the pores of the sediment and is driven by the difference in pore water concentration between the sediment and the cap. The initial concentration of the contaminant in the cap pore water is generally zero, while the concentration in the sediment is given by Equation B15. Even without degradation, however, migration of contaminants into the cap will deplete the underlying sediments as a result of the loss of mass by diffusion through the cap.

Thoma et al. (1993) developed a model of diffusion through a cap that explicitly accounts for depletion in the underlying sediment. A simpler model of diffusion through the cap, however, assumes that the contaminant concentration in the underlying sediment is essentially constant. This would be most appropriate if the contaminant concentration in the sediment far exceeds the critical concentration defined by Equation B7. Because the assumption of no depletion in the underlying sediment overpredicts the driving force for diffusion, and therefore the flux through the cap, it represents a conservative assumption of the effectiveness of the cap. It will therefore be employed in the description that follows.

One should first estimate the steady long-term flux of contaminants through the cap via diffusion. This is the maximum flux that can occur through the cap by the diffusive mechanism.

Maximum flux estimation (steady state)

If diffusion is the only operative transport process through the cap, the pseudo steady-state flux through the cap (assuming constant contaminated sediment pore water concentration and no sorption effects in the cap layer) is given by

$$F = \frac{D_{eff}}{L_{eff}} (C_0 - C_w) \approx K_{cap}(C_0 - C_w) \quad \text{(B17)}$$

where

F = chemical flux, ng·cm^{-2}·sec^{-1}

D_{eff} = effective binary diffusivity of chemical in cap, cm^2/sec

ε = sediment porosity (void volume/total volume)

L_{eff} = effective cap thickness

C_0 = pore water concentration in sediment beneath cap including dissolved and sorbed to colloidal species, ng/cm^3

C_w = total contaminant concentration in overlying water, ng/cm^3

K_{cap} = effective mass transfer coefficient through cap, cm/sec

The effective diffusion coefficient is generally estimated by the equation of Millington and Quirk (1961)

$$D_{eff} = D_w\, \epsilon^{4/3} \quad \text{(B18)}$$

where

D_w = molecular diffusivity of compound in water

ϵ = void fraction or porosity of sediment

Millington and Quirk suggest the factor $\varepsilon^{4/3}$ to correct for the reduced area and tortuous path of diffusion in porous media.

In general, the chemical flux is influenced by bioturbation and a variety of water column processes. Figure B1 shows the definitions of fluxes in a capped system at this pseudo steady state. The flux of chemical through each layer is equal to the sum of the rate of evaporation and flushing. Mathematically, in terms of mass transfer coefficients, one has:

$$\begin{aligned} M &= K_{ov}A_s\, C_0 = K_{cap}A_s(C_0 - C_{bio}) = K_{bio}A_s(C_{bio} - C_{sw}) \\ &= K_{bl}A_s\,(C_{sw} - C_w) = (K_eA_e + Q)C_w \end{aligned} \quad \text{(B19)}$$

where

M = rate of chemical loss from system, mg/day = $F*A_s$

K_{ov} = overall mass transfer coefficient, cm/day

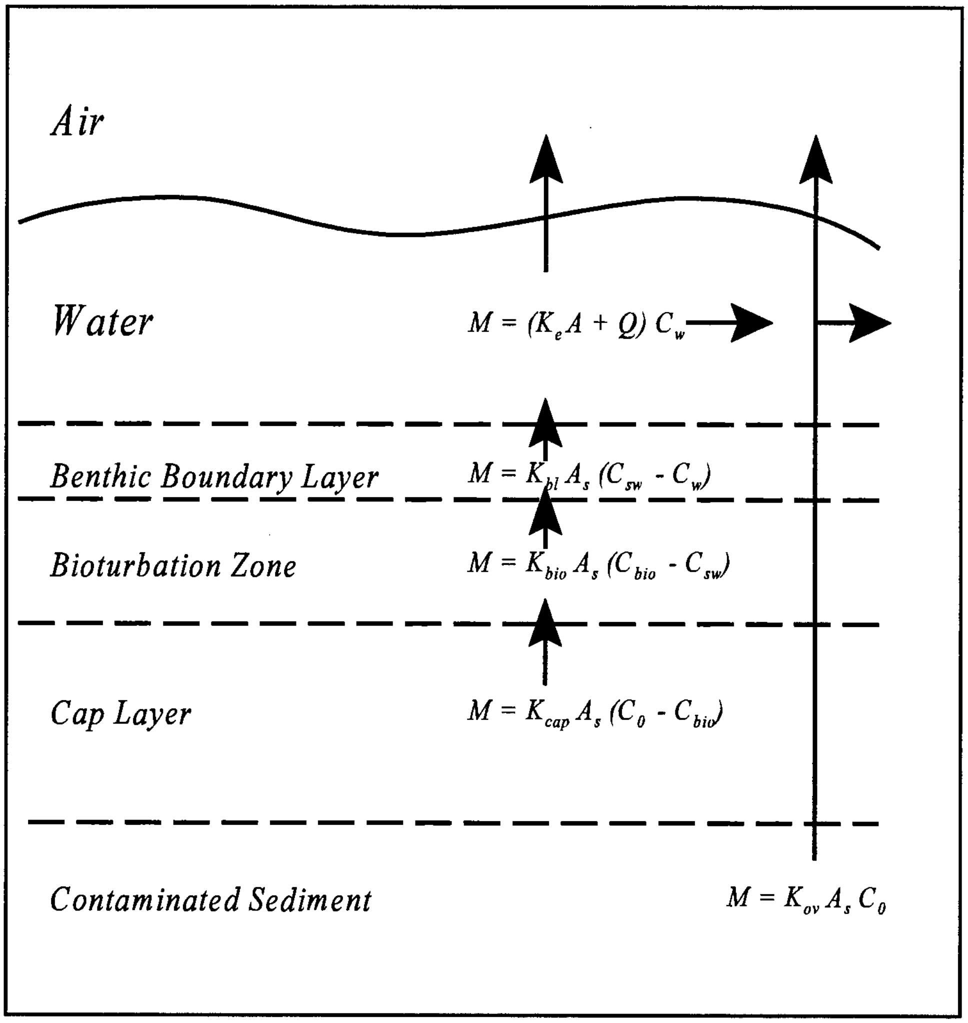


Figure B1. Idealized multilayer contaminant release rates showing individual and overall mass transfer coefficient definitions

A_s = contaminated sediment area, m^2

A_e = evaporative surface area, m^2

C_0 = pore water concentration within contaminated sediment including dissolved and any sorbed to colloidal material

K_{cap} = cap mass transfer coefficient = $D_w\, \epsilon^{4/3}/L_{eff}$, cm/day

C_{bio} = pore water concentration at top of cap, ng/cm^3

K_{bio} = bioturbation mass transfer coefficient = $\dfrac{\eta D_{bio}\, R_f}{L_{bio}}$, cm/day

C_{sw} = pore water concentration at sediment water interface, ng/cm^3

η = desorption efficiency of contaminant from sediment particles

D_{bio} = biodiffusion coefficient, cm^2/day

R_f = retardation factor = $\epsilon + \rho_B K_d^{obs}$

L_{bio} = depth of bioturbation, cm

K_{bl} = benthic boundary layer mass transfer coefficient, cm/day

K_e = evaporation mass transfer coefficient, cm/day

D_e = effective diffusivity = $D_w \cdot \epsilon^{4/3}$, cm^3/day

Q = basin flushing rate, cm^3/day

C_w = chemical concentration in the overlying water, ng/cm^3

K_d = sediment water partition coefficient for chemical = $K_{oc} foc$, cm^3/g

K_{oc} = organic carbon-water coefficient for chemical, cm^3/g

f_{oc} = sediment fractional organic carbon content

ρ_B = sediment bulk density

The overall mass transfer coefficient, K_{ov}, can be obtained from the following

$$\frac{1}{K_{ov}} = \frac{1}{K_{cap}} + \frac{1}{K_{bio}} + \frac{1}{K_{bl}} + \frac{A_s}{K_e A_e + Q} \tag{B20}$$

An analysis of this relationship for reasonable values of L_{eff} suggests that $1/K_{ov} \cong 1/K_{cap}$; therefore, the cap controls the flux to the overlying water, and Equation B17 is valid.

This flux can be used to estimate concentrations in the water (C_w) or at the sediment water interface (C_{sw}) or multiplied by the capped area to determine total release rate. For hydrophobic organics, the concentration in the overlying water at steady state is defined by a balance between the flux through the cap, the rate of evaporation to the air, and the rate of flushing of the water column. For metals and elemental species not associated with volatile compounds, the flux through the cap is balanced only with the flushing of the water column. The overlying water concentration of the contaminant is given by:

$$C_w = \left(\frac{K_{ov} A_s}{K_e A_\ell + Q} \right) C_0 \tag{B21}$$

The concentration at the cap-water interface, which would be indicative of the level of exposure of bottom-surface dwelling organisms, is defined by the balance of the flux through the cap with the flux through the benthic boundary layer. The contaminant concentration at the cap-water interface is:

$$C_{cw} = \frac{K_{ov} C_0}{K_{bl}} + C_w \tag{B22}$$

Either of these concentrations or the estimated fluxes may be compared with applicable criteria for the chemical in question to determine if a specified cap thickness is adequate.

Transient diffusion—breakthrough time estimation

The simple steady-state analysis presented above is not capable of predicting the time required for the contaminant(s) to migrate through the cap layer. Until sorption and migration in the cap is complete, the flux to the water column will be less than predicted by Equation B17. Addressing this problem requires incorporation of time explicitly in the differential mass balance. The following partial differential equation represents a differential mass balance on the contaminant in the pore water of the cap as it diffuses from the contaminated sediment below.

$$R_f \frac{\partial C_{pw}}{\partial t} = D_w \varepsilon^{4/3} \frac{\partial^2 C_{pw}}{\partial z^2} \tag{B23}$$

The conditions of a constant concentration at the sediment-cap interface are applied as specified by Equation B15 and the concentration of the overlying water at the height L_{eff} in the cap. Carslaw and Jaeger (1959) present a solution to the equivalent heat transfer problem that in terms of concentration and mass diffusion can be written

$$F_{diff} = \frac{(C_0 - C_w)\, D_{eff}}{L_{eff}} \left[1 + 2\sum_{n=1}^{\infty} (-1)^n \exp\left(-\frac{D_{eff}\{n\pi\}^2 t}{R_f L_{eff}^2} \right) \right] \tag{B24}$$

where D_{eff} represents $D_w \epsilon^{4/3}$. This solution is also given in this form by Thoma et al. (1993). Note that as $t \to \infty$, the exponential term approaches zero and the flux approaches the value obtained by the approximation $K_{ov} \approx D_{eff} / L_{eff}$ as indicated by Equation B17. From Equation B24, one can obtain relations for the breakthrough time and the time required to approach the steady-state flux.

Breakthrough time, τ_b, is defined as the time at which the flux of contaminant from the contaminated sediment layer has reached 5 percent of its steady-state value, and the time to reach steady state, τ_{ss}, is defined as the time when the flux is 95 percent of its steady-state value. It is easily shown that

$$\tau_b = \frac{0.54 L_{eff}^2 R_f}{D_w \varepsilon^{4/3} \pi^2} \tag{B25}$$

and

$$\tau_{ss} = \frac{3.69 L_{eff}^2 R_f}{D_w \varepsilon^{4/3} \pi^2} \tag{B26}$$

Advective-dispersive models

When advection cannot be neglected during the operation of a cap, the basic equation governing contaminant movement is

$$R_f \frac{\partial C_{pw}}{\partial t} + U \frac{\partial C_{pw}}{\partial z} = D_{disp} \frac{\partial^2 C_{pw}}{\partial z^2} \tag{B27}$$

where

C_{pw} = contaminant concentration in pore water

$U = U_{pw}$ = Darcy velocity directed outward

D_{eff} = effective diffusion/dispersion coefficient

The effective diffusion/dispersion coefficient is often modeled by a relationship of the form (Bear 1979)

$$\begin{aligned} D_{disp} &= D_{eff} + \alpha U \\ &\approx D_w \epsilon^{4/3} + \alpha U \end{aligned} \tag{B28}$$

The first term in this relation is associated with molecular diffusion and is again modeled by the Millington and Quirk (1961) relation. The second term is mechanical dispersion associated with the additional mixing due to flow variations and channeling. α is the dispersivity and is typically taken to be related to the sediment grain size (uniform sandy sediments) or travel distance (heterogeneous sediments). Little guidance exists for the estimation of field dispersivities for vertical flow in sediments. In uniform sandy sediments, the longitudinal dispersivity is approximately one-half the grain diameter, while the transverse dispersity tends to be an order of magnitude smaller (Bear 1979). Dispersion in heterogeneous sediments would be expected to be larger than these estimates.

If the effective dispersivity can be estimated, the contaminant concentration and flux through the cap can be estimated by solutions to Equation B27. One should first consider the long-time behavior of Equation B27 when the sediment originally exhibits a contaminant pore water concentration C_0. If the contaminant is not subject to significant depletion by either degradation or migration through the cap, the flux through the cap ultimately reaches that given by

$$F_{adv} \rightarrow U\,(C_0 - C_w) \qquad as\ t \rightarrow \infty \tag{B29}$$

That is, the contaminant flux due to advection approaches that which would be observed if no cap were placed over the sediment. In such a situation, the cap can be viewed only as a temporary confinement measure until the sediment is removed or depletion renders the contaminant harmless. It should be emphasized, however, that this will only occur when depletion of contaminant in the capped sediment is negligible, a conservative assumption that may significantly overestimate the flux of contaminant through the cap. This assumption is compared with more realistic approaches in an example below.

In the advection-dominated case, it is important to examine the transient release of the contaminant. The conditions on Equation B27 that are appropriate for a cap include

$$\begin{aligned} &cap\text{-}sediment\ interface\ (z=0) && C_{pw} = C_0 \\ &cap\text{-}water\ interface\ (z=L_{eff}) && C_{pw} = C_w \quad (Generally\ C_w \approx 0) \\ &initial\ cap\ concentration && C_{pw} = C_w \end{aligned} \tag{B30}$$

Available analytical solutions describe only homogeneous cap properties and do not satisfy the cap-water interface condition of Equation B30. Instead there are two approximate conditions that are commonly applied instead of the cap-water interface condition.

$$\begin{aligned} &\frac{\partial C_{pw}}{\partial z} = 0 \qquad at\ z = L_{eff} \quad (finite\ cap) \\ &\frac{\partial C_{pw}}{\partial z} = 0 \qquad as\ z \rightarrow \infty \quad (infinite\ cap) \end{aligned} \tag{B31}$$

The first explicitly recognizes the finite thickness of the cap, while the second assumes that it is infinitely thick. The solution subject to the finite boundary condition is given by Cleary and Adrian (1973), while the solution subject to the infinite boundary condition can be found in Carslaw and Jaeger (1959). For Pe > 1, however, the concentration and flux predictions of either model are essentially identical. Moreover, for Pe < 1 when diffusion dominates, the given finite cap condition is inappropriate and causes the solution to underpredict the contaminant flux through the cap. The solution for the infinite cap is also simpler to use. For these reasons, only the infinite cap model will be described in this section. However, the full boundary conditions of Equation B30 or heterogeneous sediment properties can be described using numerical solvers as illustrated in the example.

The solution to Equation B27 subject to the infinite cap condition in homogeneous sediment is given by

$$C_{pw}(z,t) = \frac{(C_0 - C_w)}{2}\left[erfc\left(\frac{R_f\,z - Ut}{2\sqrt{R_f\,Dt}}\right) + \exp\left(\frac{Uz}{D}\right) erfc\left(\frac{R_f\,z + Ut}{2\sqrt{R_f\,Dt}}\right)\right] \tag{B32}$$

Here *erfc* represents the complementary error function that is given by 1 - *erf*, the error function. The error function is a tabulated function (e.g., Thibodeaux 1996) and is commonly available in spreadsheets and computer languages. It ranges from 0 at a value of the argument equal to zero to 1 at a value of the argument equal to infinity. The model is most useful in predicting the penetration of the contaminant into the cap and the time until the sediment-water interface begins to be significantly influenced by the cap, i.e., the breakthrough time. The breakthrough time can be estimated by evaluating Equation B32 for $z = L_{eff}$ and determining the time required until $C_{pw}(L_{eff},t)$ is equal to some fixed fraction of the concentration in the underlying sediment; for example, until $C_{pw}(L_{eff},t) = 0.05\,C_0$. The flux into the overlying water at any time could also be evaluated by computing

$$F(L_{eff},t) = U\,C_{pw}(L_{eff},t) - D_{eff}\,\frac{\partial C_{pw}(L_{eff},t)}{\partial z} \tag{B33}$$

Note that Equations B32 and B33 can also be applied to conditions of mild erosion or deposition on the cap. Erosion or deposition give rise to an effective velocity directed downward with deposition and upward with erosion. Because erosion buries or uncovers sediment and its associated contaminants, the effective velocity influencing the pore water concentration is the erosion or deposition velocity multiplied by the retardation factor.

$$U = \begin{array}{ll} U_{pw} + U_{erosion}\,R_f & \textit{Erosion} \\ U_{pw} - U_{deposition}\,R_f & \textit{Deposition} \end{array} \tag{B34}$$

That is, sediment burial or deposition gives rise to a rapid burial or exposure of contaminants as a result of the sorbed load on the sediment particles.

Models for More General Cases: Numerical Solutions

All of the models discussed thus far assume that the concentration in the sediment remains unchanged despite the loss of contaminant to the overlying water. This simplification is necessary to apply the presented analytical solutions but leads to overly conservative results. For example, in an advective dominated system, Equation B29 will describe the flux to the overlying water at long time only if depletion is not accounted for. It should be emphasized that the depletion referred to here is simply accounting for the mass of contaminant lost to the overlying water. Degradation of the contaminant is not considered.

To overcome this limitation of the preceding models, it is necessary to turn to a numerical simulation of Equation B27. The numerical simulation should apply Equation B27 both within the cap and in the underlying sediment assuming that the concentrations and fluxes are continuous at the sediment water interface. Arbitrary initial and boundary conditions could be applied. For the particular case of an initially clean sediment cap overlying a finite layer of contaminated sediment, the author has developed such a numerical solution. This model is coded in FORTRAN and employs IMSL subroutines to conduct the numerical calculations. An illustrative example using the model is presented later as is a contact address for acquisition of the model.

Models for Uncapped Sediment

Although the primary purpose is the evaluation of contaminant concentrations and fluxes associated with capped sediment, it is often convenient to compare these quantities with concentrations and fluxes that would be observed in the absence of a cap. Models similar to those above are available for uncapped conditions and are especially useful for comparison purposes.

Let us consider the solution to Equation B27 subject to the uncapped boundary conditions

$$\begin{aligned} &\textit{sediment-water interface } (z=0) && C_{pw} = C_w \\ &\textit{deep sediment } (z\to\infty) && C_{pw} = C_0 \textit{ or } \frac{\partial C_{pw}}{\partial z} \to 0 \\ &\textit{initial sediment concentration} && C_{pw} = C_0 \end{aligned} \qquad \text{(B35)}$$

These are the same conditions, however, as those leading to Equation B32 if the z coordinate is directed into the sediment rather than out through the cap and if the roles of C_0 and C_w are reversed. Thus Equation B32 can be used to evaluate concentrations in the uncapped case as well. Both the sense of U and z must be reversed, and $z = 0$ now represents the sediment-water interface. Similarly, the flux from the sediment to the overlying water is given by

$$F(0,t) = U\, C_{pw}(0,t) - D_{eff} \frac{\partial C_{pw}(0,t)}{\partial z} \qquad \text{(B36)}$$

Similarly, finite contaminated layer models could be adapted from Equation B24. This would not be a fair basis for comparison, however, in that the uncapped model would explicitly account for depletion of the sediment contaminants as a result of the loss to water while the cap version of the solution assumes that the sediment concentration remains constant.

Parameter Estimation

Use of any of the above models requires estimation of a variety of model parameters. The most important of these parameters and an example calculation are presented below. These include the porosity (ϵ), bulk density (ρ_b), and organic carbon content (f_{oc}) of the cap material; the partition coefficient (K_d) for the chemical(s) between the pore water and the cap material; the diffusivity of the chemical(s) in water (D_W); the depth of bioturbation (L_{bio}) and a biodiffusion coefficient (D_{bio}); benthic boundary layer (K_{bl}) and evaporation (K_e) mass transfer coefficients; and for flowing systems, the water flushing rate (Q). Information should be obtained on the degradation half-life or reaction rate of chemicals of concern in the specific project if such information is available.

Contaminant properties

Contaminant properties include water diffusivity and sediment-water or cap-water partition coefficient. The water diffusivity of most compounds varies less than a factor of two from 1×10^{-5} cm^2/sec. Higher molecular weight compounds such as PAHs tend to have a water diffusivity of the order of 5×10^{-6} cm^2/sec. The water diffusivity can be estimated using the Wilke-Chang method (Bird, Stewart, and Lightfoot 1960). Compilations of diffusivities are also available (Thibodeaux 1996; Montgomery and Welkom 1990).

The preferred means of determining the partition coefficient is through experimental measurement of sediment and pore water concentration in the sediment or cap. In this manner, any sorption of contaminant onto suspended particulate or colloidal matter is implicitly incorporated. If such measurements are unavailable, it is possible to predict values of the partition coefficient, at least for hydrophobic organic compounds, using Equation B8. K_{oc} values are tabulated (e.g., Montgomery and Welkom 1990) or may be estimated from solubility or the octanol-water partition coefficient using the methods in Lyman, Reehl, and Rosenblatt (1990). For other contaminants, including metals, little predictive guidance exists.

It should be emphasized that the pore water concentration, C_0, appearing in the models is not the truly dissolved concentration but that corrected for the amount sorbed on the colloidal matter. Note that Equation B8 suggests that the apparent partition coefficient approaches the constant, f_{oc}/ρ_{oc} as $K_{oc} \rightarrow \infty$. That is, the apparent partition coefficient is no longer a function of the hydrophobicity of the contaminant when the product $\rho_{oc}K_{oc}$>>1. For example, the apparent partitioning of pyrene, with a K_{oc} ~10^5 L/kg and any compound more hydrophobic, is dominated by pore water organic matter at concentrations greater than about 10 mg/L.

Physical characteristics

The long-term average water flushing rate should be measured onsite to evaluate water-side mass transfer resistances. Cap material properties are dependent on the specific materials available and should be measured using standard analytical methods.

Mass transfer coefficients

A turbulent mass transfer correlation (Thibodeaux 1996) can be used to estimate the value of K_{bl} in the water above the cap:

$$Sh = 0.036\ Re^{0.8}\ Sc^{1/3} \tag{B37}$$

where

Sh = Sherwood number = $\dfrac{K_{bl} \cdot x}{D_w}$

Re = Reynolds number = $\dfrac{x \cdot u}{\nu}$

Sc = Schmidt number = $\dfrac{\nu}{D_w}$

ν = kinematic viscosity of water, 0.01 cm²/sec at 20 °C

u = benthic boundary layer water velocity, cm/s

x = length scale for the contaminated region - here $x = \sqrt{A_s}$ is taken where A_s is area of contaminated region, cm

As indicated previously, however, the benthic boundary layer mass transfer coefficient is rarely significant in the estimation of contaminant flux through the cap.

Transport by bioturbation has often been quantified by an effective diffusion coefficient based on particle reworking rates. A bioturbation mass transfer coefficient can then be estimated from the following relation assuming linear partitioning between the sediment and water in the bioturbation layer

$$K_{bio} = \frac{D_{bio}\rho_b K_d \eta}{L_{bio}} \tag{B38}$$

where η is a desorption efficiency of the chemical once the particle carrying it has been reworked to the sediment-water interface. η would tend to be small for more hydrophobic compounds that tend to desorb slowly at the surface and large for compounds that are more soluble. In the absence of experimental information to the contrary, η is assumed to be 1. The biodiffusion coefficient and the depth of bioturbation are important factors in the determination of the required cap thickness, and thus the best possible estimates should be used. The ranges for D_{bio} and L_{bio} are quite large, and an extensive tabulation is presented by Matisoff (1982). An examination of these data suggests that a depth of bioturbation of 2 to 10 cm is typical and that biodiffusion coefficients are generally in the range of 0.3 to 30 cm^2/year. As indicated previously, however, the contaminant flux is controlled by transport through the cap and is essentially insensitive to the bioturbation mass transfer coefficient. The contaminant concentration in the bioturbated layer, however, is heavily dependent upon the biodiffusion coefficient.

Evaporation mass transfer coefficient

The overall evaporation mass transfer coefficient is taken as equal to the water-side mass transfer coefficient. This is generally valid for volatile organic compounds but less true for many PAHs, which tend to exhibit significant air-side mass transfer resistances. A water-side mass transfer coefficient for evaporative losses is given by Lunny, Springer, and Thibodeaux (1985) as

$$K_e = 19.6 U_x^{2.23} D_w^{2/3} \tag{B39}$$

where U_x is the wind speed at 10 m (miles/hour), D_w has units of square centimeters/second, and K_e has units of centimeters/hour. Lyman, Reehl, and Rosenblatt (1990) provide information on air-side coefficients that may be important for some compounds, notably low-volatility PAH compounds.

Example

Several design bases are possible for specifying the physico-chemical containment afforded by a cap. There are at least five quantities that may be of interest to the cap designer and for which models were presented here. These are the breakthrough time, the pollutant release rate (as a source term input to other fate and effects models), concentrations at the sediment-water interface or in the overlying water column, and the time to approach steady state. The two physico-chemical properties of the cap material that have the largest effect on the efficacy of the cap are the organic carbon content and the cap thickness. Each of these calculations will be illustrated given a cap thickness. In general, the process would be applied iteratively using a guessed cap thickness until the desired breakthrough times, fluxes, etc, are achieved.

The selected example considers a sediment contaminated with a moderately hydrophobic polyaromatic hydrocarbon, pyrene. The contaminant is initially present in the upper 35 cm of sediment at a level of 100 mg/kg. A cap of initial thickness of 50 cm is placed over this sediment. Both the cap and the sediment contain 1-percent organic carbon. Consolidation of the cap after placement reduces the cap thickness to 45 cm. The sediment also consolidates 5 cm as a result of cap placement. Bioturbation is expected to influence the upper 10 cm of sediment or cap. These and other problem parameters are collected in Table B1. The calculation procedure is detailed below.

Table B1
Physico-Chemical Properties of Site Parameters for Example

Cap Properties		
Initial cap thickness	(L_0)	50 cm
Consolidation distance within cap	(ΔL_{cap})	5 cm
Consolidation distance of underlying sediment	(ΔL_{sed})	5 cm
Organic carbon content	(f_{oc})	0.01
Porosity	(ϵ)	0.5
Bulk density	(ρ_b)	1.25 g/cm^3
Colloid concentration	(C_c)	10 mg/L
Effective cap thickness	(L_{eff})	35 cm
Pyrene Properties		
Solubility	(s)	150 μg/L
Diffusivity in water	(D_w)	5×10^{-5} cm^2/sec
Organic carbon partition coeff.	(K_{oc})	10^5 L/kg
Mass transfer coeff. at air-water interface	(K_e)	7 cm/hr
Mass transfer coeff. at cap-water interface	(K_{bl})	1 cm/hr
Site Properties		
Bioturbation depth	(L_{bio})	10 cm
Biodiffusion coefficient	(D_{bio})	10 cm^2/year
Seepage velocity in sediment (assume outflow)	(U)	10 cm/year
Pyrene sediment loading	(ω_s)	100 mg/kg
Pore water concentration	(C_{pw})	200 μg/L
Area of contaminated sediment	(A_s)	10^4 m^2
Evaporative area	(A_e)	10^4 m^2
Benthic boundary layer velocity	(u)	10 cm/sec
Basin flushing rate	(Q)	1.7×10^{13} cm^3/day
Thickness of contaminated region		35 cm (used in numerical model only)

Estimation of effective cap thickness

The initial cap thickness is reduced by bioturbation (10 cm), consolidation of the cap (5 cm), and penetration of pore water expressed by the consolidation of the underlying sediment. Although the sediment consolidates a distance of 5 cm, causing movement of pore water 10 cm into the cap (cap porosity of 50 percent), the contaminant migration is retarded by sorption onto the organic carbon in the cap. After estimation of the retardation factor associated with sorption onto the cap materials, it is estimated that the chemical penetration into the cap as a result of sediment consolidation is only about 80 μm. Thus the effective cap thickness is

$$\begin{aligned} L_{eff} &= 50\ cm \\ &- 10\ cm (bioturbation) \\ &- 5\ cm\ (consolidation\ of\ cap) \\ &- 80\ \mu m\ (sediment\ consolidation) \\ &\approx 35\ cm \end{aligned}$$

This calculation included an estimate of the partition coefficient and retardation factor for the migration of pyrene through the cap. The partition coefficient and pore water concentrations were estimated based on the sediment loading (Equation B5 and the second of Equations B8). The maximum truly dissolved concentration in the pore water is given by the solubility of pyrene in water (150 μg/L) meaning that in the 1-percent organic carbon sediment with a pyrene K_{oc} = 10^5 L/kg, the sediment loading must be less than 150 mg/kg for this to be true. At sediment loadings above 150 mg/kg, the pore water concentration in the contaminated region must be estimated by Equation B7.

Estimation of long-term losses

The simple analytical models presented in this appendix assume that the zone of contamination is infinitely large and is not depleted by losses through the cap. Since a groundwater seepage velocity is specified in this example, such an assumption means that ultimately the flux through the cap is given by the seepage velocity times the pore water concentration in the sediment beneath the cap or 20 $mg{\cdot}m^{-2}{\cdot}year^{-1}$. In the absence of any seepage through the cap, the steady-state diffusive flux would apply, 3.6 $mg{\cdot}m^{-2}{\cdot}year^{-1}$. Both estimates overestimate the actual long-term flux, however, in that they assume that the sediment beneath the cap exhibits a constant concentration. A numerical calculation of the flux is provided later to illustrate the degree of conservatism by these calculations, even if no chemical degradation of the pyrene occurs.

Evaluation of diffusion only mechanism

Using Equations B25 and B26, the breakthrough and steady-state times are given by 669 and 4,600 years, respectively. These estimates assume only diffusion is applicable and that the concentration is again constant.

At steady-state conditions assuming constant sediment concentrations, the diffusion model also allows estimation of pore and overlying water concentrations. Although the predominant mass transfer resistance is the undisturbed cap, the bioturbation zone and the benthic boundary layer resistance influence the concentrations observed in the bioturbation layer, at the sediment-water interface, and in the overlying water.

Example Calculation of Contaminant Flux-Advection/Diffusion Mechanism

In this example, flux predictions by the analytical model of capped sediment are compared with an uncapped case and a numerical model that recognizes the depletion in the underlying sediment due to transport to the overlying water. The numerical model is capable of describing arbitrary and heterogeneous initial conditions and depletion within the sediment. The model is written in FORTRAN and employs IMSL routines for some calculations. Both the analytical model in the form of a Mathcad spreadsheet and the numerical model are available from the author

Danny Reible, Director
Hazardous Substance Research Center/S&SW
Louisiana State University
Baton Rouge, LA 70803
Ph: 504/388-3070, Fax: 504/388-1476, e-mail: reible@che.lsu.edu

The model predictions for flux are shown in Figure B2.

Comparison of Uncapped and Analytical and Numerical Capped Model Predictions

The first case is for a contaminated system with no cap. The result is presented as the solid line in Figure B2. The flux starts out at a high value (effectively infinite at time of first exposure of the contaminated sediment) and decreases with time.

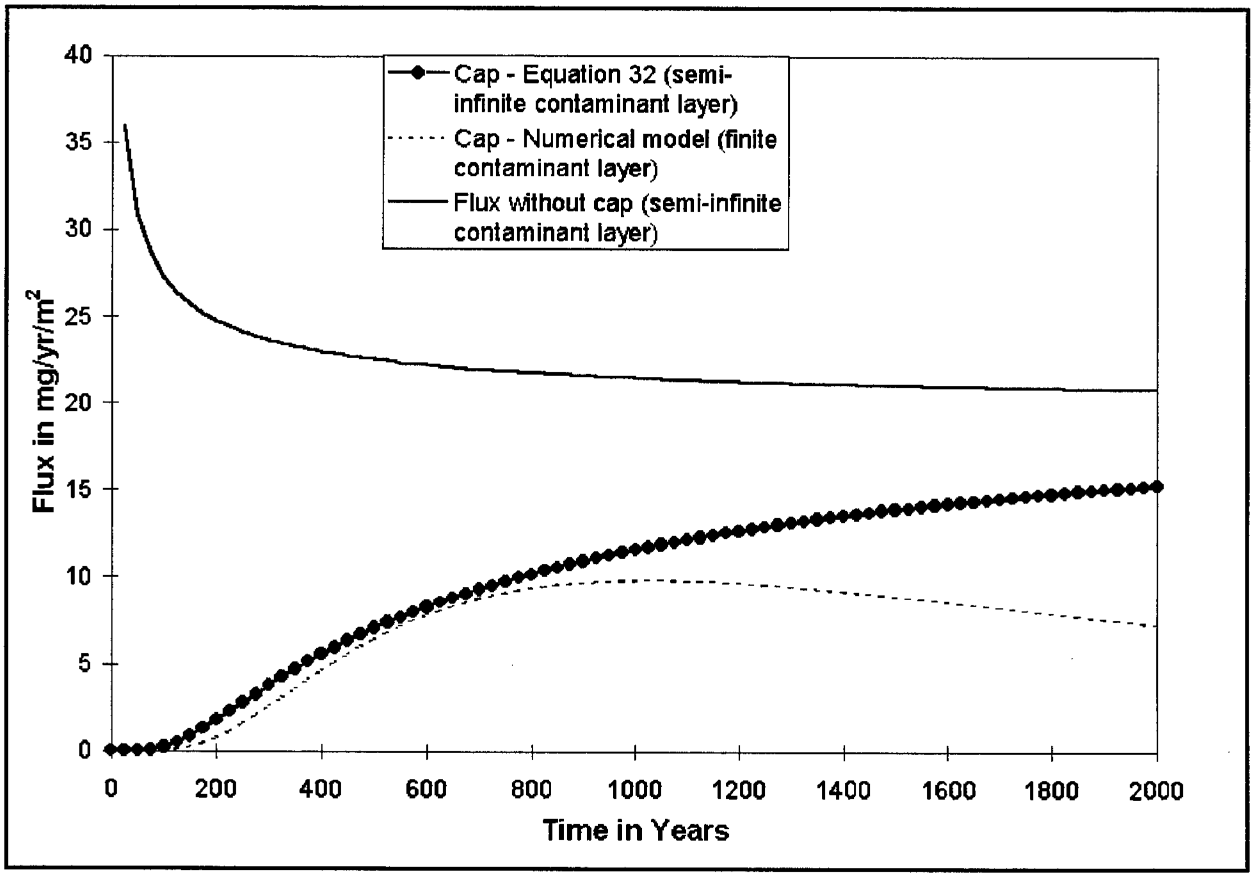


Figure B2. Example calculations of contaminant flux through cap

Example - Mathcad Spreadsheet

Note - All numerical values employed in this simulation are for illustration only. Although some of these values may represent typical field conditions, they do not indicate the range of values encountered in the field and do not therefore allow the drawing of general conclusions as to the effectiveness of capping

Estimation of effective cap thickness

$L_0 := 50 \cdot cm$ Initial thickness of cap

$L_{bio} := 10 \cdot cm$ Thickness effectively mixed by bioturbation

$\Delta L_{cap} := 5 \cdot cm$ Consolidation distance within the cap

$\Delta L_{sed} := 5 \cdot cm$ Consolidation distance of underlying sediment

$\varepsilon := 0.5$ Void fraction in cap

$\rho_b := 0.5 \cdot 2.5 \cdot \frac{gm}{cm^3}$ Bulk density of sediment

$\Delta L_{sed.pw} := \frac{\Delta L_{sed}}{\varepsilon}$ Pore water penetration distance in cap

$\Delta L_{sed.pw} = 0.1 \cdot m$

Estimation of sorption characteristics in cap and retardation factor

$L := 1000 \cdot cm^3$

$\mu g := 10^{-6} \cdot gm$

$K_{oc} := 10^5 \cdot \frac{L}{kg}$ Organic carbon based partition coefficient
Compound assumed: Pyrene

$\rho_{oc} := 10 \cdot \frac{mg}{L}$ Dissolved organic carbon concentration in pore water

$f_{oc} := 0.01$ Fraction organic carbon in sediment

$S := 0.150 \cdot \frac{mg}{L}$ Solubility of pyrene in water

$\omega_{crit} := K_{oc} \cdot f_{oc} \cdot S$ Critical sediment loading $\omega_{crit} = 150 \cdot \frac{mg}{kg}$

$$K_d := \frac{K_{oc} \cdot f_{oc}}{1 + \rho_{oc} \cdot K_{oc}}$$

Observed partition coefficient between sediment and water assumes K_{oc} governs partitioning to dissolved org. carbon

$K_d = 500 \cdot \frac{L}{kg}$ Also assumes sediment $< \omega_{crit}$

$$R_f := \varepsilon + \rho_b \cdot K_d$$

Retardation factor due to sorption onto solid

$R_f = 625.5$

$$\Delta L_{sed.A} := \frac{\Delta L_{sed}}{R_f}$$

Penetration distance of chemical into cap due to consolidation of sediment

$\Delta L_{sed.A} = 7.994 \cdot 10^{-5} \cdot m$ Typically negligible for sorbing caps

$$L_{eff} := L_0 - L_{bio} - \Delta L_{cap} - \Delta L_{sed.A}$$

Effective cap thickness

$L_{eff} = 0.35 \cdot m$

Estimation of long-term losses

a. Determination of Peclet number defining the relative importance of advection to diffusion

$U := 10 \cdot \frac{cm}{yr}$ Seepage velocity in sediment- assume outflow

$D_w := 5 \cdot 10^{-6} \cdot \frac{cm^2}{sec}$ Molecular diffusion coefficient in water

$D_{eff} := D_w \cdot \varepsilon^{\frac{4}{3}}$ Millington and Quirk model for effective diffusivity

$D_{eff} = 1.984 \cdot 10^{-6} \cdot \frac{cm^2}{sec}$

$$Pe := \frac{U \cdot L_{eff}}{D_{eff}}$$

Peclet number

$Pe = 5.588$ Advection/diffusion both important

Chemical concentration level - assumed deep layer of sediment contaminated to 100 mg/kg

$W_s := 100 \cdot \frac{mg}{kg}$ $C_0 := \frac{W_s}{K_d}$ $C_0 = 200 \cdot \frac{\mu g}{L}$

Note - Ws<150 mg/kg - below critical loading as assumed

Advective flux

$F_{adv} := U \cdot C_0$

Advective flux - since a deep layer of contaminated sediment is assumed, the flux at long time is given by this for a seepage outflow

$F_{adv} = 20 \circ \dfrac{mg}{m^2 \cdot yr}$

Dffusive flux - hypothetical unless Pe <<1 and depletion of material in sediment can be neglected

$F_{diff} := \dfrac{D_{eff}}{L_{eff}} \cdot C_0$

Steady-state diffusive flux (assuming no advection and no depletion of contaminants by diffusion through cap)

$F_{diff} = 3.579 \circ \dfrac{mg}{m^2 \cdot yr}$

Transient behavior- assuming diffusion only

$\tau_b := \dfrac{0.54 \cdot L_{eff}^2 \cdot R_f}{D_{eff} \cdot \pi^2}$

Breakthrough time assuming no depletion of contaminant in sediment

$\tau_b = 669.218 \circ yr$

$\tau_{ss} := \dfrac{3.69 \cdot L_{eff}^2 \cdot R_f}{D_{eff} \cdot \pi^2}$

Time required to reach hypothetical steady state flux (F_{diff}) assuming no depletion of contaminants in sediment

$\tau_{ss} = 4572.99 \circ yr$

Estimation of overall mass transfer coefficient and concentrations in water and at the sediment-water interface assuming quasi-steady diffusion

$K_{cap} := \dfrac{D_{eff}}{L_{eff}}$

Effective mass transfer coefficient in cap–assuming quasi-steady diffusion

$K_{cap} = 1.789 \circ \dfrac{cm}{yr}$

$D_{bio} := 10 \cdot \dfrac{cm^2}{yr}$

Effective bioturbation diffusion coefficient

$\eta := 1$

Fraction of contaminants released at surface between arrival at surface and reburial by bioturbation

$$K_{bio} := \frac{\eta \cdot D_{bio} \cdot R_f}{L_{bio}}$$

Effective bioturbation mass transfer coefficient for particle movement at effective diffusion coefficient Dbio

$$K_{bio} = 625.5 \cdot \frac{cm}{yr}$$

$$K_{bl} := 1 \cdot \frac{cm}{hr}$$

Effective mass transfer coefficient at sediment (cap) - water interface

$$K_e := 7 \cdot \frac{cm}{hr}$$

Effective mass transfer coefficient at air-water interface

$$Q := 1.7 \cdot 10^{13} \cdot \frac{cm^3}{day}$$

Effective flushing rate of overlying water

$$A_s := 10^4 \cdot m^2$$

Area of contaminated sediment

$$A_e := 10^4 \cdot m^2$$

Evaporative area

$$K_{ov} := \left(\frac{1}{K_{cap}} + \frac{1}{K_{bio}} + \frac{1}{K_{bl}} + \frac{A_s}{K_e \cdot A_e + Q} \right)^{-1}$$

Effective overall mass transfer coefficient

$$K_{ov} = 1.784 \cdot \frac{cm}{yr}$$

Typically same as cap coefficient

$$C_w := \frac{K_{ov} \cdot A_s}{K_e \cdot A_e + Q} \cdot C_0$$

Water concentration assuming steady diffusion through cap and only evaporation and flushing losses from water

$$C_w = 5.741 \cdot 10^{-6} \cdot \frac{\mu g}{L}$$

$$C_{sw} := \frac{K_{ov} \cdot C_0}{K_{bl}}$$

Concentration in porewater at sediment (cap)- water interface
This should indicate exposure of benthic organisms

$$C_{sw} = 0.041 \cdot \frac{\mu g}{L}$$

Flux via full - advection diffusion model

$\alpha := L_{eff}$ Set dispersivity to upper bound of cap thickness

$D := D_{eff} + \alpha \cdot U$ Dispersion coefficient sum of diffusion and advective dispersion

$D = 1.307 \cdot 10^{-5} \cdot \frac{cm^2}{sec}$

Concentration model - semi-infinite cap with concentration in underlying sediment constant

$$C(L,t) := \left[\left[1 - \mathrm{erf}\left(\frac{R_f \cdot L - U \cdot t}{2 \cdot \sqrt{R_f \cdot D \cdot t}}\right) + \exp\left(\frac{U \cdot L}{D}\right) \cdot \left(1 - \mathrm{erf}\left(\frac{R_f \cdot L + U \cdot t}{2 \cdot \sqrt{R_f \cdot D \cdot t}}\right)\right)\right] \cdot \frac{C_0}{2}\right]$$

Concentration gradient near surface— needed for estimation of diffusion flux

$$DCDZ(L,t) := \frac{1}{2} \cdot \left[\frac{-1}{\sqrt{\pi}} \cdot \exp\left[\frac{-1}{4} \cdot \frac{(R_f \cdot L - U \cdot t)^2}{\left[R_f \cdot (D \cdot t)\right]}\right] \cdot \frac{\sqrt{R_f}}{\left(\sqrt{D} \cdot \sqrt{t}\right)} + \frac{U}{D} \cdot \exp\left(U \cdot \frac{L}{D}\right) \cdot \left[1 - \mathrm{erf}\left[\frac{1}{2} \cdot \frac{(R_f \cdot L + U \cdot t)}{\left[\sqrt{R_f} \cdot \left(\sqrt{D} \cdot \sqrt{t}\right)\right]}\right]\right] \dots + \frac{-\exp\left(U \cdot \frac{L}{D}\right)}{\sqrt{\pi}} \cdot \exp\left[\frac{-1}{4} \cdot \frac{(R_f \cdot L + U \cdot t)^2}{\left[R_f \cdot (D \cdot t)\right]}\right] \cdot \frac{\sqrt{R_f}}{\left(\sqrt{D} \cdot \sqrt{t}\right)}\right] \cdot C_0$$

$t_{int} := 100 \cdot yr$ t_{int} = time interval desired

$j := 1..20$ j = number of values of time

$F_{adv_j} := U \cdot C(L_{eff}, j \cdot t_{int})$ Advective component of flux

$F_{diff_j} := -\left(D_{eff} \cdot DCDZ(L_{eff}, j \cdot t_{int})\right)$ Diffusive component of flux

$F_{adv.diff_j} := F_{adv_j} + F_{diff_j}$ Total flux from cap-water interface

Comparison to uncapped flux (This approach recognizes that the same equation is applicable if water-side mass transfer resistances are always negligible)

$$F_{uncapped_j} := U \cdot C(0 \cdot cm, j \cdot t_{int}) - D_{eff} \cdot DCDZ(0 \cdot cm, j \cdot t_{int})$$

Note that both analytical models (capped and uncapped) assume that the contaminant layer is of infinite depth. At long times when this assumption is poor, a numerical simulation should be used in either case as shown in Figure B2.

Summary of Results–also shown in Figure B2 with numerical model results assuming a 35-cm depth of contamination

Time	Conc. at cap water interface	Fluxes via advection, diffusion and combined			
$\frac{j \cdot t_{int}}{yr}$	$\frac{C(L_{eff}, j \cdot t_{int})}{\left(\frac{\mu g}{L}\right)}$	$\frac{F_{adv_j}}{\left(\frac{mg}{m^2 \cdot yr}\right)}$	$\frac{F_{diff_j}}{\left(\frac{mg}{m^2 \cdot yr}\right)}$	$\frac{F_{adv.diff_j}}{\left(\frac{mg}{m^2 \cdot yr}\right)}$	$\frac{F_{uncapped_j}}{\left(\frac{mg}{m^2 \cdot yr}\right)}$
100	0.701	0.07	0.122	0.192	27.266
200	9.399	0.94	0.839	1.779	24.753
300	23.526	2.353	1.426	3.779	23.65
400	38.032	3.803	1.75	5.554	23
500	51.306	5.131	1.905	7.036	22.56
600	63.054	6.305	1.962	8.268	22.238
700	73.369	7.337	1.964	9.301	21.991
800	82.435	8.244	1.934	10.178	21.794
900	90.439	9.044	1.887	10.931	21.631
1000	97.544	9.754	1.831	11.585	21.496
1100	103.888	10.389	1.769	12.158	21.38
1200	109.584	10.958	1.707	12.665	21.28
1300	114.724	11.472	1.644	13.116	21.193
1400	119.387	11.939	1.583	13.521	21.116
1500	123.634	12.363	1.523	13.887	21.047
1600	127.519	12.752	1.466	14.218	20.986
1700	131.086	13.109	1.411	14.519	20.931
1800	134.373	13.437	1.358	14.796	20.88
1900	137.411	13.741	1.308	15.049	20.835
2000	140.227	14.023	1.26	15.283	20.793

Capped Flux < 1% Uncapped Flux for more than 100 years

Capped Flux approximately 1/2 uncapped flux after 1,000 years (Maximum flux if initial contaminant thickness is 35 cm) from numerical model)

In the next case a cap has been placed and the flux through the cap is estimated subject to the previously discussed assumptions of constant concentration in the underlying sediment. This system is described by Equation B32. The result is presented by the broken line in Figure B2. The flux is initially zero until cap breakthrough, and the flux then slowly increases with time. After several thousand years in this example, the flux with and without the cap approaches the constant value of 20 $mg \cdot m^{-2} \cdot year^{-1}$. Again, both models approach the same value because the contaminated region is assumed infinitely thick and advection ultimately controls the flux.

In the final case, the conditions are identical to the capped case above, but mass transfer is recognized to cause depletion of the contaminant beneath the cap and the actual thickness (and therefore finite mass) of the contaminated region is explicitly considered. The thickness of the contaminated region is assumed identical to the effective thickness of the cap, 35 cm. No degradation is assumed, consistent with the previous examples. The solution by the numerical model is given as the dotted line on Figure B2. Of the three models, this is the only one that satisfies the material balance in that the loss to the overlying water is reflected in reductions in mass in the contaminants in the sediment.

The plot of flux with time for an uncapped system shows a high initial flux owing to a large concentration gradient at the surface initially. With depletion in the near-surface sediment, the flux asymptotically approaches a limit given by the advective flux from the deep-sediment concentrations. With a cap, the contaminant takes some time to seep through the clean capped region. Hence there is an initial time period when there is essentially no contaminant flux. Since there is an assumption of constant contaminant concentration at the base of the cap, the flux asymptotically approaches a maximum that would ultimately equal the uncapped flux. The realistic model that accurately accounts for contaminant depletion in the sediment shows a flux that never reaches as high as the flux from either of the two preceding models, and it steadily decreases at long time.

Note that in either capped case, the total mass released to the water column is significantly reduced for any period of time. The total mass released is the integral under the flux curves.

In this example it was assumed that the bioturbated region offers no resistance to the transport of contaminants. A model explicitly accounting for the bioturbated region could also be developed. Similarly, the effect of cap thickness and contaminated layer thickness or inhomogeneity on the long-term flux profile can be studied using the numerical model. This is not possible using the conservative analytical model Equation B32.

Acknowledgments

This appendix was prepared with the partial support of the U.S. Environmental Protection Agency through the Hazardous Substance Research

Center/South and Southwest and through cooperative agreement CR 823029-01-0 from the National Risk Management and Research Laboratory, Cincinnati, OH.

References

Bear, J. (1979). *Hydraulics of groundwater*. McGraw-Hill, New York.

Bird, R. B., Stewart, W. E., and Lightfoot, E. N. (1960). *Transport phenomena.* John Wiley & Sons, New York.

Carslaw, H. S., and Jaeger, J. C. (1959). *Conduction of heat in solids*. 2d ed., Oxford University Press, Oxford, England.

Cleary, R. W., and Adrian, D. D. (1973). "Analytical solution of the convection-dispersive equation for cation adsorption in soils," *Soil Sci Soc. America Proc. 37*, 197-199.

IMSL. (1994). Visual Numerics, Inc., Houston, TX.

Lunney, P. D., Springer, C., and Thibodeaux, L. J. (1985). "Liquid phase mass transfer coefficients for surface impoundments," *Environmental Progress 109* (4), 203-211.

Lyman, W. J., Reehl, W. F., and Rosenblatt, D. H. (1990). *Handbook of chemical property estimation methods: Environmental behavior of organic chemicals*, American Chemical Society: Washington DC.

Matisoff, G. (1982). "Mathematical models of bioturbation," *Animal-sediment relations*. P. L. McCall and M. J. Tevesz, ed., Plenum Press, New York, 289-331.

Millington, R. J., and Quirk, J. M. (1961). "Permeability of porous solids," *Trans. of Faraday Soc.* 57, 1200-1207.

Montgomery, J. H., and Welkom, L. M. (1990). *Goundwater chemicals desk reference*. Vol 1. Lewis Publishers, Inc., Chelsa, MI.

Palermo, M. R., Maynord, S., Miller, J., and Reible, D. D. (1996). "Guidance for in-situ subaqueous capping of contaminated sediments," Environmental Protection Agency, EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Stark, T. D. (1991). "Program documentation and user's guide: PCDDF89, primary consolidation and dessication of dredged fill," Instruction Report D-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Thibodeaux, L. J. (1996). *Environmental chemodynamics: Environmental movement of chemicals in air, water and soil.* 2d ed., Wiley & Sons, New York.

Thibodeaux, L. J., and Bosworth, W. S. (1990). "A theoretical evaluation of the effectiveness of capping PCB contaminated New Bedford Harbor Bed Sediment," Final Report, Hazardous Waste Research Center, Louisiana State University, Baton Rouge, LA.

Thoma, G. J., Reible, D. D., Valsaraj, K. T., and Thibodeaux, L. J. (1993). "Efficiency of capping contaminated sediments in situ: 2. Mathematics of diffusion-adsorption in the capping layer," *Environmental Science and Technology* 27, 12, 2412-2419.

Appendix C
Capping Effectiveness Tests

Introduction

Results of laboratory tests conducted with samples of the contaminated sediments to be capped and the proposed capping sediments should yield sediment-specific and capping-material-specific values of diffusion coefficients, partitioning coefficients, and other parameters needed to model long-term cap effectiveness. Model predictions of long-term effectiveness using the laboratory-derived parameters should be more reliable than predictions based on so-called default parameters. At present, there are several tests that have been applied for this purpose.

Louisiana State University has conducted laboratory tests to assess diffusion rates for specific contaminated sediments to be capped and materials proposed for caps. A capping simulator cell was used in which a cap material layer is placed over a contaminated sediment, and flux due to diffusion is measured in water that was allowed to flow over the cap surface. Initial tests measured flux of 2,4,6-trichlorophenol (TCP) through various cap materials. These tests showed that the breakthrough time and time to steady state were directly dependent on the partitioning coefficient and that cap porosity and thickness were the dominant parameters at steady state (Wang et al. 1991).[1]

Environment Canada has performed tank tests on sediments from Lake Ontario to qualitatively investigate the interaction of capping sand and compressible sediments. The tests were carried out in 3.6- by 3.6- by 3.7-m observation tanks in which the compressible sediments were placed and allowed to consolidate; sand was released through the water column onto the sediment surface. In the initial tests, physical layering and consolidation behavior were observed. Additional tests are planned in which migration of contaminants due to consolidation-induced advective flow will be evaluated (Zeman 1993).

[1] References cited in this appendix are listed in the References at the end of the main text.

The U.S. Army Corps of Engineers (USACE) has also developed leach tests to assess the quality of water moving through a contaminated sediment layer into groundwater in a confined disposal facility environment (Myers and Brannon 1991). This test has been applied to similarly assess the quality of water potentially moving upward into a cap due to advective forces.[1]

USACE Small-Scale Column Test

The USACE developed a first-generation capping effectiveness test in the mid-1980s as part of the initial examination of capping as a dredged material disposal alternative. The test was developed based on the work of Brannon et al. (1985, 1986), Gunnison et al. (1987), Environmental Laboratory (1987), and Sturgis and Gunnison (1988).

The tests basically involve layering contaminated and capping sediments in columns (Figure C1) and experimentally determining the cap sediment thickness necessary to chemically isolate a contaminated sediment by monitoring the changes in dissolved oxygen, ammonium-nitrate, orthophosphate-phosphorous, or other tracers in the overlying water column.

The thickness of granular cap material for chemical isolation determined using this procedure is on the order of 1-ft for most sediments tested to date. However, this column testing procedure does not account for potential advection nor long-term flux of contaminants due to diffusion. The USACE Small-Scale Column Test is therefore only applicable for evaluation of capping thicknesses for isolation of nutrient-rich sediments.

The procedure for conducting the small-scale column test is presented below.

Chemical tracers

The test uses dissolved oxygen (DO) depletion, ammonium-nitrogen, and orthophosphate phosphorus as tracers because they are easy and inexpensive to measure. A cap thickness that is effective in preventing the movement of these inorganic constituents will also be effective in preventing the movement of organic contaminants that are more strongly bound to sediment (e.g., polynuclear aromatic hydrocarbons (PAHs), petroleum hydrocarbons, and polychlorinated biphenyls (PCBs)). The behavior of soluble-reduced inorganic species (e.g., arsenic) is also similar to the tracers.

Dissolved oxygen depletion in the water column is normally not a problem in an open-water disposal environment, due to mixing and reaeration of the water

[1] Personal Communication, 1995, Tommy E. Myers, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

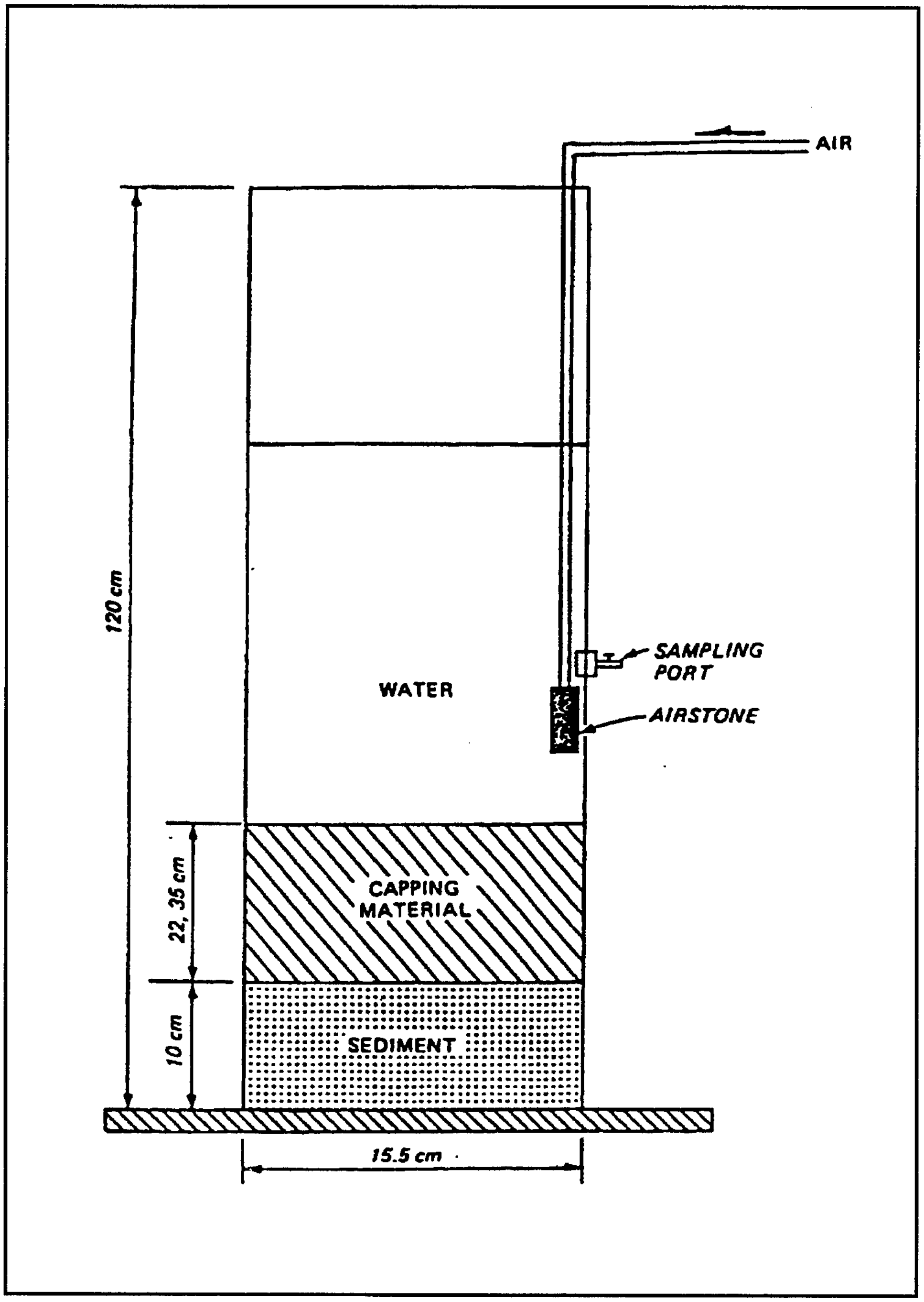


Figure C1. Small-scale column test unit for capping effectiveness (Sturgis and Gunnison 1988)

column. However, DO depletion can be used as a tracer for determining the effectiveness of a cap in isolating an underlying contaminated dredged material having an oxygen demand exceeding that of the capping material. A cap thickness that is effective in preventing or reducing the diffusion of DO into the contaminated sediment will also prevent or reduce the diffusion of DO-demanding species from the contaminated sediment into the overlying water column. Once an effective cap thickness has been achieved, there will be no significant difference in oxygen-depletion rates between the contaminated sediment with cap material and the cap material alone.

A similar rationale is applicable for using ammonium-nitrogen and orthophosphate-phosphorus as tracers. These constituents are released only under anaerobic conditions. However, if the layer of cap material is thick enough to prevent the diffusing materials in the underlying contaminated dredged material from reaching the water column, the release rates from the capped contaminated sediment will be the same as from the cap material alone.

Because of the potential variation of chemical and biochemical properties in sediments, more than one tracer (ammonium-nitrogen, orthophosphate-phosphorus, and DO depletion) must be considered for each application (Brannon et al. 1985, 1986; Gunnison et al. 1987; Environmental Laboratory 1987). Frequently, the contaminated sediment and the proposed capping material are so different that a chemical property of the contaminated sediment is easily distinguishable from that same property of the cap material. However, when the cap material has chemical properties similar to the contaminated sediment, chemical differences are harder to distinguish. In such a case, if only one tracer is measured and negative results are obtained, a second series of tests is necessary.

Water analysis

The release rates of ammonium-nitrogen and orthophosphate-phosphorus must be determined in accordance with procedures recommended by Ballinger (1979). The depletion rate of DO is determined using either the azide modification of the Winkler method, as described in Standard Methods (American Public Health Association 1986), or a DO meter.

Sediment collection

Samples of contaminated sediment must be collected that are representative of sediment to be dredged. Samples of the proposed capping material must also be taken. To ensure that sediment samples are not diluted with large volumes of water, a clamshell dredge or similar device is used to sample both contaminated sediment and capping material. Representative subsamples of both materials are taken for initial bulk analysis and characterization. All sediments are to be placed into polyethylene-lined steel barrels, sealed, and stored at 4 °C until tested.

Sediment sampling and preparation

The capping effectiveness test is run using representative samples of the contaminated and capping sediments (see Chapter 3 of the main text). Sediment samples are composited and mixed, using a motorized mixer (to ensure a homogenous sediment sample). Any unused sediment is returned to the containers, stored at 4 °C, and later discarded if there is no further need for the sediment.

Materials and equipment

The following items are required to conduct the laboratory test:

a. Twelve to fifteen 22.6-L cylindrical plexiglass units, 120 cm in height and 15.5 cm in diameter attached to a 30-cm, 2-plexiglass base (Figure C1). The units should be fitted with a sampling port.

b. Twelve plexiglass plungers, 80 cm in length with a wire hook attached at the top.

c. Twelve pint-size bottles of mineral oil.

d. Six aquarium pumps (two small-scale units per pump) or some other source of air supply.

e. Twelve 1-cm-long air stones.

f. Two plexiglass tubes, 130 cm in length, 7.28-cm inside diameter.

g. Two large funnels, 40.8-cm top diameter, 6.60-cm outside diameter at the base.

h. Tygon tubing, 3.02-mm inside diameter.

Test procedure

Step 1 - Add contaminated sediment to the units. The contaminated sediment is mixed, then placed in the bottom of the small-scale units to a depth of 10 cm (Figure C1). It is important to add the sediment carefully to avoid splashing on the sides of the units. Three of the units are reserved for capping material only as described in Step 2.

Step 2 - Add capping material. The capping material is mixed and then added in varying thicknesses (e.g., 10, 20, and 30 cm) to triplicate units containing the contaminated sediment (Figure C1). Three units with contaminated sediment receive no cap. An additional three units receive 10 cm each of capping material only. Units containing contaminated sediment alone and units with capping material alone serve as controls.

Step 3 - Water addition and unit aeration. For an estuarine or marine simulation, 10 L of artificial seawater is prepared using artificial sea salts to achieve the salinity of the proposed disposal area. For a freshwater simulation, 10 L of either distilled or reverse osmosis water is used. The water is added as gently as possible to each small-scale unit and allowed to equilibrate for 3 days while being aerated. Aeration will ensure that the DO concentration in all units is at or near saturation (within *0.5 mg/L) at the start of the test.

After 3 days of aeration, the airstone is removed, and a plunger and mineral oil are added. The plunger is used for daily mixing to prevent the establishment of concentration gradients in the water column and to ensure a well-mixed column. Mineral oil is used to seal the surface of the water column from the atmosphere to allow the development of anaerobic conditions in the water column. The plunger is suspended between the sediment and the mineral oil. Mixing should be done in a manner that will not disturb the sediment in the bottom of the unit or breach the mineral oil on the surface of the water. After mixing, the plunger is left suspended in the water column.

Step 4 - DO measurements. Water samples are taken immediately after aeration for initial DO determination. Dissolved oxygen is measured daily until the DO is depleted in the water column of the uncapped contaminated sediment. The consequences of reducing the volume of the water column by taking DO samples is accounted for by multiplying the DO concentration (milligrams per liter) by the volume of water remaining in the unit after a given sampling. (See the Calculations section that follows.)

Step 5 - Water sampling and preservation. Water samples to be analyzed for ammonium-nitrogen and orthophosphate-phosphorus are taken immediately after the DO is depleted (Day 0) and subsequently on Days 15 and 30. These water samples should be cleared of particulate matter by passing through a 0.45-m membrane filter, preserved by acidification with concentrated hydrochloric acid (HCl) to pH 2, then stored at 4 °C. After the water column is sampled on Day 30, all water samples (Days 0, 15, and 30) are analyzed. Results from previous small-scale studies (Brannon et al. 1985, 1986; Gunnison et al. 1987; Environmental Laboratory 1987) have shown that complete anaerobic conditions are achieved in the water column within 30 days.

Data interpretation and analyses

The results from these laboratory tests indicate which of the thicknesses tested reduce overlying-water oxygen demand and transfer of ammonium-nitrogen and orthophosphate-phosphorus from the contaminated sediment to the level of the cap material alone.

Oxygen-depletion rates and ammonium-nitrogen and orthophosphate-phosphorus release rates are determined by performing linear regression analyses of mass uptake or release per unit area (milligrams per square meter) versus time. Means and standard deviations are determined for the triplicates, and t-tests are conducted to determine the statistical significance of differences between the means. Rates plotted are the means and standard deviation of three replicates and represent values greater than the controls.

Calculations

The rates in this test are defined as milligrams per square meter per day. The total tracer concentration is determined by Equation C1:

$$T_t = P_d \cdot V_r \tag{1}$$

Then, the rate of release or mass uptake is evaluated using Equation 2,

$$R_a = T_t / A_u / day \tag{2}$$

where

T_t = tracer total concentration (mg) in the unit

P_d = tracer dissolved concentration (mg/ml) as determined by chemical analysis

V_r = volume of water (ml) remaining in the water column after a given sampling

R_a = rate of release or mass uptake, mg/m^2/day

A_u = area (m) of the unit

day = number of days of study

The recommended thickness can then be evaluated by comparing the release rates (R_a) of tracers through the thicknesses tested to the release rates of tracers from the capping material alone. For a given thickness to be considered effective, its release rates must equal those from the capping material alone, or there should be no statistically significant difference.

Figure C2 is an example graph showing oxygen-depletion rates of the Black Rock Harbor sediment capped with sand plotted against cap thickness (centimeters). It is important to note that a series of cap thicknesses ranging from 2 to 26 cm were evaluated. The data points for Figure C2 are means and standard deviations of three replicates. Results show that a 22-cm cap of sand resulted in inhibition of oxygen demand equal to that of the sand cap itself, thus indicating a seal effective in isolating the overlying water column from oxygen demand due to Black Rock Harbor sediment. In this case, the recommended thickness for reducing oxygen demand on the overlying water by the contaminated sediment is 22 cm.

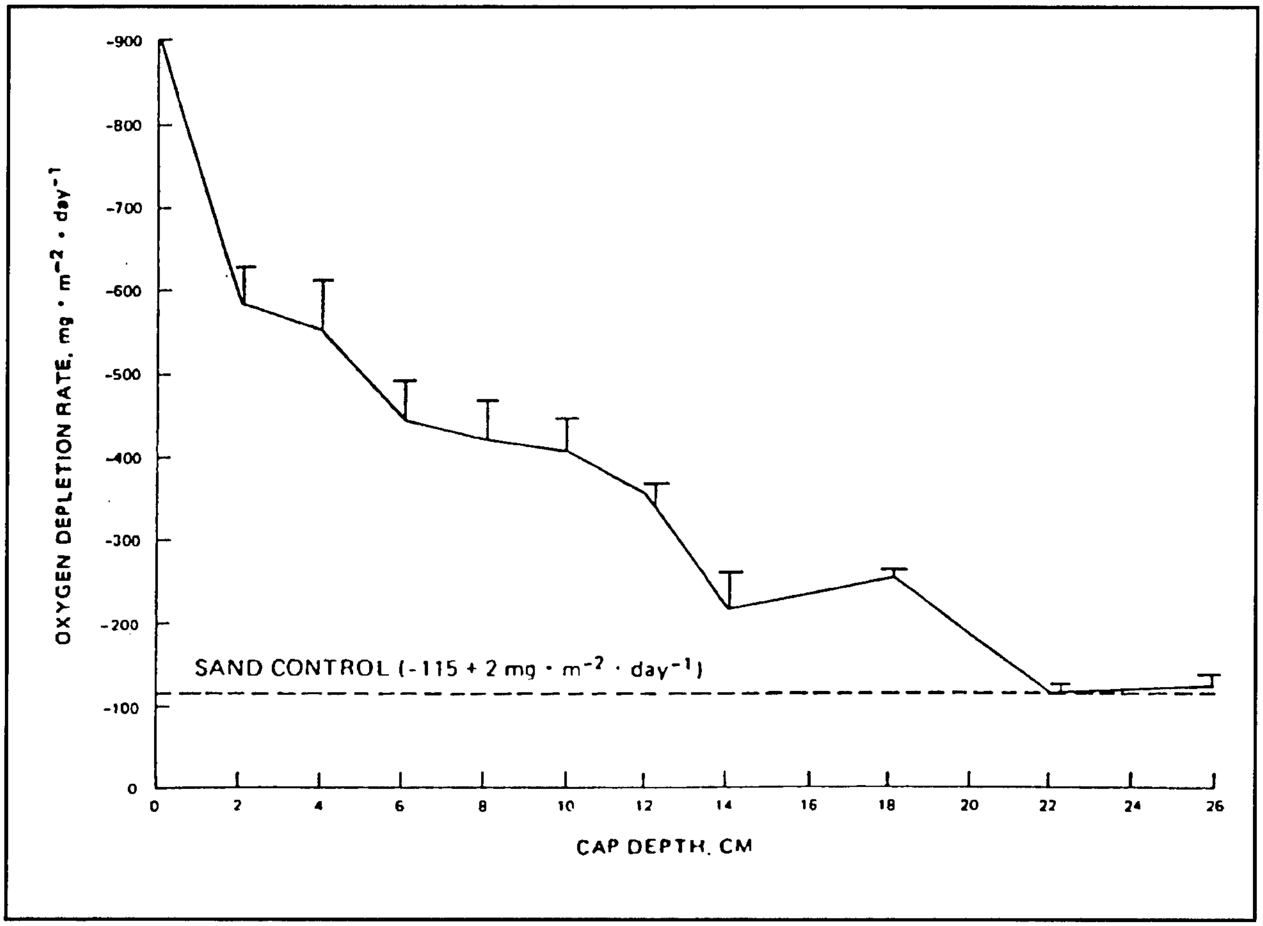


Figure C2. Typical results for effect of sand cap on oxygen command (Sturgis and Gunnison 1988)

Appendix D
Short-Term Fate (STFATE) of Dredged Material Model

Introduction

This appendix presents a summary description of the STFATE (Short-Term FATE of dredged material disposal in open water) model, a module of the Automated Dredging and Disposal Alternatives Management System (ADDAMS) (Schroeder and Palermo 1990). ADDAMS is an interactive computer-based design and analysis system in the field of dredged-material management. The general goal of the ADDAMS is to provide state-of-the-art computer-based tools that will increase the accuracy, reliability, and cost effectiveness of dredged-material management activities in a timely manner. The description of STFATE given in this appendix is a summary of the detailed information available in the users guide for the model provided in the inland testing manual for dredged material disposal (U.S. Environmental Protection Agency/U.S. Army Corps of Engineers (EPA/USACE), in preparation).

Theoretical Basis

The STFATE module is based on the earlier DIFID (DIsposal From an Instantaneous Discharge) model originally prepared by Koh and Chang (1973). STFATE has been refined several times to expand its predictive capability over a wider range of project conditions. The model is used for discrete discharges from barges and hoppers. The behavior of the material during disposal is assumed to be separated into three phases: convective descent, during which the disposal cloud falls under the influence of gravity and its initial momentum imparted by gravity; dynamic collapse, occurring when the descending cloud either impacts the bottom or arrives at a level of neutral buoyancy where descent is retarded and horizontal spreading dominates; and passive transport-dispersion, commencing when the material transport and spreading are determined more by ambient currents and turbulence than by the dynamics of the disposal operation. Figure D1 illustrates these phases. Details on the theoretical basis of the model are found in EPA/USACE (1991), EPA/USACE (in preparation), Johnson (1990), Koh and Chang (1973), and Brandsma and Divoky (1976).

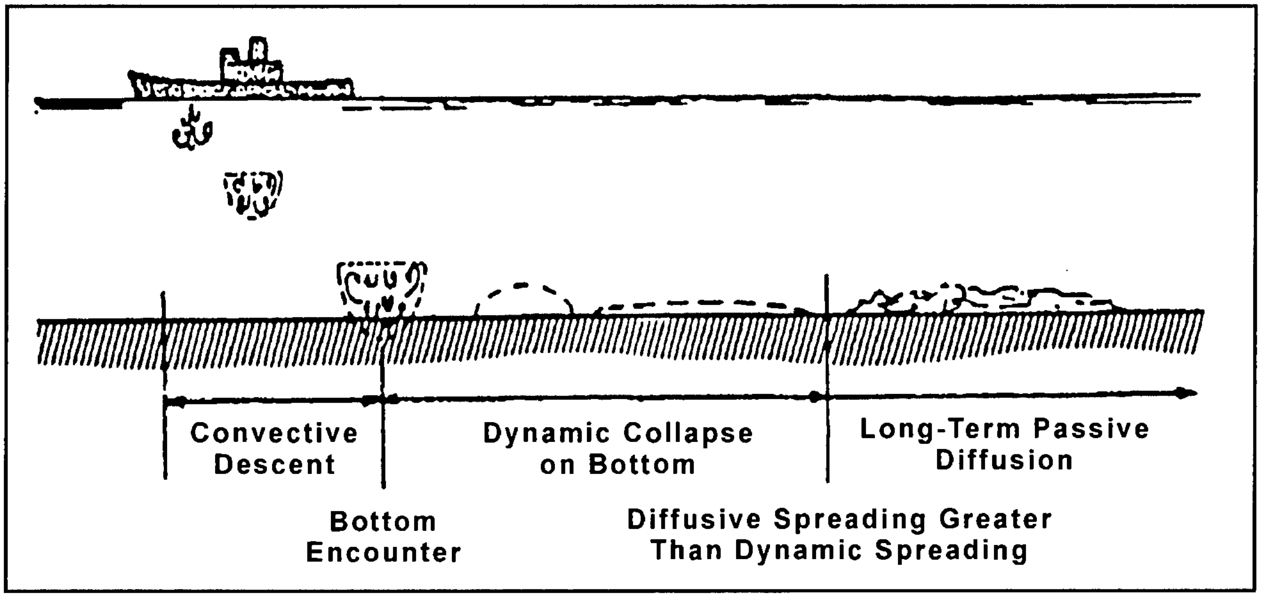


Figure D1. Illustration of placement processes

Model Input

Input data for the model are grouped into the following general areas: (a) description of the disposal site, (b) description of site velocities, (c) controls for input, execution, and output, (d) description of the dredged materials, (e) description of the disposal operation, and (f) model coefficients.

Ambient conditions include current velocity, density stratification, and water depths over a computational grid. The dredged material is assumed to consist of a number of solid fractions, a fluid component, and conservative dissolved contaminants. Each solid fraction has to have a volumetric concentration, a specific gravity, a settling velocity, a void ratio for bottom deposition, critical shear stress, and information on whether or not the fraction is cohesive and/or strippable. For initial-mixing calculations, information on initial concentration, background concentration, and water quality standards for the constituent to be modeled has to be specified. The description of the disposal operation includes the position of the disposal barge or hopper dredge on the grid; the barge or hopper dredge velocity, dimensions, and draft; and volume of dredged material to be dumped. Coefficients are required for the model to accurately specify entrainment, settling, drag, dissipation, apparent mass, and density gradient differences. These coefficients have default values that should be used unless other site-specific information is available. Table D1 lists the necessary input parameters with their corresponding units. Table D1 also lists the input parameters for determining the contaminant of concern to be modeled based on dilution needs. More detailed descriptions and guidance for selection of values for many of the parameters are provided directly on-line in the system.

Model Output

The output starts by echoing the input data and then optionally presenting the time history of the descent and collapse phases. In descent history, the location of the cloud centroid, the velocity of the cloud centroid, the radius of the hemispherical cloud, the density difference between the cloud and the ambient water, the conservative constituent concentration, and the total volume and concentration of each solid fraction are provided as functions of time since release of the material.

At the conclusion of the collapse phase, time-dependent information concerning the size of the collapsing cloud, its density, and its centroid location and velocity as well as contaminant and solids concentrations can be requested. The model performs the numerical integrations of the governing conservation equations in the descent and collapse phases with a minimum of user input. Various control parameters that give the user insight into the behavior of these computations are printed before the output discussed above is provided.

At various times, as requested through input data, output concerning suspended sediment concentrations can be obtained from the transport-diffusion computations. With Gaussian cloud transport and diffusion, only concentrations at the water depths requested are provided at each grid point.

For evaluations of initial mixing, results for water column concentrations can be computed in terms of milligrams per liter of dissolved constituent for Tier II evaluations or in percent of initial concentration of suspended plus dissolved constituents in the dredged material for Tier III evaluations. The maximum concentration within the grid and the maximum concentration at or outside the boundary of the disposal site are tabulated for specified time intervals. Graphics showing the maximum concentrations inside the disposal-site boundary and anywhere on the grid as a function of time can also be generated. Similarly, contour plots of concentration can be generated at the requested water depths and at the selected print times.

Target Hardware Environment

The system is designed for the 80386-based processor class of personal computers using DOS. This does not constitute official endorsement or approval of these commercial products. In general, the system requires a math coprocessor, 640 KB of RAM, and a hard disk. The STFATE executable model requires about 565 KB of free RAM to run; therefore, it may be necessary to unload network and TSR software prior to execution. The model is written primarily in Fortran 77, but some of the higher level operations and file-management operations are written in BASIC; some of the screen control operations in the Fortran 77 programs are performed using an Assembly language utility program.

Availability of Models

All U.S. Army Engineer Waterways Experiment Station (WES) computer models referred to in this report are available as a part of the Automated Dredging and Disposal Alternatives Modeling System (ADDAMS), and can be downloaded from the World Wide Web from the WES Dredging Operations Technical Support (DOTS) homepage at http://www.wes.army.mil/el/dots/dots.html.

References

Brandsma, M. G., and Divoky, D. J. (1976). "Development of models for prediction of short-term fate of dredged material discharged in the estuarine environment," Contract Report D-76-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Johnson, B. H. (1990). "User's guide for models of dredged material disposal in open water," Technical Report D-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Koh, R. C. Y., and Chang, Y. C. (1973). "Mathematical model for barged ocean disposal of waste," Environmental Protection Technology Series EPA 660/2-73-029, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, P. R., and Palermo, M. R. (1990). "Automated dredging and disposal alternatives management system, User's Guide," Technical Note EEDP-06-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

U.S. Environmental Protection Agency/U.S. Army Corps of Engineers. (1991). "Evaluation of dredged material proposed for ocean disposal (Testing Manual)," EPA-503/8-91/001, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

__________. "Evaluation of dredged material proposed for discharge in inland and near-coastal waters - Testing manual," Report in preparation, U.S. Environmental Protection Agency, Washington, DC.

Table D1
STFATE Model Input Parameters

Parameter	Disposal Operation Types[1]	Units	Options[2]
Contaminant Selection Data			
Solids concentration of dredged material		g/L	
Contaminant concentration in the bulk sediment		μg/kg	
Contaminant concentration in the elutriate		μg/L	
Contaminant background concentration at disposal site		μg/L	
Contaminant water quality standards		μg/L	
Site Description			
Number of grid points (left to right)	H, B		
Number of grid points (top to bottom)	H, B		
Spacing between grid points (left to right)	H, B	ft	
Spacing between grid points (top to bottom)	H, B	ft	
Constant water depth	H, B	ft	C
Roughness height at bottom of disposal site	H, B	ft	
Slope of bottom in x-direction	H, B	degrees	
Slope of bottom in z-direction	H, B	degrees	
Number of points in density profile	H, B		
Depth of density profile point	H, B	ft	
Density at profile point	H, B	g/cc	
Salinity of water at disposal site	H, B	ppt	Optional
Temperature of water at disposal site	H, B	Celsius	Optional
Grid points depths	H, B	ft	V
Velocity Data			
Type of velocity profile	H, B		
Water depth for averaged velocity	H, B	ft	
Vertically averaged x-direction velocity	H, B	ft/sec	
			(Sheet 1 of 4)

[1] The use of a parameter for disposal operations by a multiple bin hopper dredge is indicated in the table by an H, while a parameter used for disposal from a split-hull barge or scow is indicated by a B.
[2] The use of a parameter for the constant depth option or variable depth option is indicated in the table by a C or V, respectively. Other optional uses for parameters are so indicated.

Table D1 (Continued)

Parameter	Disposal Operation Types	Units	Options
Velocity Data (Continued)			
Vertically averaged z-direction velocity	H, B	ft/sec	
Water depths for 2-point profile	H, B	ft	
Velocities for 2-point profile in x-direction	H, B	ft/sec	
Velocities for 2-point profile in z-direction	H, B	ft/sec	
Velocities for entire grid in x-direction	H, B	ft/sec	
Velocities for entire grid in z-direction	H, B	ft/sec	
Input, Execution, and Output Keys			
Processes to simulate	H, B		
Duration of simulation	H, B	sec	
Long-term time step for diffusion	H, B	sec	
Convective descent output option	H, B		
Collapse phase output option	H, B		
Number of print times for long-term diffusions	H, B		
Location of upper left corner of mixing zone on grid	H, B	ft	
Location of lower right corner of mixing zone on grid	H, B	ft	
Water quality standards at border of mixing zone for contaminant of concern	H, B	mg/L	
Contaminant of concern	H, B		
Contaminant concentration in sediment	H, B	mg/kg	
Background concentration at disposal site	H, B	mg/L	
Location of upper left corner of zone of initial dilution (ZID) on grid	H, B	ft	
Location of lower right corner of ZID on grid	H, B	ft	
Water quality standards at border of ZID for contaminant of concern	H, B	mg/L	
Number of depths in water column for which output is desired	H, B		
Depths for transport - diffusion output	H, B	ft	
Predicted initial concentration in fluid fraction	H, B	mg/L	
Dilution required to meet toxicity standards	H, B	percent	
Dilution required to meet toxicity standards at border of ZID	H, B	percent	

(Sheet of 2 of 4)

Table D1 (Continued)			
Parameter	**Disposal Operation Types**	**Units**	**Options**
Material Description Data			
Total volume of dredged material in the hopper dredge	H	yd^3	
Number of distinct solid fractions	H, B		
Solid-fraction descriptions	H, B		
Solid-fraction specific gravity	H, B		
Solid-fraction volumetric concentration	H, B	yd^3/yd^3	
Solid-fraction fall velocity	H, B	ft/sec	
Solid-fraction deposited void ratio	H, B		
Solid-fraction critical shear stress	H, B	lb/sq ft	
Cohesive? (yes or no)	H, B		
Stripped during descent? (yes or no)	H, B		
Moisture content of dredged material as multiple of liquid limit	H, B		Cohesive
Water density at dredging site	H, B	g/cc	
Salinity of water at dredging site	H, B	ppt	Optional
Temperature of water at dredging site	H, B	Celsius	Optional
Desired number of layers	B		
Volume of each layer	B	yd^3	
Velocity of vessel in x-direction during dumping of each layer	B	ft/sec	
Velocity of vessel in z-direction during dumping of each layer	B	ft/sec	
Disposal Operation Data			
Location of disposal point from top of grid	H, B	ft	
Location of disposal point from left edge of grid	H, B	ft	
Length of disposal vessel bin	H, B	ft	
Width of disposal vessel bin	H, B	ft	
Distance between bins	H	ft	
Predisposal draft of hopper	H	ft	
Postdisposal draft of hopper	H	ft	
Time required to empty all hopper bins	H	sec	
Number of hopper bins opening simultaneously	H		
			(Sheet 3 of 4)

Table D1 (Concluded)

Parameter	Disposal Operation Types	Units	Options
Disposal Operation Data (Continued)			
Number of discrete openings of sets of hopper bins	H		
Vessel velocity in x-direction during each opening of a set of hopper bins	H	ft/sec	
Vessel velocity in z-direction during each opening of a set of hopper bins	H	ft/sec	
Bottom depression length in x-direction	H, B	ft	Optional
Bottom depression length in z-direction	H, B	ft	Optional
Bottom depression average depth	H, B	ft	Optional
Predisposal draft of disposal vessel	B	ft	
Postdisposal draft of disposal vessel	B	ft	
Time needed to empty disposal vessel	B	sec	
Coefficients			
Settling coefficient	H, B		
Apparent mass coefficient	H, B		
Drag coefficient	H, B		
Form drag for collapsing cloud	H, B		
Skin friction for collapsing cloud	H, B		
Drag for an ellipsoidal wedge	H, B		
Drag for a plate	H, B		
Friction between cloud and bottom	H, B		
4/3 Law horizontal diffusion dissipation factor	H, B		
Unstratified water vertical diffusion coefficient	H, B		
Cloud/ambient density gradient ratio	H, B		
Turbulent thermal entrainment	H, B		
Entrainment in collapse	H, B		
Stripping factor	H, B		

(Sheet 4 of 4)

Appendix E Multiple Dump Fate (MDFATE) of Dredged Material Model

Introduction

This appendix provides information on the computer program Multiple Dump Fate (MDFATE) formally known as Open-Water Disposal Area Management Simulation (ODAMS) (Moritz and Randall 1995). MDFATE is a site management tool that bridges the gap between the STFATE (Johnson 1990) and LTFATE (Scheffner et al. 1995) models. It simulates multiple disposal events at one site to predict the creation of navigation hazards, examine site capacity, and conduct long-term site planning. MDFATE uses modified versions of STFATE and LTFATE for simulations. Similar to LTFATE, local wave and tide information input is required as well as disposal-site boundaries and bathymetry. The disposal-site bathymetry can be either automatically generated (flat or sloping), or actual bathymetric data from an ASCII file can be imported. The suspended solids and conservative tracer portions of STFATE are removed so the modified STFATE version models the convective descent, dynamic collapse, and passive diffusion process only.

Because of the modified LTFATE version, MDFATE can also account for cohesive and noncohesive sediment transport, cohesive sediment consolidation, and noncohesive avalanching. MDFATE can also simulate capping based on the slow release of material from a barge/hopper so it may spread evenly on the bottom with a minimum amount of momentum imparted to the primary mound.

This appendix provides an overview of the theoretical background of MDFATE, personal computer (PC) requirements, required input, and typical output.

Overview of MDFATE

MDFATE was developed to address dredged material placement site management issues. By tracking the volume of material placed in an offshore disposal site from multiple dredging operations, site managers can plan for maximum utilization of the site. Multiple disposals that are point dumped during one specific operation can be simulated to determine if navigation obstructions would be created. For site-use planning, MDFATE will ultimately allow site managers to plan for additional disposal sites as sites reach capacity.

While STFATE simulates short-term processes (seconds to hours) and LTFATE simulates long-term processes (days to months) of dredged material mounding, MDFATE brackets these processes by modeling the accumulation of material on the bottom resulting from multiple disposals.

MDFATE may be roughly categorized into three primary components: grid generation, model execution, and postprocessing. The initial step in executing MDFATE and the foundation of the model is grid generation. Subsequent to grid generation, model execution consists of running the modified versions of LTFATE and STFATE, which provide information to augment the grid. Postprocessing consists of various plotting routines to present model results.

Disposal site-grid generation is based on a user-specified horizontal control (state plane or latitude-longitude) to create a horizontal grid. Presently, MDFATE can accommodate a grid with 40,000 nodes, which will allow representation of a disposal site up to approximately 22,000 by 22,000 ft (100-ft grid interval). ODMDS corner points are specified by the user, and MDFATE creates the horizontal grid based on desired grid intervals.

Vertical control is based on a user-specified datum. MDFATE can automatically create a uniform flat or sloping bottom based on the datum of interest, or MDFATE can overlay actual bathymetric data in ASCII form and apply it to the horizontal grid by a multipoint polynomial interpolation.

Once grid generation is completed, MDFATE can simulate multiple (hundreds) disposal events that can extend over 1 year. The disposal operation is broken down into individual week-long episodes during which long-term processes are simulated by the modified version of LTFATE. Within each week-long episode, the modified version of STFATE is executed that simulates dredged material dumped through the water column to bottom accumulation. Cumulative results are generated for self-weight consolidation, sediment transport by waves and currents, and mound avalanching.

The original version of STFATE simulates single disposal events (i.e., one dump) to model water column concentrations of suspended solids and a conservative tracer (not done for MDFATE version). STFATE also generates a disposal mound footprint identifying the extent of dredged material coverage for the dump as well as mound volume and thickness. Water column currents can be accounted for as well as sloping or depression disposal areas. Differences in material composition can be considered, and layering of different materials in the hopper can be modeled also. Based on material properties, currents, etc., stripping of fines is accounted for, and an estimate of how the material accumulates on the seafloor is provided. STFATE output consists of plots of mound footprint coverage and thickness of bottom accumulation. MDFATE modifies the existing bathymetric grid according to the STFATE-predicted mound footprint and bottom thickness. Subsequent STFATE outputs are appended to the grid, thus creating a composite mound.

For the week-long simulations, LTFATE models the long-term processes affecting the created composite mound. The processes modeled include morphological changes resulting from cohesive and noncohesive sediment erosion, noncohesive sediment avalanching, and cohesive sediment consolidation. For the sediment erosion processes, LTFATE requires input from hydrodynamic databases for tides and waves. The tidal current time-series is generated from user-specified tidal constituents for the site of interest by the program TIDE. Wave statistics from the Wave Information Study (WIS) are used (provided by the user for the site of interest) by the program HPDSIM to generate a wave time-series and ultimately wave-induced currents. The net resulting tidal and wave currents are then used to drive the sediment transport portion of the model. These two routines are also used by the STFATE model within MDFATE to generate the water column currents that affect material settling for the short-term processes.

A summary of the noncohesive and cohesive sediment transport algorithms used by MDFATE can be mound in the description of LTFATE (Appendix F).

The avalanching routine applied in LTFATE is based on a routine developed by Larson and Kraus (1989), who adapted the work of Allen (1970) on slope failure. Allen's (1970) experiments showed that two limiting slopes occurred, angle of initial yield and the residual angle after shearing, which were influenced by the particle deposition-rate gradient, particle concentration at the time of deposition, and particle size and density. Allen (1970) examined the effect of a larger deposition rate at the top of a slope versus the toe of a slope, which in effect produced a steepening by rotating the slope around the toe. When the slope becomes unstable, it avalanches, and a new more stable slope is formed.

To account for consolidation of cohesive sediment, the procedure developed by Poindexter-Rollings (1990) for predicting the behavior of a subaqueous sediment mound was followed. The consolidation calculations used by Poindexter-Rollings (1990) and used in LTFATE were based on finite strain theory introduced by Gibson, England, and Hussey (1967). Numerical solutions were developed by Cargill (1982, 1985). Finite strain theory is well-suited for the prediction of consolidation in cases of thick deposits of fine-grained sediments because it provides for the effect of self-weight, permeability that varies with void ratio, nonlinear void ratio-effective stress relationship, and large strains (Scheffner et al. 1995).

Data Requirements

Data requirements for running MDFATE are much the same as those for STFATE (Appendix D) and LTFATE (Appendix F). As described previously, the user must specify ODMDS corner coordinates and interval size for grid generation. Bathymetric data (including datum) must be provided from an external source or automatically generated. Site locations must be identified to specify necessary constituents for the tidal constituent program and to create the wave time series from the WIS location of interest. Other data needs include volume of material to be dredged, dredged material properties (i.e., composition, voids, density, etc.), characteristics of disposal equipment, disposal duration, water column data (density, currents), and method of disposal vessel control. Four options exist for simulating disposal vessel control:

a. Disposal within a given radial distance of a specific geographic location (i.e., disposal within a certain radius of a buoy). Dumps are randomly placed with a bias applied toward the direction of approach of the disposal vessel.

b. Disposals along transect lines identified by starting and ending coordinates.

c. User-specified coordinates for each disposal load.

d. Prerecorded coordinates for each disposal load.

System Requirements

Recommended minimum system requirements for running MDFATE are as follows:

a. IBM compatible 486.

b. DOS version 5.0 or greater.

c. 592 KB RAM.

d. 8 MB available hard disk space.

e. Printer capable of printing graphics (recommended).

Postprocessing

Model output from MDFATE consists of two-dimensional (2-D) contour plots and 3-D surface images. Output can be either viewed within MDFATE or data exported to an external graphics package for plotting. MDFATE also allows grid comparison where before/after scenarios can be examined to analyze mounding and/or erosion of a dredged material mound. Generic mounds may also be created to model long-term morphological behaviors.

Capping Option

A dredged material capping option was developed for inclusion in the MDFATE model. It is based on a modification to STFATE that allows for the slow release of material from a barge/hopper so it may spread evenly on the bottom with a minimum amount of momentum. The capping option specifically addresses the short-term processes that affect dredged material as it experiences passive transport, diffusion, and settling of solids based on individual particle fall speed. The capping option assumes the material will be placed along multiple transects that are repeated and offset to achieve the desired cap thickness.

The STFATE model and its associated grid domain is used as a kernel within the MDFATE grid domain for every disposal/capping event. The capping module uses STFATE with a grid limited to 25 by 25 square elements as opposed to the standard 45 by 45 rectangular grid elements available in the original version of STFATE. If the capping site is large, each load of cap material may require partitioning to ensure its fit within the adapted STFATE grid. Running the adapted STFATE grid as a kernel within the MDFATE grid and possible material partitioning contributes to a higher level of complexity for the capping module than for MDFATE alone. This complexity, therefore, leads to increased execution time.

Two disposal methods can be simulated with the capping module. One method is the slow release of cap material through the slightly cracked (1 to 2 ft) split hull of a split hull barge/hopper dredge. The second method simulates hydraulic pipeline discharge from a hopper dredge reversing its dredge pumps. The simulation can be either for pumping in the direction of vessel transport or counter to vessel transport as the vessel transects the disposal area.

Due to the DOS 640K memory limitations, the capping module must be run independently of the LTFATE long-term processes simulation. If the user desires to simulate both capping and long-term processes, the MDFATE capping module must first be executed followed by the LTFATE portion of MDFATE.

Typical Output

Figures E1 and E2 show typical MDFATE graphical output, 2-D and 3-D contour plots of bathymetry resulting from MDFATE simulations. Textual output consists of tables showing locations of the dumps, volume differences between two bottom bathymetries, and maximum elevation of mounds created. Also, ASCII files containing tables showing the amount of sediments on the bottom and in the water column, identical to those produced by STFATE are created. Finally, the velocity of the descending jet can also be determined from the STFATE-like files.

Availability of Models

All U.S. Army Engineer Waterways Experiment Station (WES) computer models referred to in this report are available as a part of the Automated Dredging and Disposal Alternatives Modeling System (ADDAMS) and can be downloaded from the World Wide Web from the WES Dredging Operations Technical Support (DOTS) homepage at http://www.wes.army.mil/el/dots/dots.html.

References

Ackers, P., and White, W. R. (1973). "Sediment transport: New approach and analysis," *Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers* 99 (HY11).

Allen, J. R. L. (1970). "The avalanching of granular solids on dune and similar slopes," *Journal of Geology* 78.

Ariathurai, R., MacArthur, R. C., and Krone, R. B. (1977). "Mathematical model of estuarial sediment transport," Technical Report D-77-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cargill, K. W. (1982). "Consolidation of soft layers by finite strain analysis," Miscellaneous Paper GL-82-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1985). "Mathematical model for the consolidation/desiccation process in dredged material," Technical Report D-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

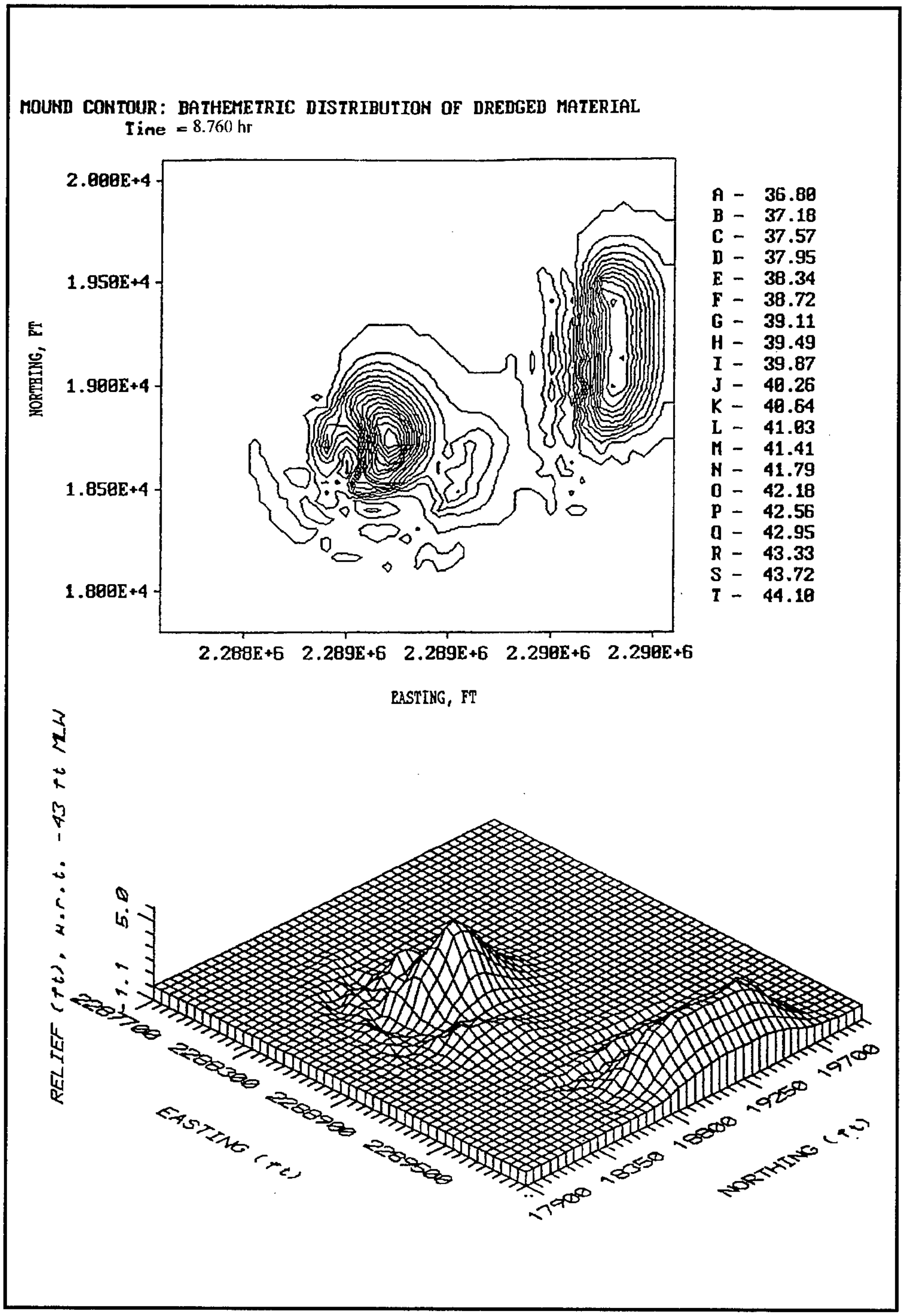


Figure E1. Typical MDFATE model output showing differences between pre-disposal and postdisposal bathymetry

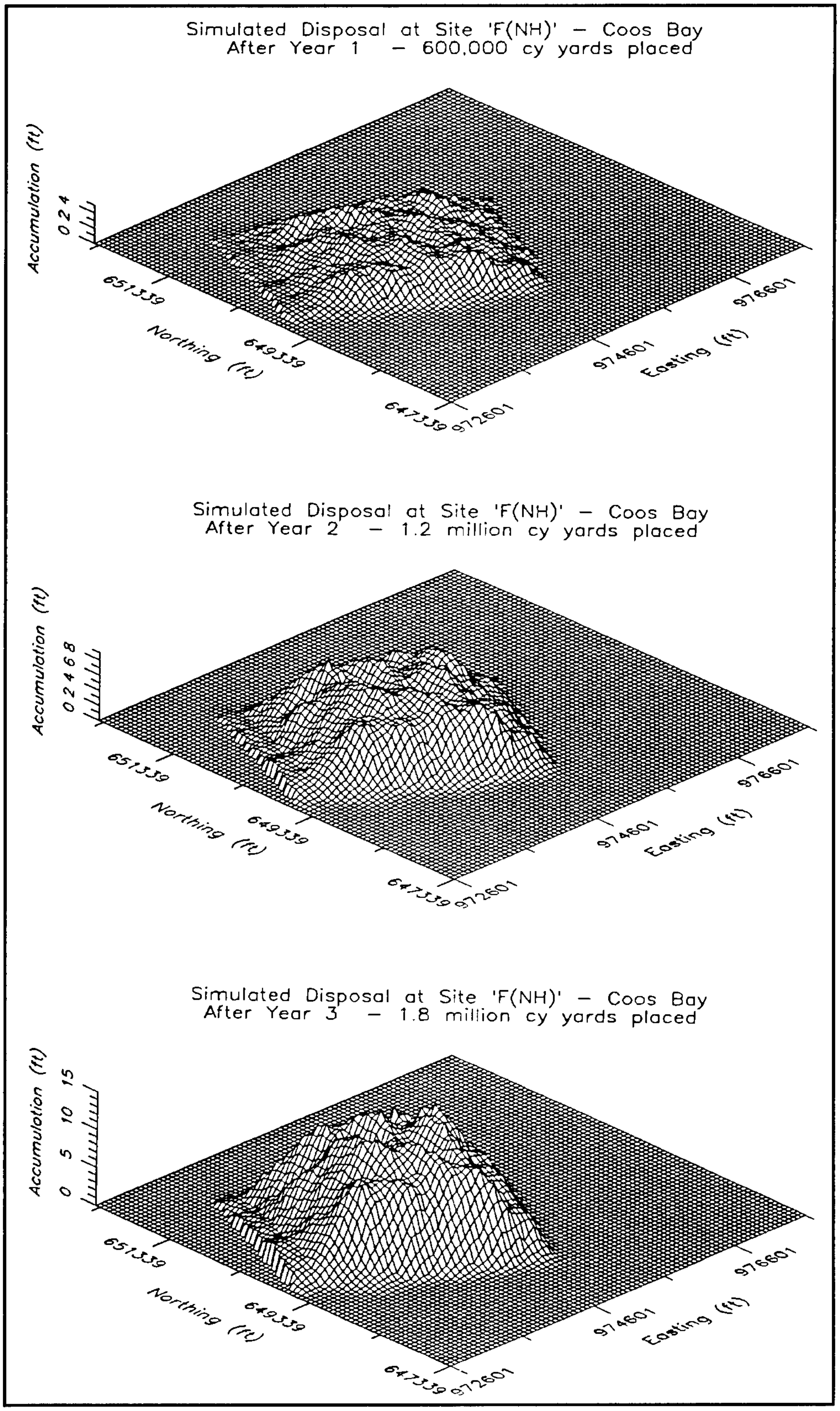


Figure E2. Typical MDFATE model output showing mound formation 1-3 years of disposal at Coos Bay

Gibson, R. E., England, G. L., and Hussey, M. J. L. (1967). "The theory of one-dimensional consolidation of saturated clays; I. Finite non-linear consolidation of thin homogeneous layers," *Geotechnique* 17, 261-273.

Johnson, B. H. (1990). "User's guide for models of dredged material disposal in open water," Technical Report D-90-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Larson, M., and Kraus, N. C. (1989). "SBEACH: Numerical model for simulating storm induced beach change, Report 1: Empirical foundation and model development," Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Moritz, H. R., and Randall, R. E. (1995). "Simulating dredged-material placement at open-water disposal sites," *Journal of Waterway, Port, Coastal, and Ocean Engineering* 121(1).

Poindexter-Rollings, M. E. (1990). "Methodology for analysis of subaqueous sediment mounds," Technical Report D-90-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., Thevenot, M. M., Tallent, J. R., and Mason, J. M. (1995). "LTFATE: A model to investigate the long-term fate and stability of dredged material disposal sites; User's guide," Instruction Report DRP-95-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Teeter, A. M., and Pankow, W. (1989). "Schematic numerical modeling of harbor deepening effects on sedimentation, Charleston, SC," Miscellaneous Paper HL-89-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

White, P. (1972). "A sediment transport in channels: A general function," Report Int 104, Hydraulics Research Station, Wallingford, England.

Appendix F Long-Term Fate (LTFATE) of Dredged Material Model

Introduction

This appendix provides information on the computer program used to execute the Long Term FATE (LTFATE) model. LTFATE is a site-evaluation tool that estimates the dispersion characteristics of a dredged material placement site over long periods of time, ranging from days for storm events to a year or more for ambient conditions. Simulations are based on the use of local wave and currents input to the model. Local, site-specific hydrodynamic input information is developed from numerical model-generated databases; however, user-supplied data files can be substituted for the database-generated files described in this report.

LTFATE has the capability of simulating both noncohesive and cohesive sediment transport. In addition, avalanching of noncohesive sediments and consolidation of cohesive sediments are accounted for to accurately predict physical processes that occur at the site. It should be emphasized that LTFATE, although demonstrated to accurately simulate mound movement, is still under development. Modifications are underway that will improve the basic description of sediment processes. These additions include modifications for mounds on a sloped bottom bathymetry and layering of sediments to account for the decrease in cohesive sediment resuspension potential with depth. Also, additional field and laboratory work are necessary to fully understand (and thus be able to model) cohesive sediment erosion and deposition processes under high shear stresses. LTFATE is designed to lend itself easily to code modification to include new processes.

This appendix provides an overview of the theoretical background on which the model is based, the personal computer (PC) requirements to run the model, required input, and typical output. Details on all of these aspects can be found in Scheffner et al. 1995.

Overview of LTFATE

LTFATE is a site-analysis program that uses coupled hydrodynamic, sediment transport, and bathymetry change models to compute site stability over time as a function of local waves, currents, bathymetry, and sediment size. LTFATE was developed to simulate the long-term fate and stability of dredged material placed in open water with an initial intended use for classifying existing or proposed disposal sites as dispersive or nondispersive. If the site is demonstrated to be dispersive, model output will provide an estimate of the temporal and spatial fate of the eroded material. This determination is often difficult to quantify because the movement of sediment is a function of not only the local bathymetry and sediment characteristics, but also the time-varying wave and current conditions. LTFATE overcomes these difficulties by using an information database to provide design wave and current time series boundary conditions that realistically represent conditions at the candidate disposal site.

The wave simulation methodology and the elevation and current databases referenced in this report were developed through the Dredging Research Program (DRP) at the U.S. Army Engineer Waterways Experiment Station (WES). The procedures for generating stochastic wave height, period, and direction time series are reported in Borgman and Scheffner (1991). The database of tidal elevations and currents for the east coast, Gulf of Mexico, and Caribbean Sea are described in Westerink, Luettich, and Scheffner (1993), and the database of tropical storm surge and current hydrographs is reported in Scheffner et al. (1994). These data are used to generate wave and current boundary condition data for use as input to LTFATE for evaluating mound stability. If these databases are not available for the geographic area of interest to the user, then replacement input files will have to be supplied by the user and copied into the appropriately designated files.

Noncohesive mound movement

The LTFATE model uses four coupled subroutines to predict dredged material movement of various types of noncohesive material during different stages of mound evolution. These subroutines simulate hydrodynamics, sediment transport, mound cascading, and bathymetry change. LTFATE uses the equations reported by Ackers and White (1973) as the basis for the noncohesive sediment transport model. The equations are applicable to uniformly graded noncohesive sediment with a grain diameter in the range of 0.04 to 4.0 mm (White 1972). Because many disposal sites are located in relatively shallow water, a modification of the Ackers-White equations was incorporated to reflect an increase in the transport rate when ambient currents are accompanied by surface waves. The modification is based on an application of the concepts developed by Bijker (1971) and enhanced by Swart (1976). This preliminary model was verified to prototype data by Scheffner (1991) and was shown to be a viable approach to providing quantitative predictions of disposal-site stability.

Kraus and Larson (1988) found that in some large wave tank cases, the local slope of a mound of noncohesive material exceeded the angle of repose due to constant waves and water levels. Therefore, the concept of slope failure was incorporated in LTFATE to ensure stability of the dredged material mound by employing an algorithm developed by Larson and Kraus (1989). The algorithm is based on laboratory studies conducted by Allen (1970), who investigated steepening of slopes consisting of granular solids. Allen (1970) recognized two limiting slopes, the angle of initial yield and the residual angle after shearing. If the slope exceeds the angle of initial yield, material is redistributed along the slope through avalanching, and a new stable slope is attained, known as the residual angle after shearing.

Cohesive mound movement

An improved cohesive sediment transport model has recently been incorporated into LTFATE to account for transport of fine-grained material, i.e., silts and clays. Fine-grained sediments are hydraulically transported almost entirely in suspension rather than as bed load; therefore, the Ackers-White equations are not applicable for these conditions. The cohesive sediment transport model requires bottom shear stress as input. The total bottom shear stress due to currents and waves is determined using the combined current/wave >perceived velocity=, V_{wc} (Bijker 1971; Swart 1976) and bottom roughness parameters. This method for calculating shear stress, like most others, is influenced by bottom roughness parameters. These parameters are frequently not available for the study area, and the results may change significantly depending on their values. Bottom roughnesses for typical ocean sediments can be used in lieu of actual data.

The factors influencing the resistance of a cohesive sediment bed to erosion may be best described by Ariathurai and Krone (1976) as: (a) the types of clay minerals that constitute the bed; (b) structure of the bed (which in turn depends on the environment in which the aggregates that formed the bed were deposited), time, temperature, and the rate of gel formation; (c) the chemical composition of the pore and eroding fluids; (d) stress history, i.e., the maximum overburden pressure the bed had experienced and the time at various stress levels; and (e) organic matter and its state of oxidation. It is obvious from this description that the resistance of the bed to erosion will be different not only from site to site, but also potentially with depth at a given location. Therefore, erosion potential is usually considered a site-specific function of shear stress (and sometimes depth). Methods have been developed to determine erosion based on stresses, but these equations require parameters whose values are site specific. A commonly used method of relating erosion to shear stress has been incorporated into LTFATE. This method relates erosion as a function of shear stress to some exponential power. The equation for the erosion rate in grams/square centimeter/second is:

$$\varepsilon = A_O \left(\frac{J - J_{cr}}{J_r} \right)^m$$

where

A_0 and m = site-specific parameters

J = shear stress due to currents and waves

J_{cr} = site-specific critical shear stress below which no erosion occurs (which can reasonably be set to 5 *dynes/cm²* if site data are not available)

J_r = a reference shear stress (assumed to be 1 $dyne/cm^2$)

Most research on cohesive sediment erosion has been performed in laboratory settings at moderate shear stresses less than 20 $dynes/cm^2$ (Lavelle, Mofjeld, and Baker 1984). The method incorporated into LTFATE was developed for moderate stresses. Data for high shear stresses are sparse, and the experimental methods are still under development (McNeil, Taylor, and Lick 1996). Despite this, a lot can be determined by using the moderate shear equations in high-shear regions. It would appear from bathymetry measurements in high-shear regions that the above equation can adequately simulate these conditions.

It should be noted that the values of the site-specific parameters used in these methods can vary significantly. Experimentally determined values of A_0 range over several orders of magnitude from 1×10^{-9} to 5×10^{-6} ($g/cm^2/sec$) and m ranges from 1 to 5 (Lavelle, Mofjeld, and Baker 1984). The experimental range of exponent m values coupled with the equation for J demonstrate that the relationship between velocity and erosion is highly nonlinear (J is a function of V^2 and ε is a function of J^m resulting in ε is a function of V^{2m}). Therefore, the rare storm events will produce most of the cohesive sediment erosion for a given year. This is well known to occur in many rivers, lakes, and nearshore environments. Some studies on San Francisco Bay sediments suggest that m ranges from 1-2 for these sediments, assuming they have had long compaction periods (Parthenaides 1965). The higher values of m are reserved for freshwater lake and river sediments. For application of LTFATE, erosion tests should be performed on site sediments. If at all possible, values for A_0 and m should be determined from laboratory experiments on sediment cores extracted from the study area. If no such data are available, values for A_0 and m can be set to 7.6×10^{-8} $g/cm^2/sec$ and 2, respectively. These values will produce a decent conservative (i.e., high) estimate for erosion potential. They were developed for recently deposited sediments at the New York Bight Mud Dump site. They will produce a conservative estimate because they are for recently deposited, and therefore more easily resuspended, sediments.

Required hardware

The following are recommended minimum hardware requirements for running the LTFATE interface on a PC with a standard Disk Operating System (DOS) Version 3.3 or greater:

a. 386-25 MHZ processor (faster processors are recommended, they greatly reduce execution time).

b. Math coprocessor.

c. 620 K resident memory.

d. VGA monitor (required).

e. Hard disk with several megabytes free.

f. HP LaserJet II or III (or compatible) printer for hard copy.

A compiler is not required because the LTFATE interface and model are distributed as executable files together with several data files. The PC version of the LTFATE interface may access all memory within the 640-K DOS limit. Therefore, the LTFATE interface should be run from the DOS prompt with all resident memory programs removed to ensure enough memory exists for model execution. The graphic routine provided in this package, HGRAPH,[1] is non-proprietary and property of the U.S. Government.

Program files

The LTFATE package presently consists of the following three main programs:

a. PC_WAVEFIELD.

b. PC_TIDAL.

c. PC_LTFATE.

LTFATE in its entirety may be used as a complete site evaluation package, or individual programs may be accessed independently for other applications.

PC_WAVEFIELD creates a time series of wave height, period, and direction based on the computed intercorrelation matrix describing the statistical properties of wave height, period, and direction, and their respective interrelationships.

[1] The program HGRAPH was developed by Mr. David W. Hyde, Structural Engineer, WES, Structures Laboratory, Vicksburg, MS.

The matrix is computed from a time series of data corresponding to the location of interest.

In PC_TIDAL, a database containing the harmonic constituents for tidal elevation and currents for a site-specific location are used to generate an arbitrarily long sequence of tidal data. PC_TIDAL includes the following two options: (a) simulation of the long-term tide sequence, and (b) generation of time history plots for the tide elevation, velocity components, and direction.

Lastly, the program PC_LTFATE automatically accesses data generated by the programs PC_WAVEFIELD and PC_TIDAL to simulate long-term dredged material mound movement. These two programs require input files describing the statistical distribution of a site-specific wave field and tidal harmonic constituents relative to that site. If these data are not available, the user is required to supply the appropriately named files to substitute for the output files ordinarily generated by the programs PC_WAVEFIELD and PC_TIDAL.

The PC_LTFATE program should be employed only after executing programs PC_WAVEFIELD and PC_TIDAL. PC_LTFATE includes the following four options: (a) seabed geometry configuration program, (b) simulation of dredged material mound movement, consolidation, and avalanching, (c) generation of dredged material mound evolution contour plots, and (d) generation of dredged material mound evolution cross-sectional plots.

Databases for waves, tides, and storm surge to support LTFATE are available only for the east and Gulf coasts of the United States. For these applications in other areas, the user is required to supply time series data for waves and storm surge (for storm-event applications) or provide tidal elevation and current constituents, and wave time series (for long-term simulations). Therefore, it is assumed that the user is proficient in the use of a PC, is able to use an editor (if necessary), and can write simple data construction programs and manipulate files. These skills are necessary in order to transfer user-supplied data into the PC and copy it into the appropriate files that are accessed by LTFATE.

Three external user-supplied input files are required by the model to specify wave, tidal, and storm surge boundary conditions for a specific location of interest. Site-specific files will have to be obtained (the Coastal and Hydraulics Laboratory (CHL), WES, can provide these files) or generated by the user in order to define wave and current boundary condition input corresponding to the location of interest.

The first of these external files, named TIDAL.DAT, is used to define a time series tidal elevation and current boundary condition at the subject disposal mound. The TIDAL.DAT file contains amplitude and epoch harmonic tidal constituents for both elevation and currents corresponding to the location of the mound.

Because the LTFATE model requires both tidal elevation and current (*U* and *V*) time series input, harmonic constituents for all three variables must be contained in the data file. This input file can be generated through execution of the program TIDES.EXE. However, the TIDES.EXE program requires an input database of harmonic constituents at discrete locations and, through interpolation, generates elevation and current constituents for any desired location into the appropriate format in the file TIDAL.DAT. The constituent database has been generated for the east coast, Gulf of Mexico, and Caribbean Sea (Westerink, Luettich, and Scheffner 1993) and described in DRP Technical Note DRP-1-13 (Scheffner 1994). Constituent output for a specific location can be obtained by contacting CHL. The tidal constituent database for the west coast is currently under development.

If tidal constituent coverage of the area of user interest is not available, tidal constituent data will have to be obtained from alternate sources; for example, WES technical reports, the National Oceanic and Atmospheric Administration, university sources, open literature, etc., or through harmonic analyses of available or collected elevation and current time series. Adequate data are usually available, but will have to be located and supplied by the user. An example use of external data is reported by Scheffner and Tallent (1994). If the user supplies the necessary data, it must be formatted as shown in Table F1 and should be named TIDAL.DAT.

Table F1
Example LTFATE Tidal Input Data File—TIDAL.DAT

```
  MOBILE, ALABAMA
   TIDAL HEIGHT HARMONIC CONSTITUENTS  (CM/SEC)
        6     0.0     -5.8    -10.4
 CONST    SPEED-D/H      AMP-M   EPOCH-D   AMP-C/S   EPOCH-D
AMP-C/S   EPOCH-D
                      HEIGHT              VEL-U               VEL-V
   M2      28.984104      .01    321.00    4.3      46.        6.7     41.
   S2      30.000000      .01    309.60    1.2      47.        1.8      5.
   N2      28.439730      .00    339.10    0.6     317.        1.2    255.
   K1      15.041069      .13    325.70    8.5     229.       14.3    231.
   O1      13.943036      .12    313.30    6.7     242.       10.4    235.
   M1      14.492754      .00    332.80    0.6     330         0.6    346
```

The second file required for long-term simulation of dredged material mound movement is a file containing a time series of wave height, period, and direction named HPDSIM.OUT. This file can either be user supplied or generated internally by LTFATE and is in the format shown in Table F2. If LTFATE generates the file, the additional file HPDPRE.OUT is required. The HPDPRE.OUT file represents the precomputed cross-correlation matrix corresponding to a WIS station location nearest the mound. The combined LTFATE/HPDPRE.OUT

Table F2
Example LTFATE Wave Input Data File—HPDSIM.OUT

```
START MO = 3  START YR =1987  END MO = 8  END YR =1987
 NYR,NNY,NMO=    20  20  12
 IYEARS=  1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 MONTHS=  1 1 1 1 1 1 1 1 1 1 1 1
 CUTOFF=    0.083333   0.083333   0.083333   0.083333   0.083333
 CUTOFF=    0.083333   0.083333   0.083333   0.083333   0.083333
 CUTOFF=    0.083333   0.083333
 IJY=  1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
 IJM=  1 2 3 4 5 6 7 8 9 10 11 12
 198703 100      1.00000    5.00002   343.83057
 198703 103      1.10000    5.00000    35.42109
 198703 106      1.20000    5.00001    52.58537
 198703 109      1.20000    5.00000    58.00993
 198703 112      1.20000    5.00000    53.44814
 198703 115      1.10000    5.00000    36.73721
 198703 118      1.00000    5.00000   340.76096
 198703 121      0.90000    5.00000   293.34930
 198703 200      0.80000    5.00000   283.34152
 198703 203      0.76876    5.00000   279.52328
 198703 206      0.70000    5.00000   277.62357
 198703 209      0.60000    5.00001   276.96350
 198703 212      0.60000    5.00000   276.80725
 198703 215      0.70000    5.00001   277.28809

   ......................................................

 1987082903      0.90000    6.00001    81.11949
 1987082906      0.90000    6.00002    81.50021
 1987082909      0.90000    5.00002    81.90755
 1987082912      0.80001    5.00003    82.21406
 1987082915      0.80000    5.00001    82.76773
 1987082918      0.70000    5.00002    83.25628
 1987082921      0.60000    5.00000    83.61486
 1987083000      0.60000    5.00000    83.84423
 1987083003      0.60000    5.00002    83.97083
 1987083006      0.50000    5.00001    84.04659
 1987083009      0.50000    5.00001    84.10904
 1987083012      0.50000    5.00000    84.17479
 1987083015      0.50000    5.00000    84.23292
 1987083018      0.50000    5.00000    84.25816
 1987083021      0.60000    5.00003    84.26725
 1987083100      0.80000    5.00003    84.27031
 1987083103      0.90000    5.00002    84.25816
 1987083106      1.00000    6.00002    84.21492
 1987083109      1.10000    6.00001    83.96118
 1987083112      1.10000    6.00001    83.34565
```

wave simulation capability is described by Borgman and Scheffner (1991) and Scheffner and Borgman (1992). This approach is used to generate an arbitrarily long time sequence of simulated wave data that preserves the primary statistical properties of the full 20-year WIS hindcast, including wave sequencing and seasonality. Once the matrix has been computed, multiple wave field simulations can be performed, with each time series stored on the file HPDSIM.OUT.

The primary advantage of using this statistically based wave simulation approach is that the user is not limited to a finite length of data; instead, seasonal or yearly repetitions of time series can be used for evaluations of site stability. Each simulation will be statistically similar to the hindcast data but will contain variability consistent with observations. If HPDPRE.OUT matrix is not available for the location of interest, one can be computed by the user or by CHL through use of a WIS 20-year hindcast input file and execution of the program HPDPRE. If the location of interest is not covered by the WIS hindcast database, existing time series of wave height, period, and direction will have to be supplied by the user.

The long-term simulations described above, i.e., simulations of months to years, compute disposal mound stability as a function of residual currents specified by the user in LTFATE, the normal seasonal wave climate, and the tidal elevation and currents computed from the specified tidal constituents in the TIDAL.DAT file. Storm-event erosion calculations are based on surge elevation and currents and the wave field associated with that specific event. These data are contained in the final input file required by LTFATE, the file STORM.DAT. This file must be assembled from existing databases or generated by the user. However, the file is required only if the user desires to simulate the passage of a storm event over the disposal site.

The STORM.DAT file contains either a tropical or extratropical storm surge elevation and current time series hydrograph with a corresponding storm wave height and period corresponding to the selected event. A database of tropical storm hydrographs for 134 historically based tropical storms has been completed for the 486 WIS and offshore discrete locations along the east and Gulf of Mexico coasts and for selected stations offshore of Puerto Rico. This database is described by Scheffner et al. (1994). The companion extratropical event database for the east and Gulf coasts and Puerto Rico has been completed.

A wave climate corresponding to the selected event can be obtained from either available data (if the surge is historically based) or estimated as a function of storm-associated or design peak wave height and periods. In the New York Bight Mud Dump example shown in the frequency of erosion appendix, the surge elevation and velocities were obtained from numerical simulations of the December 1992 extratropical event. The wave field corresponding to the December event was obtained from National Data Buoy Center data. For future applications, surge and current information is now available in a DRP database (reference). If wave data are not available for the selected event, then design peak wave height and period estimates can be used.

The STORM.DAT file should be created by the user of LTFATE to describe a particular storm event or a storm event of assumed shape and duration. An example of hypothetical event use in disposal analysis is given in Scheffner and Tallent (1994).

Program Output

As stated above, the LTFATE program can simulate movement of dredged material mounds both over the long-term and for storms. The final output of the model is a file containing the new mound bathymetry. The bathymetry files can be viewed either as plan view contour plots or cross sections. Figure F1 shows the initial bathymetry of a small sand mound placed in shallow water (17 ft) off Mobile, AL. Figure F2 shows the bathymetry of the same mound approximately 6 months later. Figure F3 shows the change in cross section of the mound along a line 1,500 ft below the centerline of the mound.

Availability of Models

All WES computer models referred to in this report are available as a part of the Automated Dredging and Disposal Alternatives Modeling System (ADDAMS) and can be downloaded from the World Wide Web from the WES Dredging Operations Technical Support (DOTS) homepage at http://www.wes.army.mil/el/dots/dots.html.

Additional Information

For additional information on the LFTATE program, contact Dr. Norman Scheffner (601) 634-3220 of the Research Division of the Coastal and Hydraulics Laboratory at the U.S. Army Engineer Waterways Experiment Station.

References

Ackers, P., and White, R. W. (1973). "Sediment transport: New approach and analysis," *Journal of the Hydraulics Division* 99 (HY11), 2041-60.

Allen, J. R. L. (1970). "The avalanching of granular solids on dune and similar slopes," *Journal of Geology* 78 (3), 326-51.

Ariathurai, R., and Krone, R. B. (1976). "Finite element model for cohesive sediment transport," *J. Hydraul. Div. Am. Soc. Civ. Eng.* 102(HY3), 323-338.

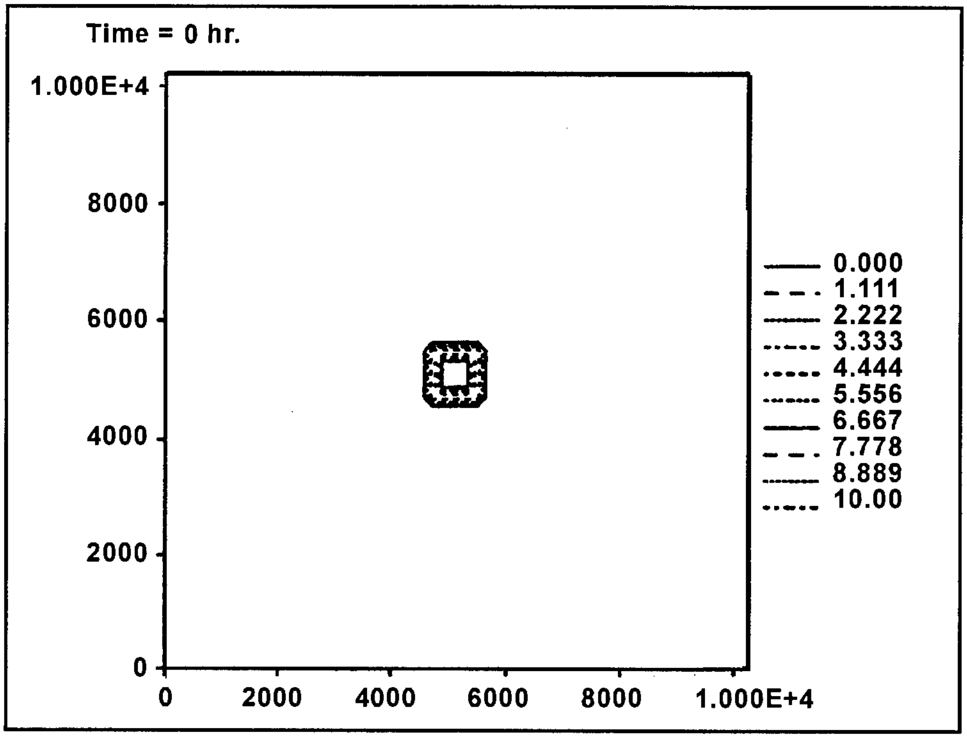


Figure F1. Initial Sand Island mound contours

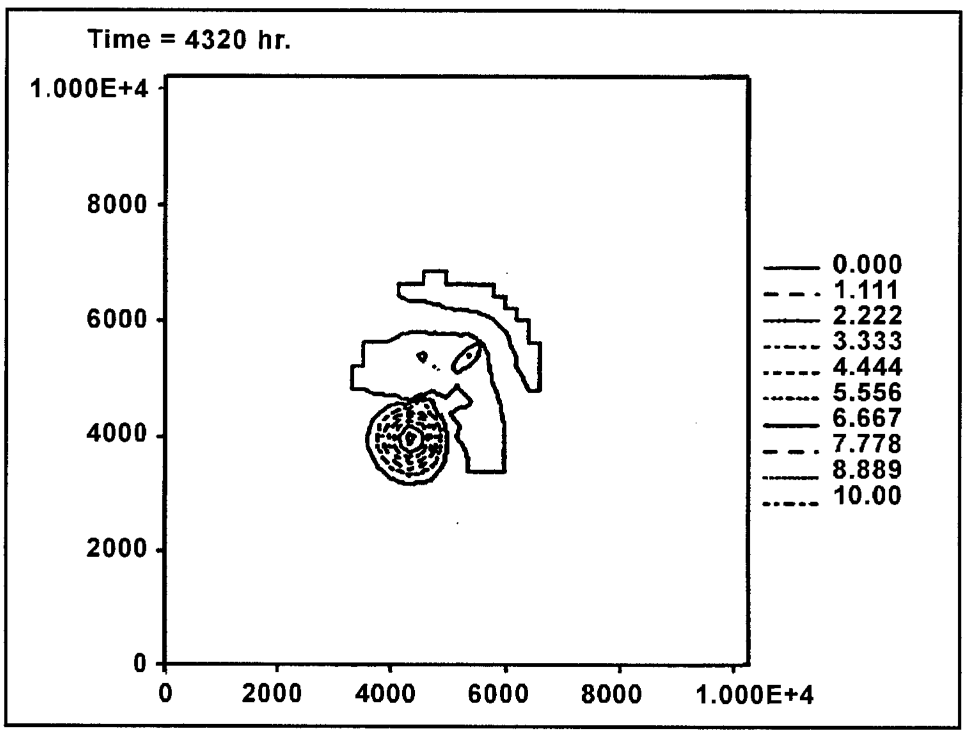


Figure F2. Simulated Sand Island mound contours after 180 days

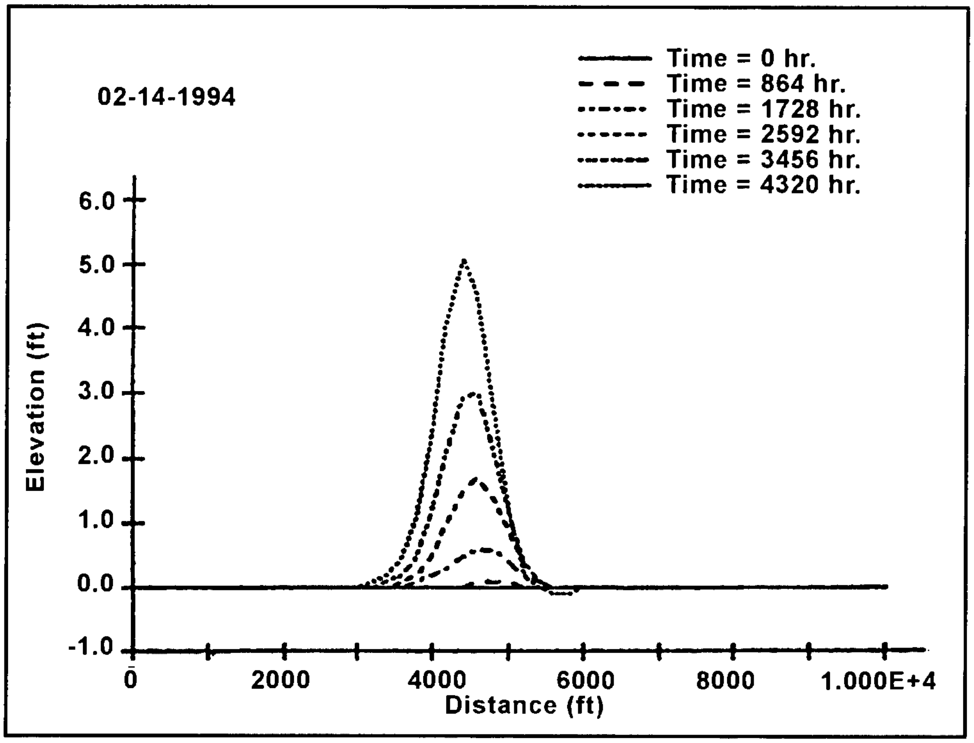


Figure F3. Simulated Sand Island cross section 1,500 ft below centerline

Ariathurai, R., MacArthur, R. C., and Krone, R. B. (1977). "Mathematical model of estuarial sediment transport," Technical Report D-77-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Bijker, E. W. (1971). "Longshore transport computations," *Journal of the Waterways, Harbors, and Coastal Engineering Division* (WW4), 687-701.

Borgman, L. E., and Scheffner, N. W. (1991). "The simulation of time sequences of wave height, period, and direction," Technical Report DRP-91-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cargill, K. W. (1982). "Consolidation of soft layers by finite strain theory," Miscellaneous Paper GL-82-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1985). "Mathematical model of the consolidation/desiccation process in dredged material," Technical Report D-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Corson, W. D., Resio, D. T., and Vincent, C. L. (1980). "Wave information study of US coastlines; Surface pressure field reconstruction for wave hindcasting purposes, Report 1," Technical Report HL-80-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Gibson, R. E., England, G. L., and Hussey, M. J. L. (1967). "The theory of one-dimensional consolidation of saturated clays; I, Finite nonlinear consolidation of thin homogeneous layers," *Geotechnique* 17(3), 261-73.

Hands, E. B., and Allison, M. C. (1991). "Mound migration in deeper water and methods of categorizing active and stable berms." *Proceedings of Coastal Sediments '91*, ASCE, 1985-99.

Kraus, N. C., and Larson, M. (1988). "Beach profile change measured in the tank for large waves, 1956-1957 and 1962," Technical Report CERC-86-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Larson, M., and Kraus, N. C. (1989). "ASBEACH: Numerical model for simulating storm induced beach change, Report 1: Theory and model foundation," Technical Report CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Lavelle, J. W., Mofjeld, H. O., and Baker, E. T. (1984). "An in situ erosion rate for a fine-grained marine sediment," *J. Geophys. Res.* 89(C4), 6543-6552.

McNeil, J., Taylor, C., and Lick, W. (1996). "Measurements of the erosion of undisturbed bottom sediments with depth," *J. Hydraul. Eng.* 122(6), 316-324.

Mehta, A. J., Hayter, E. J., Parker, W. R., Krone, R. B., and Teeter, A. M. (1989). "Cohesive sediment transport - I: Process description," *Journal of Hydraulic Engineering*, ASCE 115(3), 1076-93.

Parthenaides, E. (1965). "Erosion and deposition of cohesive soils," *J. Hydraul. Div. Am Soc. Civ. Eng.* 91(HY1), 105-138.

Scheffner, N. W. (1989). "Disposal site evaluation for the New York Bight," Coastal Engineering Research Center, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1991). "A systematic analysis of disposal site stability." *Proceedings of Coastal Sediments '91*, ASCE, 2012-26.

__________. (1992). "Dispersion analysis of Humboldt Bay, California, interim offshore disposal site," Miscellaneous Paper DRP-92-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

__________. (1994). "Tidal constituent data base - East Coast, Gulf of Mexico, and Caribbean Sea," DRP Technical Note DRP-1-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., and Borgman, L. E. (1992). "A stochastic time series representation of wave data," *Journal of Waterways, Ports, Coastal, and Ocean Engineering* 118(4).

Scheffner, N. W., Mark, D. J., Blain, C. A., Westerink, J. J., and Luettich, R. A. (1994). "AADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries; Report 5, Tropical storm database for the East and Gulf of Mexico Coasts of the United States," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, N. W., and Tallent, J. R. (1994). "Dispersion analysis of the Charleston, South Carolina, ocean dredged material disposal site," Miscellaneous Paper DRP-94-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Scheffner, et al. (1995). "LTFATE: A model to investigate the long-term fate and stability of dredged material disposal sites; User's guide," Dredging Research Program Instruction Report DRP-95-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Swart, D. H. (1976). "Predictive equations regarding coastal transports." *Proceedings of the 15th Coastal Engineering Conference.* ASCE, 1113-32.

Teeter, A. M., and Pankow, W. (1989). "Schematic numerical modeling of harbor deepening effects on sedimentation, Charleston, SC," Miscellaneous Paper HL-89-7, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Westerink, J. J., Luettich, R. A., Jr., and Scheffner, N. W. (1993). "AADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries; Report 3, Development of a tidal constituent database for the Western North Atlantic and Gulf of Mexico," Technical Report DRP-92-6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

White, P. (1972). "Sediment transport in channels: A general function," Report Int 104, Hydraulics Research Station, Wallingford, England.

Appendix G
Procedures for Conducting Frequency-of-Erosion Studies

Introduction

This appendix describes a procedure for determining frequency-of-occurrence relationships for vertical erosion (aka erosion frequency) of dredged material mounds off the Gulf and Atlantic coasts of the United States due to tropical and extratropical storms. The erosion frequency data can be used as a basis for computing the required thickness of the erosion layer portion of a contaminated dredged material mound cap. The design cap must be sufficiently thick to accommodate erosion from storm activity and still provide chemical and biological isolation. The primary goal of erosion frequency studies are therefore to develop information that can be used to determine (a) how thick a cap should be to provide sufficient protection and/or (b) at what depth must a mound with a given cap thickness be located to provide the same level of protection. Specific recommendations for erosion layer thickness design are contained in the body of this report. To make the erosion frequency discussion more easily understood, the procedures are illustrated in an example. The example used is an erosion frequency study done for the U.S. Army Engineer District, New York, as part of a site-capacity study for the Mud Dump disposal site located off Sandy Hook, NJ.

Numerical Models

The ability to effectively conduct erosion frequency studies has been made possible as a result of advances in modeling made by the Corps' Dredging Research Program (DRP) (Hales 1995).[1] The modeling advances were made in two areas. The first area was the development of an integrated hydrodynamic, sediment transport, and bathymetry change model, called Long-Term FATE of Dredged Material (LTFATE) model. This model is capable of modeling the

[1] References cited in this appendix are listed in the References at the end of the main text.

topographic evolution of dredged material mounds over time periods ranging from hours to centuries (Scheffner et al. 1995). A detailed description of LTFATE is found in Appendix F.

The second major modeling advance was the development of a series of databases containing the hydrodynamic driving force time series needed to run LTFATE - water levels and currents. Prior to the DRP, obtaining the hydrodynamic data to run LTFATE was a virtually impossible task because actual storm surge elevation and current data are unavailable except for a few recent storms at selected locations. The water level and current data needed for LTFATE required modeling tides and their associated currents and storm surges due to tropical and extratropical storms over a large area. To accomplish the modeling effort, the DRP funded the development of a state-of-the-art three-dimensional circulation model, called the advanced circulation model, or ADCIRC. A series of reports (Bain et al. 1994; Bain et al. 1995; Luettich, Westerink, and Scheffner 1992; Westerink, Luettich, and Scheffner 1993; and Westerink et al. 1994) describe the model, its development, and testing.

A primary application of ADCIRC for hydrodynamic input required by LTFATE was to compute tides and currents for the east and Gulf coasts. The 20,000 point grid over which ADCIRC computed surface elevations and currents is shown in Figure G1. A companion effort was to compute storm surge levels and the associated currents for 134 major tropical storms (hurricanes) on the east and Gulf coasts (Scheffner et al. 1994). A similar effort has also been conducted for extratropical storms. A comparable effort has been started for the West Coast (Luettich, Westerink, and Scheffner 1994), but the full suite of data needed for routine application of LTFATE for erosion-frequency studies on the West Coast and Great Lakes Coast are not yet available.

Wave data required as input to LTFATE are more readily available, both from gauges and from the Wave Information Studies (WIS) (Hubertz et al. 1994). The WIS series of reports provides hindcast wave heights, periods, and directions data at over one thousand coastal sites on all United States coasts for periods of 20 years or more. WIS wave data are provided at widely spaced (1 degree of latitude) deep-water sites and closely spaced locations (1/4 degree of latitude) in shallow water (typically about 10 m). Wave data can be accessed via a series of WIS reports, more recently electronically via the Coastal Engineering Data Retrieval System (CEDRS) available in Corps Coastal District offices (McAneny, in preparation), and the data are now available on the internet (ref).

Selecting the Proper Methodology for Determining Frequency-of-Occurrence Relationships

There are two methods that have been used by Corps' Districts in coastal design projects for computing frequency-of-occurrence relationships: (a) limited historical data and the selection of one or more "design storms" and/or

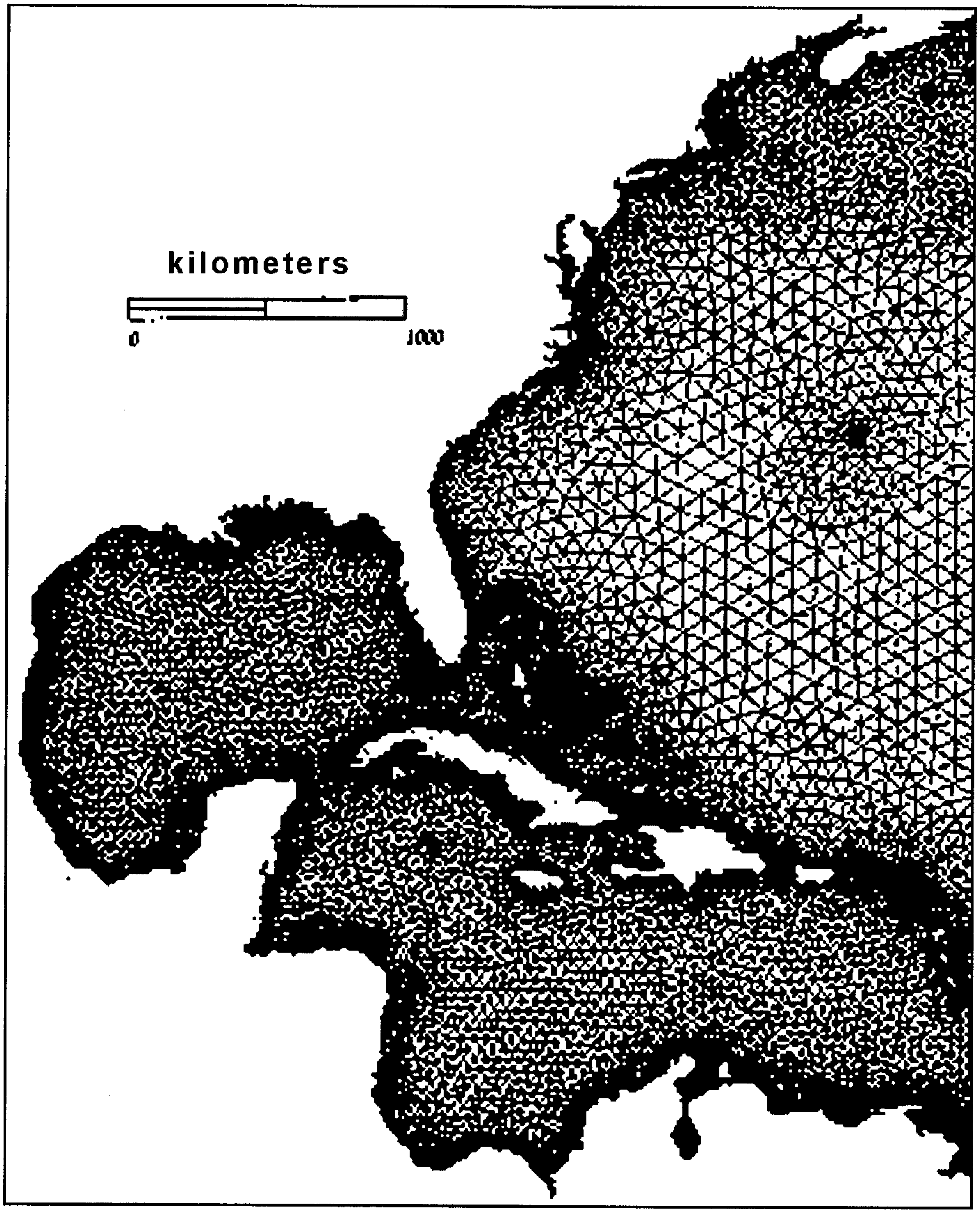


Figure G1. ADCIRC grid for computing surface elevations and currents

(b) application of the Joint Probability Method (JPM). The design storm approach basically involves selecting a severe historic storm event and using it to define a worst case scenario. The disadvantage of this method is that the frequency-of-occurrence of the design storm is usually not well known. Therefore the selected event may impose a more stringent cap design condition than necessary. Conversely, a worst case event may never have occurred at a specific location, and the design storm could lead to an overdesigned cap. In either case, the design storm event provides no information on frequency of occurrence and does not provide any error bands for use in design analysis.

The general JPM approach to assigning frequency relationships begins with parameterizing the storm that generated the effect of concern (e.g., wave height, surge level, bottom current). For hurricanes, descriptive parameters include maximum pressure deficit, maximum winds, radius to maximum winds, speed of translation, and track. The JPM is based on the assumption that the probability for each of the listed parameters can be modeled with empirical, or parametric, relationships. The joint probability of occurrence for a given effect, such as maximum surge, is defined as the probability of a particular storm event, computed as the product of the individual storm parameter probabilities via these assumed parametric relationships. This assumption is the primary basis of the JPM method used in past studies (Myers 1975).

However, the parameters that describe tropical storms are not independent, but are interrelated in some nonlinear sense (Ho et al. 1987). Because the parameters are not independent, joint probability cannot be computed as the product of individual parameter probabilities. Furthermore, it is generally recognized that extratropical storms cannot be effectively parameterized, so parametric probability relationships do not exist. Therefore, the JPM may not provide accurate approximations for tropical storms and is not appropriate for extratropical storms.

The empirical simulation technique (EST) is a statistical procedure for simulating nondeterministic multiparameter systems such as tropical and extratropical storms. The EST, which is an extension of the "bootstrap" statistical procedure (Efron 1982; Efron 1990), overcomes the JPM limitations by automatically incorporating the joint probability of the historical record. The bootstrap method on which EST is based incorporates resampling with replacement, interpolation based on a random walk nearest neighbor techniques with subsequent smoothing. More detailed descriptions of EST can be found in Scheffner, Borgman, and Mark (1993) and Borgman et al. (1992).

In EST, the various geometric and intensity parameters from storms are used to create a large artificial population (several centuries) of future storm activity (Borgman et al. 1992). The only assumption required for EST is that future storms will be statistically similar to past storms. Thus, the future storms generated during EST simulations resemble the past storms but possess sufficient variability to fill in the gaps in the historical data.

To perform the EST, historical storms impacting a site are broken down into the parameters that impact the engineering aspect of interest: storm track, maximum winds, radius to maximum, pressure deficit, etc. These variables are termed input vectors. The storm response of interest, in this case vertical erosion of the capped mound, is also calculated for each historical storm using an appropriate model (in this case LTFATE is used). The response of interest is referred to as response vector. During EST simulations, N-repetitions (say 100 or more) of T-year responses (say 100 to 200 years) of the response vector of interest (vertical erosion for capping projects) are produced providing mean value frequency relationships with accompanying confidence limits such that probability of occurrence can be defined with error band estimates. In other words, the mean vertical erosion for a range of return intervals with confidence limits (based on the number of standard deviations) are produced by the EST procedure.

There have been a number of applications of the bootstrap method and EST to coastal problems. Prater et al. (1985) described error estimation in coastal stage frequency curves for Long Island. Mark and Scheffner (1993) discuss use of the EST to compute frequency of occurrence of storm surge elevations in Delaware Bay. Farrar et al. (1994) describe the use of EST to estimate the frequency of horizontal beach erosion as part of an economic analysis for design of beach fills at Panama City, FL. Most recently, the EST technique was used to predict frequency of vertical erosion estimates for capped mounds at a range of depths at the Mud Dump disposal site located east of Sandy Hook, NJ (Clausner et al. 1996). The work was part of a larger effort for the New York District to determine remaining capacity of the Mud Dump site for both suitable sediments and those requiring capping.

Application of the EST to a capping project involves a series of sequential steps to calculate the cap erosion thickness, which are described in the remainder of this appendix.

Recommended Erosion Frequency Procedure

To define the required cap erosion layer thickness as a function of depth at a specific site, first the erosion frequency must be determined. It consists of a site-specific quantitative analysis approach that requires the completion of several sequential tasks. These tasks are (a) selection of appropriate storm events, (b) development of storm surge elevation and current hydrographs for each event, (c) development of four tidal phase elevation and current hydrographs, (d) development of a wave height and period time series corresponding to each storm event, (e) generation of input files representing the combination of tasks 2-4 to the Long-Term Fate of Dredged Material (LTFATE) model used to predict erosion, (f) execution of the LTFATE model to determine maximum vertical erosion at the site as a result of each of the storm events, (g) development of input files for the Empirical Simulation Technique (EST) program to generate multiple repetitions of storm-event activity and the corresponding vertical erosion, and finally, (h) using the EST program to generate vertical erosion frequency relationships (with error band estimates) for a particular disposal mound configuration.

Detailed descriptions of how each of the above tasks of an erosion frequency study should be conducted follow some background information on the Mud Dump case study example.

Mud Dump Disposal Site Study - Background Information

The frequency-of-occurrence methods described are illustrated in their application to concerns over erosion of capped mounds at the Mud Dump disposal site, the designated dredged material open-water disposal site for the Port of New York and New Jersey (PNY/NJ). Critical to the management of dredged material removed from the PNY/NJ is the remaining capacity within the Mud Dump site. The above procedures were developed to assist in determining the minimum water depths in which capped mounds can be placed without experiencing unacceptable amounts of erosion and therefore directly influence the ultimate capacity of the Mud Dump site to contain contaminated dredged material.

At the time this appendix was written (1996), the Mud Dump disposal site was virtually the only authorized site for open-water placement of dredged material from the PNY/NJ. The site is a 1.12 by 2 n mile rectangle located approximately 6 n miles east of Sandy Hook, NJ (Figure G2), in an area known as the New York Bight. Water depths at the site range from less than 50 ft to over 90 ft. As of October 1994, up to 65 M yd^3 of dredged material (based on scow logs) had been placed in the site. Because the Mud Dump site was the only available disposal site for fine-grained dredged material from the PNY/NJ, the remaining capacity was an extremely important issue in the overall plan for managing dredging and disposal for the Port. Because of the large volume of contaminated material inside the port, the remaining capacity of the Mud Dump site for Category II (requiring special handling, i.e., capping for open-water placement) dredged material (USACE/USEPA 1991) was critical in the sediment management process for the New York District and the PNY/NJ.

At the request of the New York District, the U.S. Army Engineer Waterways Experiment Station's Coastal Engineering Research Center (CERC) conducted a study to define Mud Dump site capacity and other issues related to capping (Clausner, Scheffner, and Allison 1995). Studies to compute the vertical erosion frequency for mounds of various elevations in the Mud Dump site were the most critical part of this effort. Previous studies have shown erosion of fine-grained materials from mound flanks as a result of severe northeasters (McDowell 1993; McDowell, May, and Pabst 1994). At the request of the New York District, mounds with cap elevations ranging from 50 to 75 ft were modeled, with ambient depths of 60 to 83 ft.

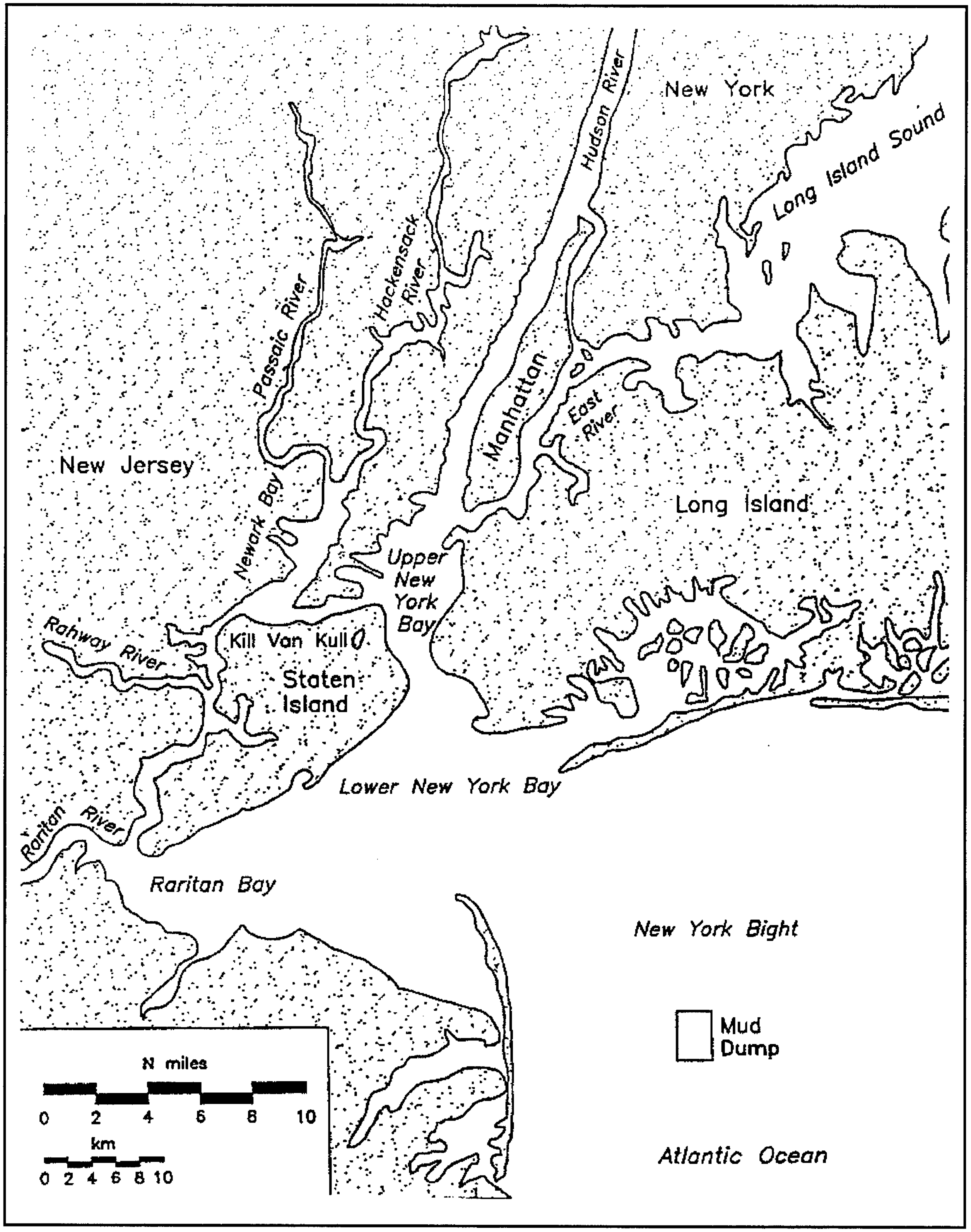


Figure G2. Mud Dump disposal site location map

Storm Selection

The first step in a frequency-of-erosion study is to identify storms that have impacted the site of interest. For sites on the east coast, particularly the northeast coast, both tropical storms (hurricanes) and extratropical storms (northeasters) have to be included. While the tropical storms often have higher winds, the longer duration of the extratropical storms allows them to produce vertical erosion of equal or greater magnitude than hurricanes. Also, northeasters occur much more frequently than hurricanes. For sites on the Gulf coast, northeasters will generally not be a major problem; hurricanes will most likely be the only storms of concern.

Tropical storm selection

The tropical storm database of the National Hurricane Center's HURricane DAT (HURDAT) database (Jarvinen, Neuman, and Davis 1988) is the recommended source of historical events that have impacted the east and Gulf coasts (and therefore the Mud Dump site). The tropical storm database generated by the DRP (Scheffner et al. 1994) contains an atlas of 134 storm events, as well as their respective tracks, that impacted the east and Gulf coasts of the United States. The database contains maximum computed storm surge elevations at up to 486 discrete locations impacted by each event according to the criteria that (a) the minimum pressure of the storm was less than or equal to 995 mb, (b) the eye of the storm passed within 200 statute miles of the location of interest (the Mud Dump site in this application), and (c) the storm generated a surge of at least 1 ft above mean sea level (MSL). The published atlas in Scheffner et al. (1994) tabulates maximum storm surges that have impacted each station and the respective storm events responsible for that surge. Cross-referencing is also provided to show which stations were impacted by each of the 134 events and the respective maximum surge at those stations.

This dual tabulation should be used to identify potential storms impacting the site of interest, the Mud Dump site in this example. Elevation and current hydrographs corresponding to each event and impacted location are available from the DRP database.

The DRP tropical storm database was constructed by simulating the 134 historically based storm events as they propagated over the east coast, Gulf of Mexico, and Caribbean Sea computational domain shown in Figure G1 using the numerical hydrodynamic model ADCIRC described earlier. The DRP database of storm-surge hydrographs and currents was archived at 240 east and Gulf coast Wave Information Study (WIS) stations (Hubertz et al. 1993) with additional locations prescribed for Puerto Rico. To use the DRP tropical storm database information, the WIS station nearest the disposal site of interest is selected. WIS Station 304 (DRP numbering system) is nearest to the Mud Dump site; therefore, storm events impacting this station were selected for the frequency analysis (Figure G3). Station 304 has a depth of approximately 108 ft.

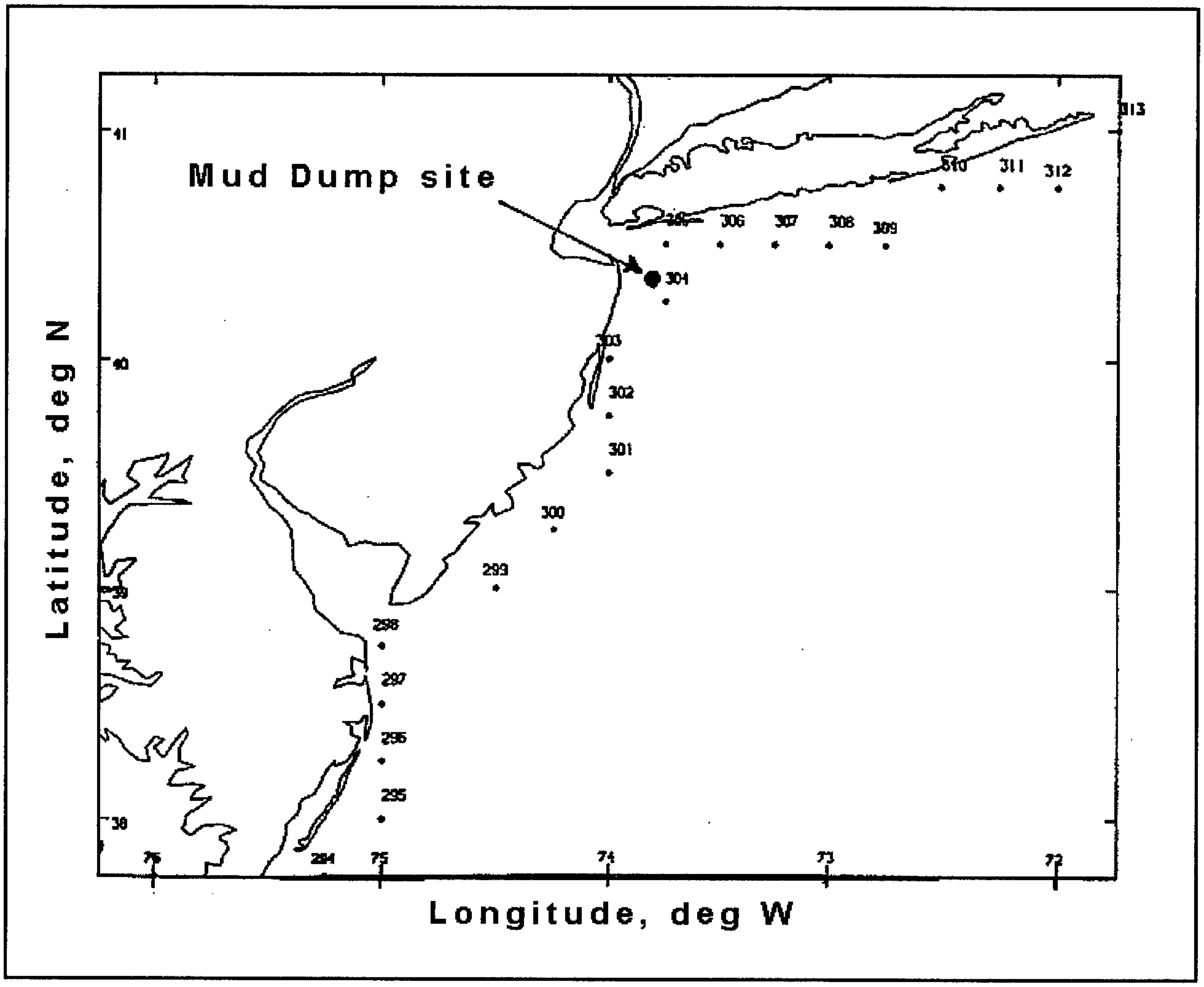


Figure G3. Map showing WIS locations relative to the Mud Dump site

To convert the surge current values from the database location to the disposal site, the mean depth at the two locations is determined. The surge current values should then be assumed to be proportional to the relative depths at the two sites. A mean depth for the Mud Dump site was determined to be approximately 83 ft; therefore, the DRP-generated surge current hydrographs were adjusted according to the criteria that Q=VA=Const; therefore, $V_{Mud} = V_{304}*108/83$.

Sixteen tropical storm events were retrieved from the DRP archives that impacted the location of DRP Station 304 (Mud Dump site) according to the criteria described above. Sixteen tropical storm events in 104 years of record correspond to an annual frequency-of-occurrence of 0.15385 events per year (or one event every 6.5 years). These events are shown in Table G1.

Table G1
Tropical Events Impacting Mud Dump Site

HURDAT Storm No.	Given Name	Date (month/day/year)
296	Not Named	9/22/1929
327	Not Named	8/17/1933
332	Not Named	9/8/1933
353	Not Named	8/29/1935
370	Not Named	9/8/1936
386	Not Named	9/10/1938
436	Not Named	9/9/1944
535	Carol	8/25/1954
541	Hazel	10/5/1954
545	Connie	8/3/1955
597	Donna	8/29/1960
657	Doria	9/8/1967
702	Doria	8/20/1971
712	Agnes	6/14/1972
748	Belle	8/6/1976
835	Gloria	9/16/1985

Extratropical storm event selection

Extratropical events occur at a much greater frequency than tropical events. As a result, a shorter historical time period can be used to represent the range of events that can be expected to impact a particular area. For the extratropical event analysis, approximately 15 to 20 years of winter activity were determined to contain an adequate representation of extratropical events[1] for any area along the east coast of the United States. The 16 winter seasons (September through March) for the period of 1977-78, 1978-79, ... , 1992-93 were selected as the time period for which the DRP extratropical storm database was generated. This time period was selected because it corresponds to dates when the Navy windfield database containing the extratropical winds was available in an ADCIRC-compatible format. The DRP database was then used as the basis for the extratropical frequency analysis described in this appendix.

The DRP extratropical storm database was also constructed by using the ADCIRC numerical hydrodynamic model to simulate all 16 winter seasons over the entire computational domain shown in Figure G1. The U.S. Navy's windfield

[1] Personal Communication, 1994, L. E. Borgman, Professor, University of Wyoming, Laramie, WY.

database, which is archived at every 2.5 degrees of latitude and longitude at a temporal period of 6 hr, was used as input to ADCIRC. The 16 winter season (September-March) input files were prepared by archiving the data within the area of 100° - 60° west longitude and 5° - 50° north latitude, which encompasses the east coast, Gulf of Mexico, and Caribbean Sea as part of ADCIRC's 20,000-node computational grid.

ADCIRC-generated surface elevation and current hydrographs for each 7-month period were archived at 686 locations at a sampling period of 1 hr. Of the 686 stations, 340 correspond to locations (WIS) stations. As for the tropical storms, extratropical storms impacting WIS Station 304 were selected for the frequency analysis.

Storm-Surge Hydrograph Development

Tropical storms

Once identified, the selected tropical storms are retrieved from the DRP database. However, each hydrograph represents the entire storm history, from beginning to end, often a week or more in duration. Because only the erosional effect of the event on the site being studied are of interest, each hydrograph was constructed at a time step of 3 hr to be 99 hr in duration, measured as 48 hr before the well-defined 3-hr duration peak and 48 hr after the peak, for example see Figure G4. The time of peak is selected as the time when the eye of the storm is closest site of interest.

Extratropical storms

For the extratropical storms, the storm event time periods of impact will not be well defined at many locations, including the Mud Dump site. Examination of surge elevation, current magnitude and wave height, and period records from the Mud Dump site did not allow extratropical storms and their duration to be readily identified.

One reason for this difficulty in identifying extratropical storms is the fact that the surge currents accompanying each event are generally relatively small (i.e., on the order of 20-30 cm/sec at the Mud Dump site), and their effects have to be considered with respect to other environmental factors occurring at the time of the storm. These factors include the local depth, the orbital velocities of the wave field, the duration of the event, and the phase of the tide. Therefore, to isolate significant events from the 7-month record, a more quantitative approach to event parameterization is recommended and was developed for the Mud Dump study. This second order parameterization approach is defined following the descriptions of tide and wave field data accompanying the hydrodynamic surge and current response.

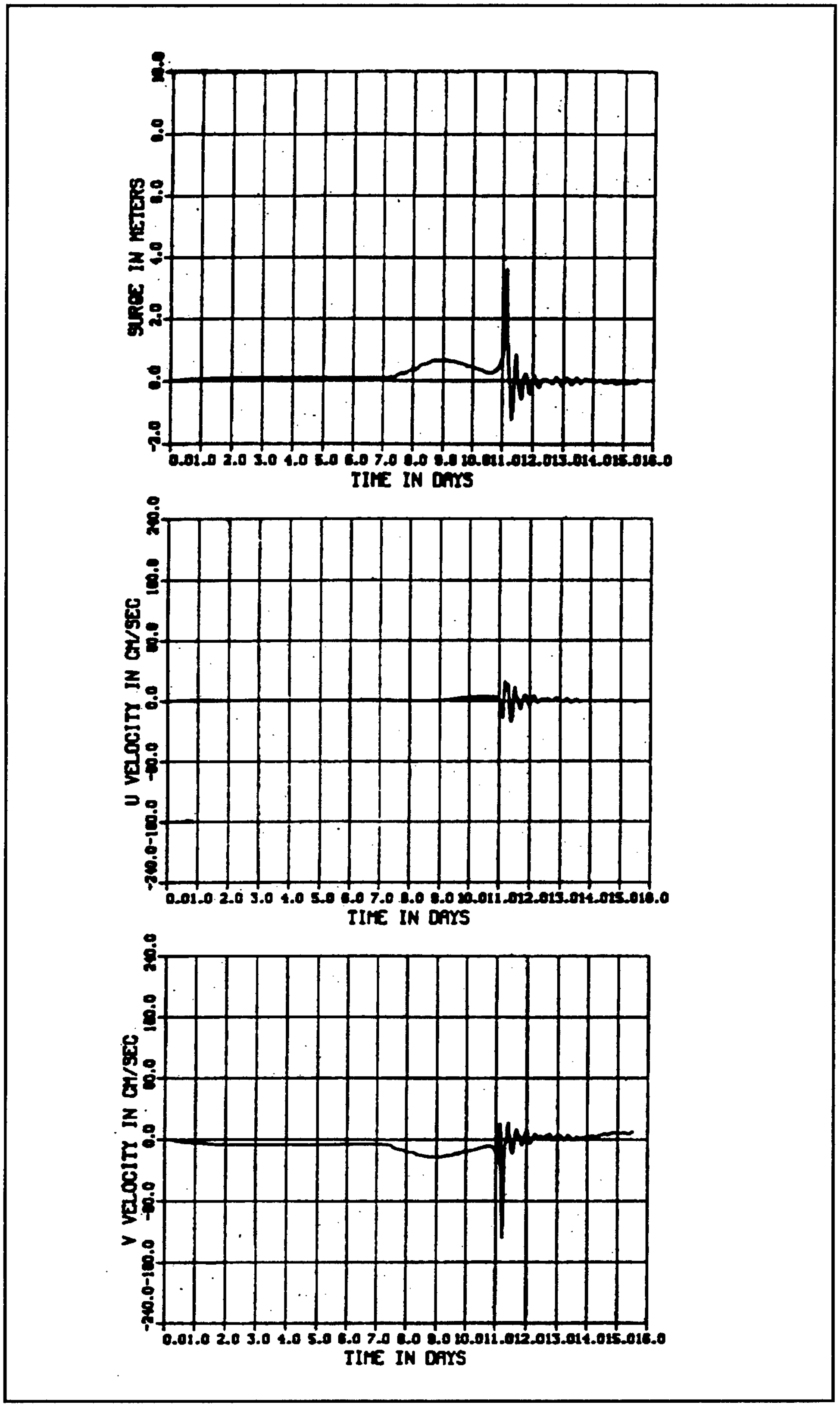


Figure G4. Surge elevation and current hydrograph for Hurricane Gloria, without tides

Tidal Hydrograph Development

The surge hydrographs corresponding to the tropical and 1977-1993 extratropical storm seasons were simulated over the domain shown in Figure G1; however, simulations did not include tides at the time of the event, i.e., they were modeled with respect to MSL. Because tide elevation and currents will be a factor in mound erosion, they must be included. When tidal phase is accounted for, each storm event has an equal probability of occurring at (a) high tide, (b) MSL during peak flood, (c) low tide, and (d) MSL during peak ebb. These four phases are designated as phases 0, 90, 180, and 270 degrees, respectively.

Obtaining the needed tidal elevation and current data can most effectively be accomplished by using the DRP-generated 8-constituent (4 primary semidiurnal and 4 diurnal) database of tidal constituents corresponding to each node shown in Figure G1 (Westerink, Luettich, and Scheffner 1993). This effort also made use of the ADCIRC program. A linear interpolation scheme (described in the report) uses this database to provide tidal constituents at any location within the domain. At the Mud Dump site the M_2 semidiurnal tidal constituent accounts for over 90 percent of the tidal energy (based on the 8-constituent database) as can be seen in the listing of constituent amplitude and local epochs k generated for DRP-WIS Station 304 shown in Table G2. (Constituents were generated at Station 304 instead of the Mud Dump site in order for the tide to correspond to the hydrographs archived at Station 304).

Table G2
Tidal Constituents for DRP-WIS Station 304

Const	h-amp, m	h-k, deg	U-amp, cm/sec	U-k, deg	V-amp, cm/sec	V-k, deg
k_1	0.0867	95.2	0.0049	194.3	0.0061	27.1
O_1	0.0589	100.4	0.0028	193.3	0.0042	43.5
P_1	0.0359	91.0	0.0020	193.5	0.0028	19.7
Q_1	0.0111	98.3	0.0006	202.4	0.0007	19.2
N_2	0.1704	195.6	0.0181	295.6	0.0226	116.0
M_2	0.7744	215.3	0.0837	313.8	0.1012	133.8
S_2	0.1507	254.6	0.0169	355.4	0.0213	173.4
K_2	0.0482	246.6	0.0054	347.2	0.0068	164.9

To account for the four tidal phases, M_2 amplitude A and local epoch phase data k for elevation (h = 0.7744 m, k = 215.3°) and current (U: A = 0.0837 m/sec, k = 313.8°; V: A = 0.1012 m/sec, k = 133.8°) were extracted from the DRP database and used to expand the 16 tropical storms and 16 extratropical season database of storms without tides to a 64 tropical storm database with tides and a 64 extratropical season database with tides. This expanded set of hydrographs represents a combination of the surge hydrograph with the tidal hydrographs generated for the four phases of the tide based on the M_2 tidal constituent.

Wave Field Hydrograph Development

Waves are a critical component of LTFATE input. This section recommends procedures for providing input waves for both tropical and extratropical storms.

Tropical storms

Because LTFATE does not have a storm wave field component, a methodology was adopted from the Shore Protection Manual (SPM) (Headquarters, Department of the Army 1984). The approximation reported in the SPM gives an estimate of the deepwater significant wave height and period at the point of maximum wind for a slowly moving hurricane. A full numerical hindcast of the wave field associated with the historical event would be more accurate than the adopted procedure; however, the SPM approach is expected to be adequate for the purposes of most erosion frequency studies.

The wave height and period are given by the following formulae:

$$H_o = 16.5\, e \frac{R\Delta p}{100} \left[1 + \frac{0.208 \alpha V_F}{\sqrt{U_R}} \right] \tag{G1}$$

and

$$T_s = 8.6\, e \frac{R\Delta p}{200} \left[1 + \frac{0.104 \alpha V_F}{\sqrt{U_R}} \right] \tag{G2}$$

where

H_o = deepwater significant wave height in feet

T_s = corresponding significant wave period in seconds

R = radius to maximum wind in nautical miles

$Dp = p_n - p_o$, where p_n is the normal pressure of 29.93 in. of mercury and p_o is the central pressure of the hurricane

V_F = forward speed of the hurricane in knots

U_R = maximum sustained windspeed in knots calculated 33 feet above MSL at radius R

α = a coefficient depending on the speed of the hurricane. The suggested value is 1.0 for a slowly moving hurricane

All of the above variables used in Equations G1 and G2 are contained in or can be calculated from the HURDAT database.

Given a maximum wave height and period, a wave field time series for tropical storms was calculated through the following expansion:

$$[H(t), T(t)] = [H_o, T_s]e\left(\frac{-9.21}{D}\right)^2\left(t - \frac{D}{2}\right)^2 \tag{G3}$$

where

t = time in hours starting 51 hr before peak surge (at hour 51) and extending 48 hr after peak surge

D = significant duration of the surge, taken as 24 hr

Given a maximum wave height and period, a wave field time series should be calculated starting 51 hr before peak surge (at hour 51) and extending 48 hr after peak surge. Wave heights and periods described by Equation G3 decay to zero; therefore, minimum values must be prescribed for the time series. These minimum values were specified based on summary tables provided by WIS (Hubertz et al. 1993) for the WIS station location cited in this report (WIS Station 72, which corresponds to DRP #304). The average direction of travel for the 16 tropical events was computed to be approximately 11° clockwise from true north (an azimuth of 191° by WIS convention). According to Hubertz et al. (1993), the largest number of waves at an azimuth of 180° were in the 5.0-6.9 sec band. Therefore, a minimum period of 6.0 sec was selected for the storm-event hydrographs. Maximum mean wave conditions for the months of September and October were reported to be 1.2 and 1.3 m, respectively; therefore, a minimum wave condition was selected to be 1.25 m. Finally, maximum wave heights were limited to the breaking wave criteria of H_b = 0.65*depth based on measurements indicating that storm-generated waves in open water are limited to approximately 0.6-0.7 times the local depth (Resio 1994). Scenarios, to be described below, included mound configurations located at three depths, the minimum of which was 63.0 ft. In order to prescribe wave field boundary conditions that are consistent for all simulations, the minimum depth was used to define maximum wave criteria. Therefore, maximum allowable waves were limited to 0.65*63.0 = 40.95 ft = 12.48 m. This criteria should be used for all simulation scenarios.

Extratropical storms

The wave field input for the extratropical database of events should normally be extracted from the WIS hindcast database unless site-specific wave data from a gauge are available. For the Mud Dump study, the wave field was extracted from the WIS hindcast database for the periods of time corresponding to each of the 1977-1993 storm seasons. These data, available at a 3-hr time step, were obtained from the WIS database and combined with the storm surge elevation and current and tidal elevation and current databases. All hydrographs were generated at a 3-hr time step to be compatible with the WIS database and input requirements of the LTFATE model.

Extratropical Storm Identification

As stated above, first order parameters such as surge elevation and currents or wave heights and periods did not immediately isolate specific extratropical storm events of interest for the Mud Dump site. For example, Figure G5 shows the WIS wave height and period time series for the 1977-79 extratropical storm season. The surface elevation and U,V current hydrographs are similar, i.e., specific storms are difficult to identify. This conclusion is in agreement with the recognized observation that extratropical events are not conducive to parameterization.[1] Because it is not feasible to model the entire season with LTFATE to determine which events impact the Mud Dump site (this would require days on a PC running at 100 MHz), a procedure had to be developed to isolate events of interest.

Developing a systematic procedure to identify and subsequently separate significant storm events from the extratropical storm database required an analysis of combinations of individual parameter components that may provide an indication of impact to east coast sites. Because the storm effect of interest for this example is vertical erosion of a disposal mound located at the Mud Dump site, a methodology for identifying storms with measurable erosional impact was developed by combining available storm-event information into a second order parameter, one which represents some combination of first order parameters such as surge, tide, wave height, etc. This parameter was chosen to be the instantaneous sediment transport magnitude, computed as a function of the storm-induced surge elevation and current, the maximum M_2 tidal amplitude and maximum M_2 tidal velocity magnitude, and the wave height and period.

The transport relationship used is based on the Ackers-White (1973) equations with a modification for additional energy provided by waves suggested by Bijker (1971) used in the LTFATE model. The result of the computation is a transport magnitude hydrograph computed as a function of surge, tide, and wave climate. For the Mud Dump site example, the mean depth was specified as 83 ft

[1] Personal Communication, 1994, L. E. Borgman, Professor, University of Wyoming, Laramie, WY.

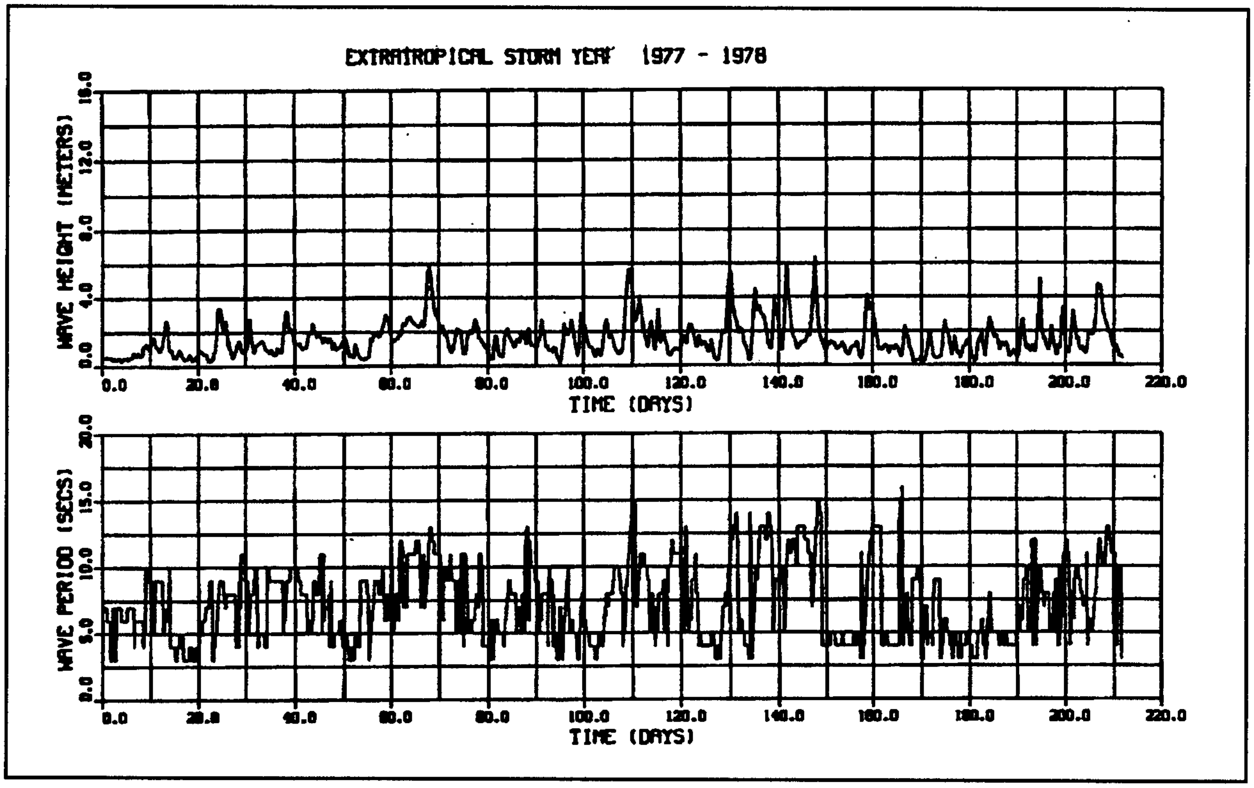


Figure G5. WIS wave height and period time series for 1977-78 extratropical storm season

and mean grain size set at 0.40 mm. The 83 ft depth was the base depth area within the Mud Dump site considered for capping; 0.40 mm sand was the suggested cap material.

The sediment transport hydrograph for the 1977-78 storm season is shown in Figure G6. As evident in the figure, distinct events are now clearly visible in the time series. This approach to event identification is in contrast to the first order parameter time series shown in Figure G5.

Analysis of the 16 seasonal transport hydrographs resulted in the adoption of a threshold value of 30.0×10^{-4} ft^3/sec/ft-width as the basis for selecting events that may cause erosion to the Mud Dump site. This value, selected by trial and error through application of the LTFATE model, will produce a maximum of 0.25 ft of vertical erosion per 24 hr at the corner of mound cap measuring 100 by 100 ft. Table G3 presents a summary of the analysis for the 1977-1993 storm years in the form of the approximate day (measured from 1 September) of occurrence and the magnitude of the peak transport value. The total number of events per season is also tabulated. According to this criteria, the computed average number of events per year that impact the Mud Dump site is 38 events/16 seasons = 2.375 events/year.

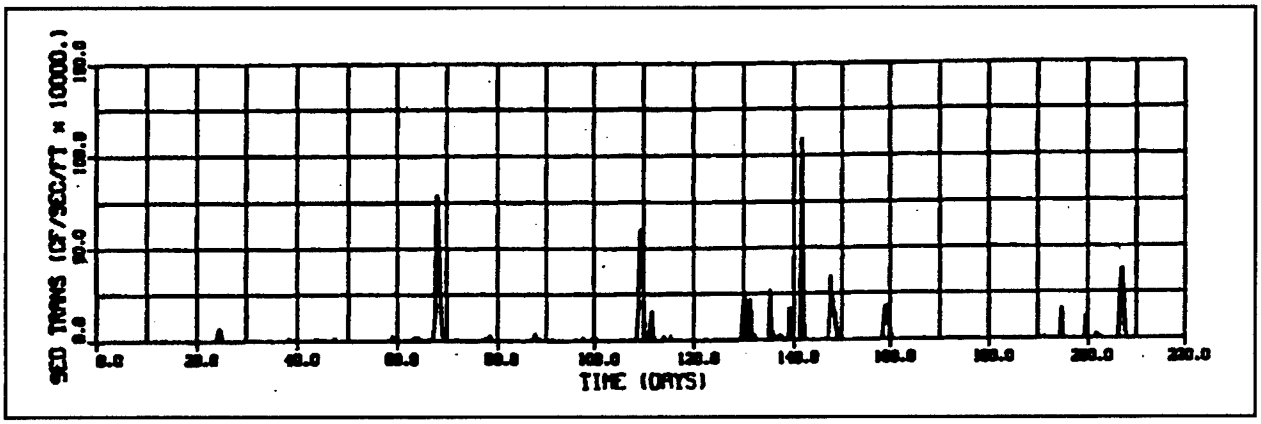


Figure G6. Sediment transport hydrograph for the 1977-78 storm season

Table G3
Summary of Storm Events by Day of Season/Maximum Transport Magnitude in ft^3/sec/ft-width x 10^{-4}

Year	1	2	3	4	5	Total
77-78	68/80	110/65	142/110	207/35	--	4
78-79	146/190	171/50	193/50	205/50	--	4
79-80	132/35	138/35	195/50	--	--	3
80-81	55/125	154/70	163/105	210/30	--	4
81-82	--	--	--	--	--	0
82-83	55/70	164/50	199/50	--	--	3
83-84	41/35	102/110	180/45	210/165	--	4
84-85	43/85	165/180	--	--	--	2
85-86	27/160	65/125	160/30	191/30	200/70	5
86-87	93/190	115/40	123/40	--	--	3
87-88	--	--	--	--	--	0
88-89	--	--	--	--	--	0
89-90	49/33	--	--	--	--	1
90-91	--	--	--	--	--	0
91-92	126/40	--	--	--	--	1
92-93	101/150	165/30	185/120	194/155	--	4

The purpose of selecting specific storms is ultimately to determine frequency-of-occurrence relationships. The specific effect of interest will clearly have a direct bearing on the selection of appropriate storm events. For example, the 10 storm events that cause the most shoreline erosion at a particular location are not necessarily the same 10 events that cause the most vertical erosion of a capped mound in the same area. A separate storm analysis would be required to identify events that cause shoreline/dune recession. However, this second-order parameter approach to storm isolation has been found to be successful in identifying events that cause erosion to a disposal mound. By defining the appropriate parameter, the approach is equally applicable to shoreline processes analyses.

Because vertical erosion is the impact of interest, the transport hydrographs (Figure G6 for 1977-78) were used to identify 38 specific events with a peak transport magnitude greater than the threshold value of 30.0×10^{-4} $ft^3/sec/$ ft-width at the Mud Dump site. These events are listed in Table G3. For each event, surge, tidal, and wave field time series were extracted from the seasonal summary tables to generate hydrographs of total water surface elevation (storm plus tide), total U and V current (storm plus tide), and wave height and period. Each of the 152 hydrographs (38 events with 4 tidal phases) was constructed to be 6 days in duration, centered on the day indicated in Table G3. These hydrographs represent input to the LTFATE model.

LTFATE Model Simulations

After the selected storms have been identified, LTFATE simulations should be used to determine the maximum amount of vertical erosion resulting from each storm for each of the disposal site configurations of interest. As noted earlier, for the Mud Dump site, six combinations of ambient depth, mound height, and crest depth were tested (Table G4). All mound configurations had side slopes of 1:50 with the cap material specified to be noncohesive sand with a d_{50} of 0.40 mm.

Table G4
Mud Dump Mound Configurations

Test Number	Ambient Depth, ft	Mound Height, ft	Crest Depth, ft
1	63	13	50
2	63	8	55
3	73	13	60
4	73	8	65
5	83	13	70
6	83	8	75

LTFATE input file generation

The surge, tidal, and wave field time series must be placed into a format compatible with LTFATE. An example LTFATE input file for hurricane #835 is shown in Table G5. For the Mud Dump study, storm-event input files

Table G5
Example LTFATE Input File

Hurricane: 835 WIS Station: 304	Wave Height, m	Wave Period sec	U-cm/sec	V-cm/sec	Surge, m
219.00	1.250	6.000	9.251	-38.308	1.164
222.00	1.250	6.000	11.406	-39.243	0.071
225.00	1.250	6.000	-3.124	-20.060	0.049
228.00	1.250	6.000	-5.420	-15.662	1.071
231.00	1.250	6.000	9.419	-30.920	1.172
234.00	1.250	6.000	15.334	-35.614	0.077
237.00	1.250	6.000	1.519	-16.542	-0.207
240.00	1.250	6.000	-4.056	-7.843	0.794
243.00	1.250	6.000	9.616	-22.601	1.095
246.00	1.250	6.000	17.646	-30.015	0.074
249.00	1.250	6.000	5.436	-13.767	-0.424
252.00	1.250	6.000	-3.789	-0.846	0.462
255.00	1.748	6.000	7.207	-12.689	1.008
258.00	4.787	6.000	17.136	-24.358	0.165
261.00	9.829	9.460	6.573	-13.044	-0.361
264.00	12.485	14.567	-7.198	-8.491	0.750
267.00	12.485	15.433	-31.538	20.684	3.775
270.00	12.485	14.567	30.319	-121.682	0.077
273.00	9.829	9.460	-28.224	13.077	-1.510
276.00	4.787	6.000	6.797	-4.497	0.262
279.00	1.748	6.000	-0.205	8.166	0.201
282.00	1.250	6.000	5.546	-6.199	0.412
285.00	1.250	6.000	13.366	-12.180	-1.050
288.00	1.250	6.000	-18.947	27.948	-0.298
291.00	1.250	6.000	2.285	1.164	0.663
294.00	1.250	6.000	5.566	-1.685	0.223
297.00	1.250	6.000	9.583	-6.201	-0.647
300.00	1.250	6.000	-6.529	13.946	-0.438
303.00	1.250	6.000	-4.978	15.048	0.544
306.00	1.250	6.000	7.271	0.057	0.589
309.00	1.250	6.000	13.559	-10.128	-0.625
312.00	1.250	6.000	-7.279	14.726	-0.672
315.00	1.250	6.000	-9.291	15.761	0.606

representing the 99-hr time sequences for each of the 16 tropical storm events and the 144-hr time sequences for each of the 38 extratropical storm events were input to LTFATE.

Model simulations

The six Mud Dump ambient depth/mound height combinations were subjected to the 64 tropical storm surge hydrographs (16 storms times four possible tide phases) to evaluate the erosion potential of the configurations shown in Table G4. An identical procedure was followed for the 152 extratropical storm surge hydrographs (38 storms times four possible tide phases). In all six simulations for each type of storm, the maximum vertical erosion experienced at any location on the mound during each of the simulations was archived for use in the EST to develop vertical erosion versus frequency-of-occurrence relationships.

EST Input File Development

As noted earlier, EST is a statistical procedure that uses a limited database of historical occurrences to generate multiple simulated scenarios from which frequency relationships and error estimates can be computed. The EST requires two types of input. The first set represents descriptive storm parameters that define the dynamics of each storm event. These parameters, referred to as input vectors, should be (a) tidal phase, (b) duration of the event measured as the number of hours during which the computed transport magnitude exceeds 10.0×10^{-4} ft^3/sec/ft-width, (c) maximum transport magnitude computed during the storm event, (d) wave height, (e) wave period, and (f) maximum depth-averaged velocity magnitude associated with the maximum transport value.

The second input parameter represents a measure of damage resulting from the passage of the storm event. These parameters are referred to as response vectors. Typical response vectors are storm surge elevation, shoreline erosion, dune recession, flood inundation, or for capping projects, vertical erosion.

Tropical storm vectors

Input and response vectors for hurricanes #296, 327, 748, and 835 for high water after flood (maximum tidal surface elevation) for the site scenario of an 8-ft mound located in 83 ft of water are shown in Table G6.

The EST uses the parameters of Table G6 for all tropical storm events and each of the four tidal phases as a basis for simulating multiple repetitions of multiple years of storm activity. In this application, 100 repetitions of a 200-year sequence of storm activity were simulated for the six scenarios shown in Table G6. As mentioned above, the EST assumes that future storm activity will be similar to past events, i.e., a hurricane such as Camille, which devastated the

Table G6
Tropical Storm Input and Response Vectors for the Mud Dump Site

Hurr. No.	Tide Phase 0-1	Min. Dist. miles	Track Angle deg	Pres. Def., mb	Max. Vel. knots	Forw. Vel. knots	Rad. Max. nm	Vert. Eros., ft
296	1.0	84.85	29.35	25.83	30.68	18.39	43.42	0.20
327	1.0	172.3	10.41	35.31	45.00	20.19	43.42	0.20
748	1.0	17.45	13.46	32.19	67.53	21.81	8.68	0.10
835	1.0	11.32	20.59	56.97	82.04	37.89	36.93	0.80

Gulf coast in 1969, cannot occur in the Bight because historical records indicate that storms of this magnitude have not impacted the Bight. This is probably due to both the exposure of the Bight and the northerly latitude. The second assumption is that the frequency of events is similar to historic activity. In the New York Bight, the frequency used is 16 events per 104 years, i.e., frequency = 0.15385.

Extratropical storm vectors

Input and response vectors for the four events of the 1977-78 extratropical storm season for the zero tidal phase for the site scenario of an 8-ft mound located in 83 ft of water are shown in Table G7.

Table G7
Extratropical Storm Input and Response Vectors for Mud Dump Site

Storm No.	Tidal pH-deg	Dur, hr	Q-Max	H, m	T,sec	V-Max cm/s	E-Max, ft
1	0	21	68.9	5.9	12.0	51.8	0.20
2	0	21	57.6	5.6	12.0	50.8	0.20
3	0	18	50.4	5.6	10.0	51.8	0.20
4	0	15	35.3	4.7	12.0	49.5	0.10

In an identical procedure to the tropical storm simulations, the EST uses the input and response vectors of Table G7 for the selected extratropical storm events and for each of the four tidal phases as a basis for simulating multiple repetitions of multiple years of storm activity. As mentioned above, the EST assumes that future storm activity will be similar to past events. In the New York Bight, the frequency used is 38 events per 16 years, i.e., frequency = 2.375 storms/year.

The EST program generates a 200-year tabulation consisting of the number of storm events that occurred each year and the vertical erosion corresponding to each event. To define an erosion magnitude consistent with the tropical storm analysis, the total summation of erosion magnitudes per year was selected as the parameter of interest. For example, if three storm events were simulated during the first year, the sum of the three vertical erosions would be used to define the parameter for which frequency-of-occurrence relationships would be computed. The computational process is described in the following section.

EST simulation results - vertical erosion versus frequency-of-occurrence

To most effectively use the results from the EST simulations for cap erosion layer thickness design, frequency of vertical erosion curves and tables should be generated from the data. For the Mud Dump site example, vertical erosion versus frequency-of-occurrence relationships were generated for each of the 100 simulations described above for each of the six depth/mound height configurations for both tropical and extratropical storms.

The frequency curves for each simulation are generated by (a) rank-ordering the computed erosion magnitudes, (b) generating a cumulative distribution function (cdf, P(x) versus magnitude), and (c) interpolating an erosion magnitude for an n-year event from the cdf for a probability of occurrence P(x) of the form resulting in an erosion versus frequency curve for each simulation.

Tropical storms. In the analysis of the 100 frequency relationships, an average vertical erosion magnitude is computed relative to each return period. From the EST simulations of tropical storms, an example plot of the 100 recurrence relationships and mean value (indicated by O) for the 8-ft mound located at an 83-ft depth is shown in Figure G7. Note that the spread of data points about the mean demonstrates a reasonable degree of variability, as would be expected of a stochastic process.

Finally, the standard deviation of the 100 events relative to the mean is computed as a measure of variability. Output for design purposes contains only the mean frequency-of-occurrence relationship with a +/- one standard deviation band. An example of this output is shown in Figure G8 for the 8-ft mound at the 83-ft depth shown in Figure G7. Table G8 summarizes the frequency-of-occurrence of vertical erosion from tropical storms for all six mound configurations in the form of a mean value and +/- standard deviation error that can be added to or subtracted from the mean value.

Extratropical storms. A set of analyses identical to those made for tropical storms should be made for the extratropical storms. From the Mud Dump site analysis, an example plot of the 100 recurrence relationships and mean value (indicated by O) for the 8-ft mound located at an 83-ft depth is shown in Figure G9. As for the tropical storms, the spread of data points about the mean demonstrates a reasonable degree of variability, as would be expected of any stochastic process. An example of the mean frequency-of-occurrence relationship with a +/- one standard deviation band is shown in Figure G10 for the 8-ft

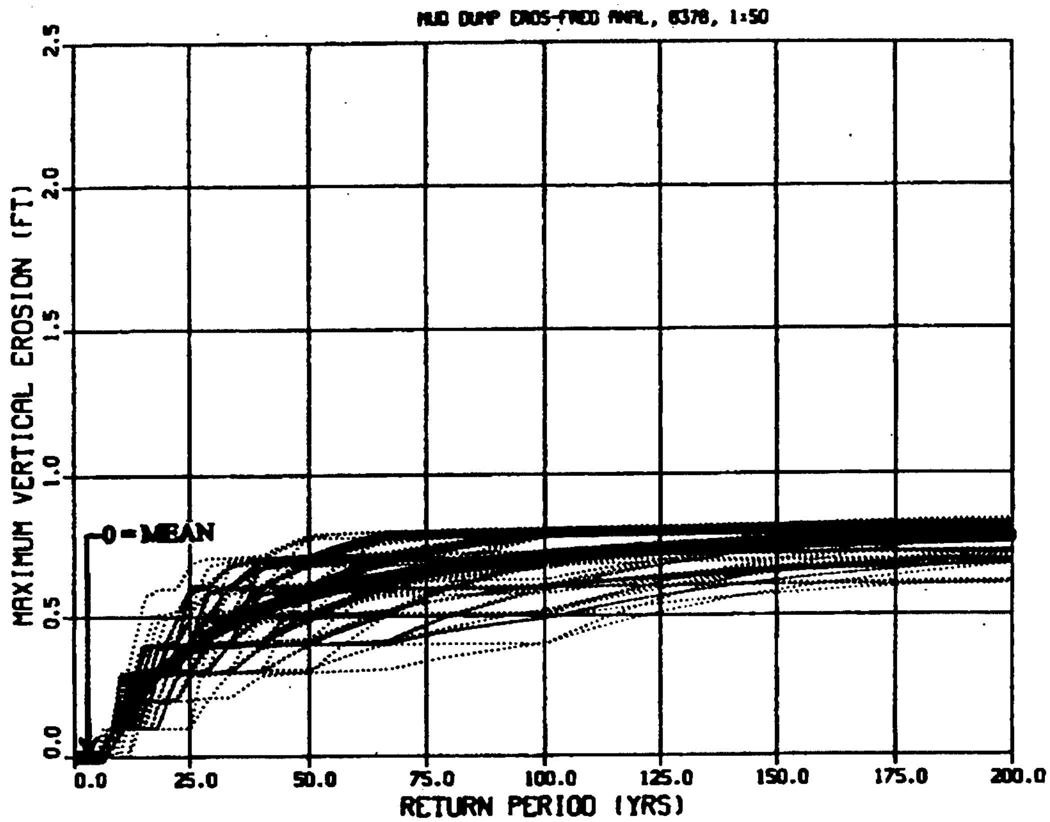


Figure G7. Simulated tropical storm-induced vertical erosion frequency curves for an 8-ft mound located at 83-ft depth, crest depth of 75 ft

Table G8
Mean Value of Vertical Erosion/Frequency-of-Occurrence for Tropical Storms at Mud Dump Site

Test Number/ Ambient Depth - Mound Height/ Crest Depth, ft	25-year mean (± sd), ft	50-year mean (± sd), ft	100-year mean (± sd), ft
1 / (63-13) / 50	1.2 (0.23)	1.6 (0.23)	1.9 (0.26)
2 / (63-8) / 55	0.9 (0.19)	1.3 (0.23)	1.5 (0.19)
3 / (73-13) / 60	0.8 (0.18)	1.2 (0.22)	1.4 (0.20)
4 / (73-8) / 65	0.6 (0.13)	0.8 (0.17)	1.0 (0.16)
5 / (83-13) / 70	0.5 (0.12)	0.8 (0.14)	0.9 (0.15)
6 / (83-8) / 75	0.4 (0.10)	0.6 (0.12)	0.7 (0.10)

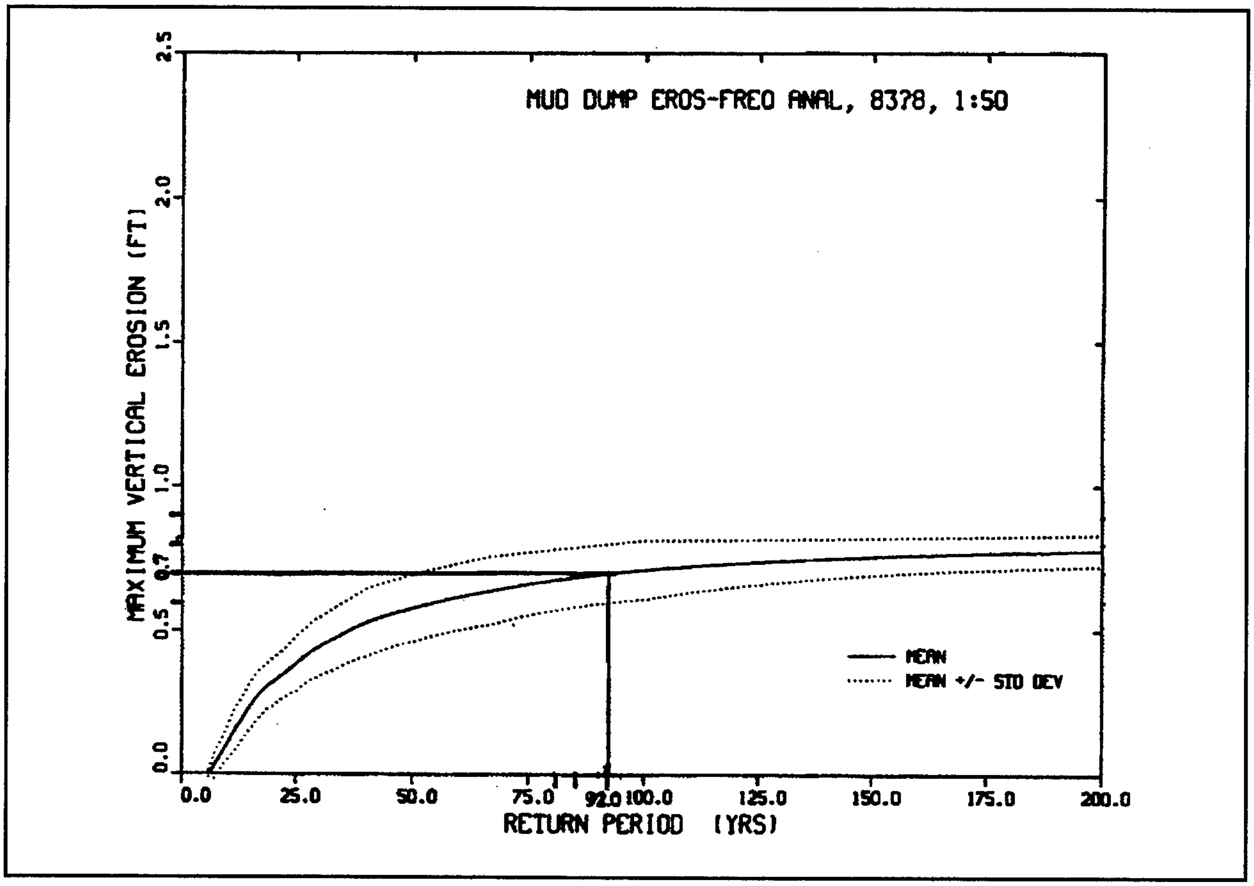


Figure G8. Mean value with error limits for frequency of vertical erosion from tropical storms for 8-ft mound located at 83-ft depth, crest depth of 75 ft

mound at the 83-ft depth. Table G9 summarizes the frequency-of-occurrence of vertical erosion from extratropical storms for all six mound configurations in the form of a mean value and +/- standard deviation error that can be added to or subtracted from the mean value.

Frequency of erosion for the combined impacts of tropical and extratropical storms

For most sites it is probably only practical (and cost effective) to replace any lost cap material due to erosion on a yearly basis. Therefore, for sites that experience both tropical and extratropical storms, the potential for vertical erosion from the combined impacts of both types of storms over a year's time must be considered. Proper design of a cap should consider both the episodic erosion from the less frequently occurring severe storms and the cumulative erosion from normal storm activity (average intensity storms experienced every year) experienced over a period of years. If this is not done, then after say 5 to 20 years of annual erosion, the remaining erosion thickness could fall below the design level (say a 100-year return frequency erosion event).

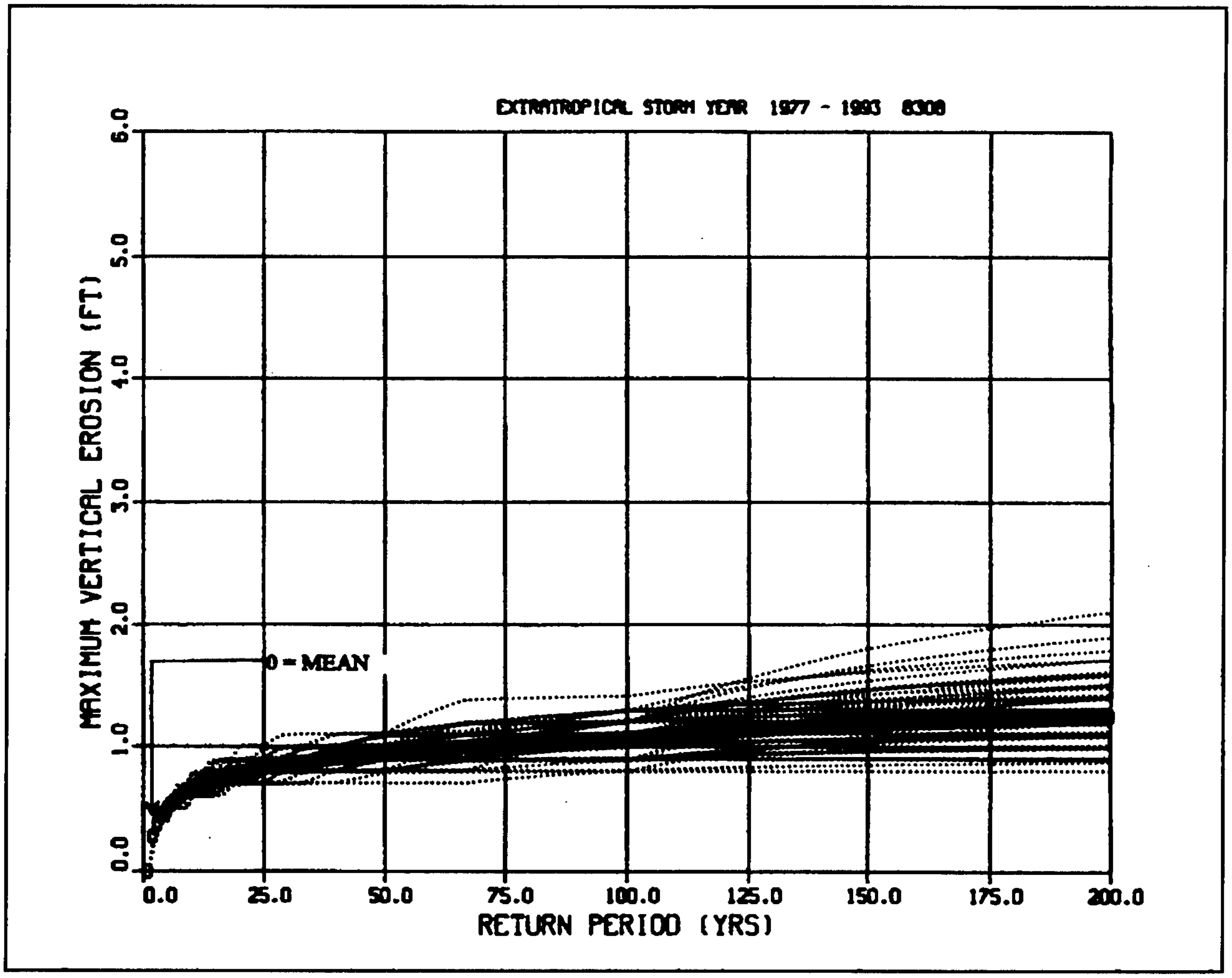


Figure G9. Simulated extratropical storm-induced vertical erosion frequency curves for an 8-ft mound located at 83-ft depth, crest depth of 75 ft

Table G9
Mean Value Erosion/Frequency-of-Occurrence for Extratropical Storms at the Mud Dump Site

Test Number/ Ambient Depth - Mound Height/ Crest Depth, ft	25-year mean (± sd), ft	50-year mean (± sd), ft	100-year mean (± sd), ft
1 / (63-13) / 50	3.0 (0.22)	3.4 (0.30)	3.9 (0.42)
2 / (63-8) / 55	2.1 (0.15)	2.3 (0.2)	2.6 (0.29)
3 / (73-13) / 60	1.8 (0.13)	2.0 (0.17)	2.3 (0.26)
4 / (73-8) / 65	1.3 (0.10)	1.4 (0.13)	1.6 (0.18)
5 / (83-13) / 70	1.1 (0.09)	1.3 (0.12)	1.5 (0.16)
6 / (83-8) / 75	0.8 (0.07)	0.9 (0.09)	1.1 (0.13)

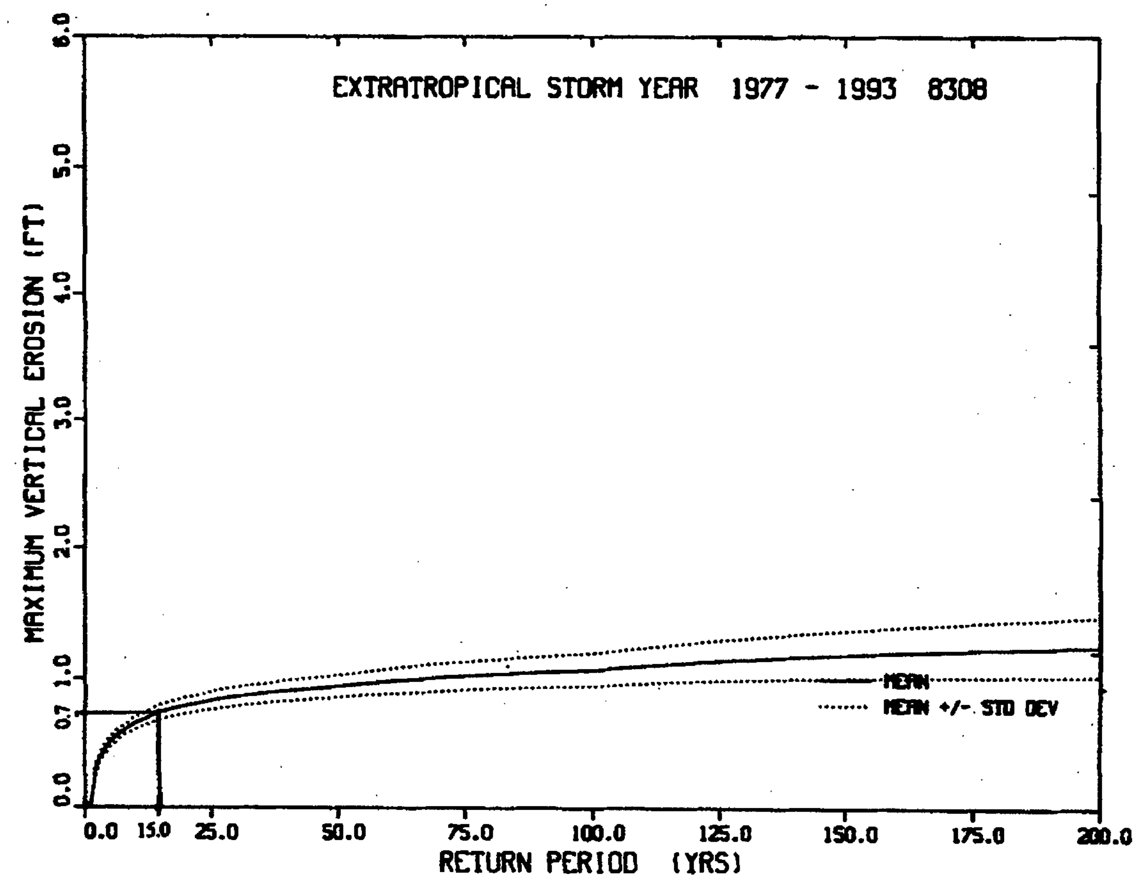


Figure G10. Mean value with error limits for frequency of vertical erosion from extratropical storms for 8-ft mound located at 83-ft depth, crest depth of 75 ft

Therefore, estimates of potential erosion of a disposal mound in the New York Bight require an analysis of both (a) episodic event erosion resulting from tropical and extratropical storms and (b) cumulative erosion. For the Mud Dump site, cumulative erosion would be considered to be due only to average intensity extratropical events. Tropical events are not considered in the average yearly erosion rate because tropical events impact the Bight at a return period of approximately 6.5 years. At more southerly east coast sites and Gulf coast sites, tropical storms may need to be considered for the yearly average erosion computations.

Cumulative erosion. As noted above, cumulative erosion is the vertical erosion expected to occur over intervals of 5 to 20 years due to a normal storm activity, i.e., moderate storms that occur regularly. Because cumulative erosion over periods of 5 to 20 years may consist of a fairly large number of storms, it is important that erosion per storm and the cumulative effects be computed as realistically as practical.

A simple method to compute cumulative erosion is to compute an annual average erosion then multiply that value by the number of years of interest. This can be done by examining the full set of training storms modeled in the erosion frequency analysis, then summing the maximum erosion from each storm and dividing by the number of storms to compute the average maximum erosion per storm. The average annual erosion could then be computed as the average maximum erosion per storm times the average number of storms per year (e.g., 2.375 for the Mud Dump site). This method would likely produce extremely conservative estimates of annual erosion because successive storms would not necessarily produce erosion in the same location. Also as the mound erodes, the elevation decreases, which decreases the erosion rate during future storms. This method also includes the erosion from severe, infrequent storms which would perhaps cause some significant cap erosion such that the cap would have to be repaired.

A correction for the gross annual erosion estimates computed by the above method could be calculated by computing the total mound erosion resulting from a series of low to moderate intensity storms (those with erosion frequencies of less than 5-10 years) applied consecutively (using LTFATE) to a specific mound configuration. The mound geometry from the first storm would be the initial geometry for the second storm and so on. The maximum total erosion at any location on the mound after a series of storms that could normally be experienced in a year (say two to four for the Mud Dump) applied consecutively could then be compared with the maximum total cap erosion of each storm summed individually. The correction factor would then be the ratio of the consecutive total maximum erosion divided by the individual total maximum erosion. Average annual erosion would then be the number of storms per year times the maximum average erosion per storm times the correction factor. Cumulative erosion would then be the corrected average annual erosion times the number of years of interest.

A more sophisticated estimate of cumulative annual erosion values would be to use LTFATE to model erosion for a particular capped mound configuration for a period of 10 to 20 years from which the training storms were selected. The storm-induced capped mound geometry from the initial storm would be, as above, the input geometry for the following storm, with the resulting capped mound geometry from each preceding storm becoming the input geometry for the subsequent storm.

At the end of each year, the maximum erosion, average erosion thickness, and area of erosion (as defined in Figure G11) would be computed. Because of the multiple years of data, running averages of each of the quantities could be computed along with basic statistics such as the average, maximum, and standard deviation. With these values a considerably more realistic estimate of annual and cumulative annual erosion is more likely. Additional research on the application of this suggested approach to actual projects is planned to determine

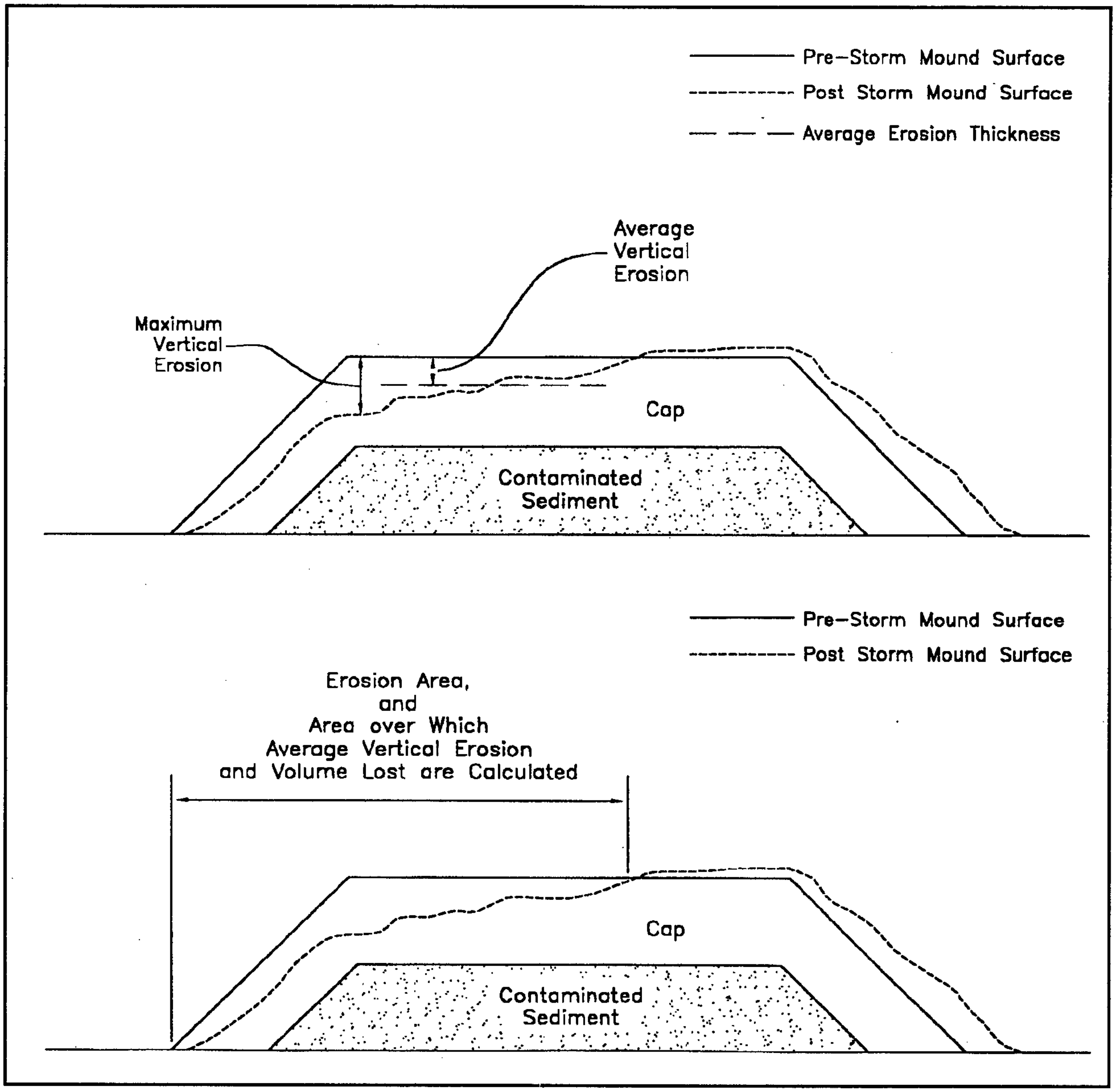


Figure G11. Idealized mound cross sections showing maximum and average vertical erosion and areas over which erosion volume is computed

if in fact, this more complicated method of computing annual and cumulative erosion estimates provides significantly different answers than the simpler methods.

Episodic erosion. Episodic event erosion was individually described for tropical and extratropical events in the prior sections. For tropical events, the curves and tables represent the vertical erosion associated with individual hurricanes. For example, a 100-year erosion value is the erosion associated with a single severe event with a return period of 100 years. However, the curves and tables presented for the extratropical events represent erosion due to multiple events occurring during a single storm season. For example, although an average of only 2.4 events occur per year at the Mud Dump site, results from the program EST generates a simulated 200-year sequence of extratropical storm activity during which it is possible to have eight or nine events in a single season. If eight or nine severe events were to occur during a single winter season, the summation of maximum erosion magnitudes for each event may be large enough for that season to be ranked as a 100-year season.

The erosion versus frequency-of-occurrence relationships for tropical and extratropical events were combined to generate a single curve and table of frequencies for each of the design configurations. The combined frequency-of-occurrence is computed by adding the frequencies associated with tropical and extratropical events for a given magnitude of erosion. For example, consider the 8-ft mound located in 83 ft of water. An erosion of 1.0 ft corresponds to a return period of 83 years for hurricanes but only 10 years for extratropical events. The combined frequency is equal to 1/83 + 1/10 or 0.11, corresponding to a return period of just 9 years. A comparison of the combined event, Table G10, shown below, and Tables G8 and G9, shows that extratropical events are the dominant storm type in the New York Bight. This dominance is evidenced by the fact that the combined event frequency relationships are very similar to the extratropical relationships. This is not surprising considering that on the average, 15 extratropical storms occur for every hurricane. Also, vertical erosion due to extratropical events is generally more severe than for tropical events due to the longer duration of extratropical storms.

Table G10
Mean Maximum Vertical Erosion Frequency due to Tropical and Extratropical Storms Impacting 0.4-mm Sand-Capped Mounds

Mound Configuration Base Depth/Mound Height/Crest Depth, ft	Combined Hurricane/Northeaster Single-Year Erosion Frequency, ft			
	10 year	25 year	50 year	100 year
63/10/50	2.4	3.0	3.4	3.9
63/08/55	1.6	2.0	2.3	2.6
73/13/60	1.5	1.8	2.0	2.3
73/08/65	1.0	1.3	1.5	1.7
83/13/70	0.9	1.2	1.3	1.6
83/08/75	0.7	0.8	0.9	1.1

A summary of results for the Mud Dump site, shown in Table G10, was prepared to provide both episodic and cumulative erosion estimates for each design option. The episodic values are provided at return periods of 10, 25, 50, and 100 years.

For example, the 100-year mean maximum erosion thickness for combined storms for a mound in 73 ft of water that is 8 ft tall with a crest elevation of 65 ft is 1.7 ft.

Use of Table G10 for evaluating disposal site design parameters such as cap thickness or site depth should consider both episodic event erosion and net cumulative erosion. Yearly monitoring of the disposal site should be conducted to ensure that the cap has maintained its integrity, i.e., cap thickness has not been reduced by erosion below the minimum safe level. Even with annual monitoring, the cap should be designed to withstand multiyear erosional events. Therefore, the disposal site should be designed such that the cap will not be compromised by either (a) episodic event (tropical) or episodic season (extra-tropical) erosion of some defined level of intensity such as the 100-year occurrence or (b) several years, 5 for example, of normal storm activity.

Summary

In conclusion, vertical erosion frequency and annual cumulative erosion estimates generated through the techniques described in this appendix can be used as a basis for designing a capped disposal mound. However, it should be emphasized that the erosion magnitudes reported can be considered somewhat conservative for the following reason:

> Single event erosion is calculated as the maximum erosion computed at any location on the cap as a result of the single event. In most cases, this erosion is limited to the edge of a cap at the intersection of the side slope and the crest. If localized erosion of the cap were indicated by annual surveys, maintenance or remedial disposal could easily restore the cap to its design thickness at the appropriate location. The amount of cap material that would be required to restore the cap to its original thickness is roughly estimated at 10 to 25 percent of the original cap volume. Computations of average mound erosion thickness and the area of mound experiencing erosion are recommended to provide additional insight on the potential for cap failure.

The storm-surge frequency analyses described in this study make extensive use of the EST. The approach requires the generation of a database of storm responses that, for this analysis, were selected to be vertical erosion. Because the procedure is a statistical one based on a training set of single-event erosion magnitudes, the above assumptions leading to conservatism cannot be eliminated from the analysis. Therefore, the fact that the estimates are conservative must be considered in the final design.

For specific cap design projects, a comprehensive and rigorous analysis of the cumulative erosion due to the occurrence of multiple events per year is recommended. This could include either computing a gross erosion reduction factor or an LTFATE simulation of multiple years of normal storm activity.

Finally, the procedures recommended in this appendix to generate vertical erosion versus frequency of occurrence utilizes a newly generated database of tropical and extratropical storm surge elevation and current hydrographs. No similar database has ever been available for use in an analysis similar to this. Because the present analysis uses this database in conjunction with thoroughly tested and documented hydrodynamic, sediment transport, and bathymetry change modeling concepts, the approach can be considered to be comprehensive, reasonably accurate, and appropriate for the purpose of developing disposal site design criteria. Future improvements in the algorithms used to compute sediment transport, better values for storm induced processes, and more high quality data on storm-induced erosion of dredged material mounds will provide higher levels of accuracy in the computations and greater confidence in cap design.

Appendix H Calculation of Required Cap Volumes for Level-Bottom Capping Projects

The primary focus of this appendix is the calculation of the volume of capping material required for level-bottom capping projects, including the influence of various operational considerations on required volumes. The information in this appendix assumes a specific capping project has been identified, a disposal site is available, the contaminated mound geometry (footprint, side-slopes, and elevation) has been estimated, and the cap has been designed with respect to the thickness of capping material required.

Capping Volumes for Circular and Elliptical Mounds

From a plan view, capped mounds typically take either a circular or elliptical/oval shape (Chapter 10, main text), so required cap volume calculations depend on this shape. For a uniform cap thickness over the entire contaminated mound surface (Figure H1), design must allow for inclusion of the cap volumes of the inner flank, outer flank, and apron in the overall mound cap volume calculation. This will be demonstrated in a generic example. If the cap thickness will be less over the apron (Figure H2), then the cap volume calculation requires isolating different sections of the cap for ease in calculation. For both cases, the volume of cap material included in the apron must also be calculated as constructed projects have shown this volume can be significant. Note that the following relationships are unit independent (i.e., either English or SI may be used as long as consistency is maintained).

For a uniformly thick cap on a circular mound (Figure H1), the following methodology is given to calculate cap volume:

$$V_M = t_c \pi r_M^2$$

$$V_{CA} = \pi (r_{TC}^2 - r_M^2) \frac{1}{2} t_{ta} \tag{H1}$$

where

V_M = volume of cap material over dredged material mound

V_{CA} = volume of material in cap apron

t_c = thickness of cap

t_{ta} = thickness of cap at toe of mound apron

r_M = radius of overall dredged material mound

r_{TC} = radius of total capped surface

For a uniformly thick cap on an elliptical mound, the following methodology is given to calculate cap volume:

$$V_M = t_c(\pi r_1 r_2)$$

$$V_{CA} = \pi [(r_1 r_2)_{TC} - (r_1 r_2)_M] \frac{1}{2} t_{ta} \tag{H2}$$

where

V_M = volume of cap material over dredged material mound

V_{CA} = volume of material in cap apron

t_c = thickness of cap

t_{ta} = thickness of cap at toe of mound apron

r_1 , r_2 = long, short radius of ellipse

$_M$ = subscript for dredged material mound

$_{TC}$ = subscript for total capped surface

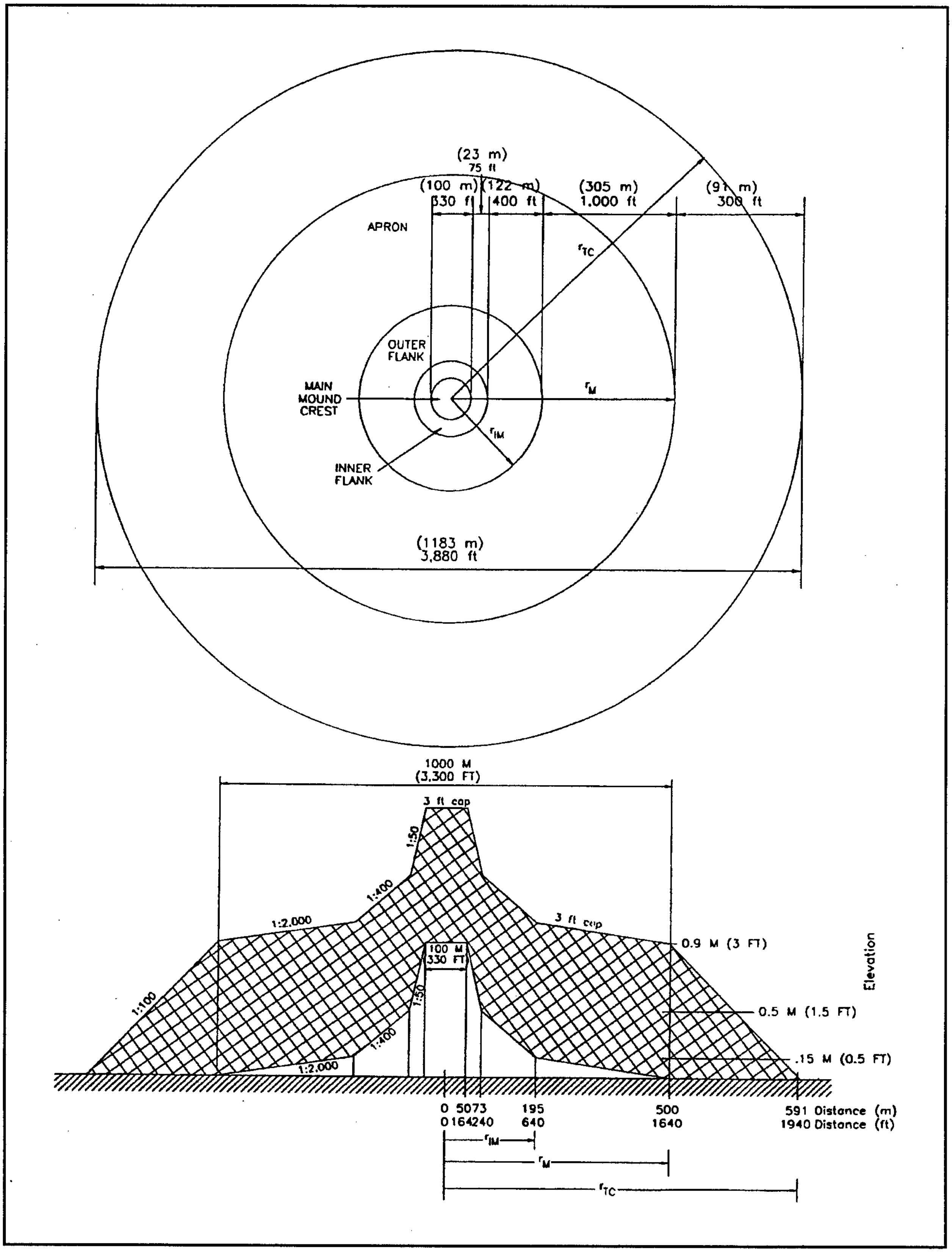


Figure H1. Geometry for a uniform cap thickness over a mound

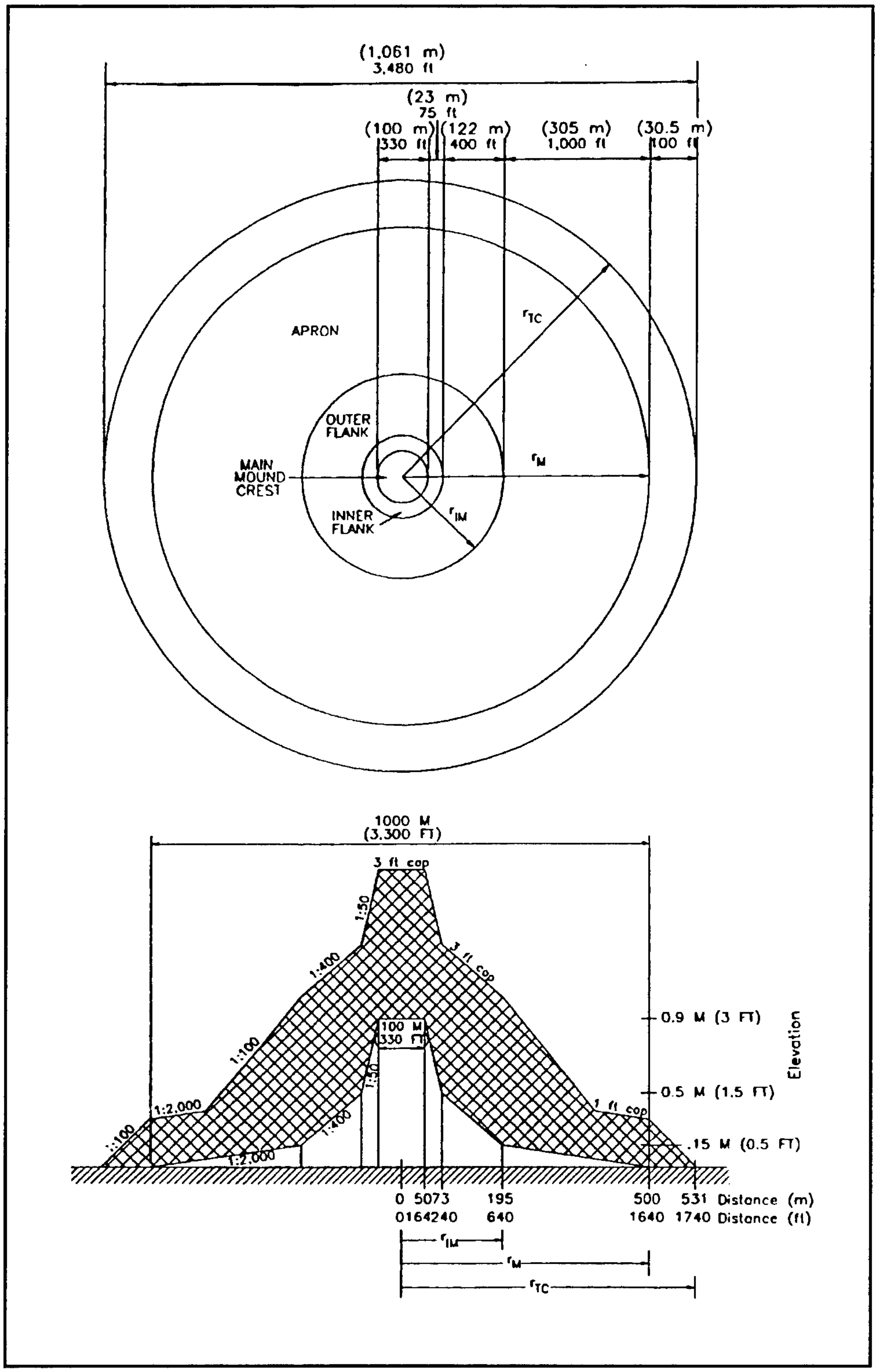


Figure H2. Geometry for a uniform cap with lesser thickness over apron

For a circular mound where the cap thickness is decreased over the apron (Figure H2, the following methodology is given to calculate cap volume:

$$V_M = t_{pc} \pi r_{IM}^2 + 0/00 \Delta t_c \pi \left[\left(r_{IM} + \Delta \frac{t_c}{m} \right)^2 - r_{IM}^2 \right] + \pi t_{ta} (r_M^2 - r_{IM}^2) \tag{H3}$$

$$V_T = V_M + V_{CA}$$

where

V_M = volume of cap material over dredged material mound

V_{CA} = volume of material in cap apron

V_T = total volume of cap material

t_{pc} = thickness of primary cap

t_{ta} = thickness of cap at toe of mound apron

t_c = change in cap thickness over apron (t_{pc} - t_{ta})

r_M = radius of overall dredged material mound

r_{IM} = radius of inner dredged material mound (crest, inner flank and outer flank)

r_{TC} = radius of total capped surface

m = slope of change in cap thickness (i.e., 1:100!m=0.01)

$$V_M = t_{pc} \pi r_1 r_2 + 0/00 \Delta t_c \pi \left[\left(r_{1_{IM}} + \frac{\Delta t_c}{m} \right) \left(r_{2_{IM}} + \frac{\Delta t_c}{m} \right) - (r_1 r_2)_{IM} \right] + \pi t_{ta} \left[(r_1 r_2)_M - (r_1 r_2)_{IM} \right] \tag{H4}$$

For an elliptic mound where the cap thickness is decreased over the apron, the following methodology is given to calculate cap volume:

$$V_T = V_M + V_{CA}$$

$$V_{CA} = \pi [(r_1 r_2)_{TC} - (r_1 r_2)_M] \frac{1}{2} t_{ta} \tag{H5}$$

where

V_M = volume of cap material over dredged material mound

V_{CA} = volume of material in cap apron

V_T = total volume of cap material

t_{pc} = thickness of primary cap

t_{ta} = thickness of cap at toe of mound apron

t_c = change in cap thickness over apron (t_{pc} - t_{ta})

r_1 , r_2 = long, short radius of ellipse

$_M$ = subscript for dredged material mound

$_{IM}$ = subscript for inner dredged material mound (crest, inner flank and outer flank)

$_{TC}$ = subscript for total capped surface

m = slope of change in cap thickness (i.e., 1:100!m=0.01)

The volume of cap material overlying the inner and outer flanks may be calculated as part of the overall dredged material mound cap volume calculations. When there is no change in cap thickness over the mound apron as in Figure H1, the cap volume over the mound apron may also be included in the overall dredged material mound cap volume calculations. To demonstrate, assume a generic circular mound having a relief of 2.1 m (7 ft) with cap 0.9 m (3 ft) thick is created (Figure H3). Approximate average inner flank, outer flank, and apron slopes are 1:50, 1:400, and 1:2000, respectively. Table H1 shows that for this example, the horizontal length and slope length are nearly equal, so use of the horizontal length in cap volume calculation is justified. For steeper slopes and/or higher mound relief, this assumption should be verified.

Table H1
Lengths Associated with Generic-Capped Mound in Figure H3

	Vertical Length		Horizontal Length		Slope Length	
	m	ft	m	ft	m	ft
A - B Inner Flank	0.9	3	46	150	46.009	150.03
B - C Inner Flank	0.9	3	366	1,200	366.0011	1,200.00375
C - D Apron	0.3	1	610	2,000	610.000074	2,000.00025

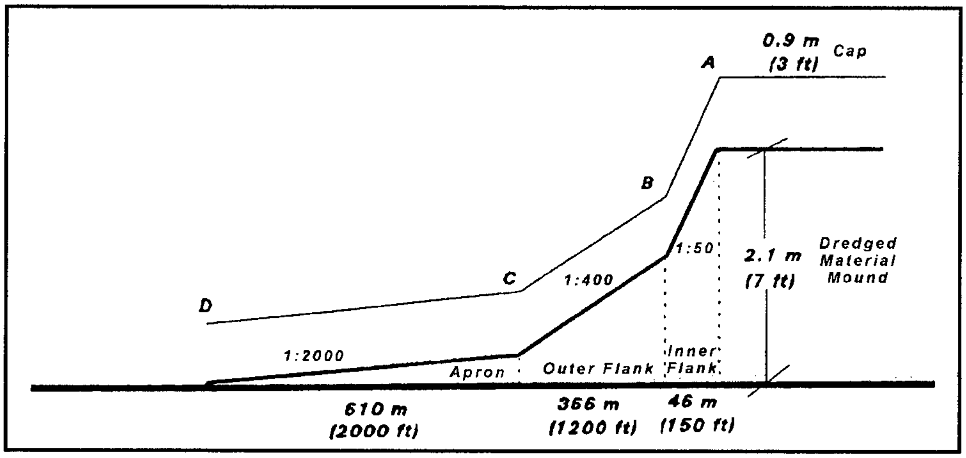


Figure H3. Cap slope length calculation

Effect of Placement Operation on Required Cap Volume

A number of operational factors should be considered in computing required cap volume. These factors include the "full" cap thickness versus "average" cap thickness, the required cap thickness over the apron, and how far beyond the contaminated boundary the cap should be placed. The following paragraphs discuss each of these factors in turn. In general, cap volume to contaminated sediment volume ratios of 1:2 to 1:5 have been used for capping projects. While the following paragraphs describe how to compute specific cap volume requirement, some generalizations can be made. Higher cap to contaminated material ratios will be found for projects that use thin mounds, those consisting of maintenance material that is fine grained with low shear strength, where barges placing contaminated material will not be required to stop, and sites with deeper water. Also, for smaller volume contaminated sediment projects, the apron will tend to occupy an increasingly large percentage of the total area, greatly increasing required cap volume to contaminated sediment volume ratio (particularly if the full cap thickness is required over the entire apron). Lower cap to contaminated sediment volumes can be expected for thicker mounds, those consisting of material with high shear strength, mounds placed in shallow water, where barges come to a complete halt or are moving at low speeds (less than 1/2 to 1 knot).

Achieving full cap thickness over the entire contaminated mound footprint is nearly impossible to accomplish without placing a considerable amount of additional material over that required for a level cap. This is because underwater placement is difficult to precisely control. Depending on the method of cap placement, the cap surface will have greater or lesser amounts of surface relief. For caps that are "sprinkled," this degree of surface relief will probably be less for sprinkled caps than for bottom-dumped caps.

One issue that must be resolved for cap design is whether or not the entire cap area requires the "full cap thickness." While a cap with a constant thickness is assumed for calculations, in reality, the cap thickness is a distribution, with an average value and the actual cap depth in specific cells (say 50 by 50 m) probably following a Gaussian distribution. For example, if a 1-m-thick cap is specified and the standard deviation of cap thickness is 15 cm (6 in.), after 100 percent of the level cap volume has been placed, 99 percent of the contaminated footprint would have 0.55 m of cap, 95 percent would have 0.70 m of cap, 67 percent would have 0.85 m of cap, 50 percent would have 1.0 m of cap, 33 percent would have 1.15 m of cap, 5 percent would have 1.3 m of cap, and 1 percent would have 1.45 m of cap. Should more cap material be placed?

It is recommended that the cap be considered complete if all the contaminated sediment has a minimum thickness equal to thickness required for chemical isolation and bioturbation plus some agreed on thickness, say 5 to 10 cm, to account for elevation variation within a given cell. The reason this procedure is acceptable is that during storms, it is extremely likely that the high spots on the cap will erode first and fill in the low areas. Thus, the requirement to place material in excess of the "level surface cap volume" should be unnecessary.

In addition to the large amount of additional material placed to meet the requirement to achieve 100-percent thickness everywhere over a cap, this requirement will also dictate repeated monitoring, which is also expensive. Finally, the actual placement process becomes less efficient as the vessel placing the cap material attempts to cover a smaller and smaller area. Statistics from the capping effort at the Port Newark/Elizabeth project (Table H2), where the goal was to place 1-m-thick cap over the entire contaminated mound, indicated that an additional 25 percent over the level cap volume was required to achieve full cap thickness coverage at over 90+ percent of the area, resulting in cap thicknesses of over 1.25 m over almost 40 percent of the area.

Table H2
Final Statistics of Cap Thickness from Port Newark/Elizabeth Project (March 1994)

Cap Thickness, m	Percent of Area Covered	Cumulative Coverage, Percent
0.00 - 0.25	0.0	0.0
0.25 - 0.50	0.2	0.2
0.50 - 0.75	2.9	3.1
0.75 - 1.00	16.4	19.5
1.00 - 1.25	42.2	61.7
1.25 - 1.50	30.4	92.1
1.50 - 1.75	6.5	98.6
1.75 - 2.00	1.1	99.7
2.00 - 2.25	0.1	99.8

To calculate required cap volume, it is recommended that the "full cap thickness" volume (i.e., a level cap at full thickness) be computed over the main mound and inner flanks. Up to an additional 10-20 percent of cap material should be identified as possibly being required and should be available.

The required cap thickness over a few centimeters-thick mound apron can become an important issue when one considers the volume (and cost) of cap material required to cover mound aprons. Table H3 compares volumes and dimensions from the Port Elizabeth/Newark project (which required a 1-m cap over the entire contaminated mound) and two generic cap projects based on the mounds shown in Figures H1 (0.9-m cap over the entire mound) and H2 (0.9-m cap over the main mound and a 0.3-m cap over the apron). Volume calculations show that over half (55.6 percent) of the 1,870,000 m^3 (2,446,000 yd^3) of material placed at the Port Elizabeth/Newark mound covered the contaminated mound apron, which contained about 12 percent of the contaminated material volume. Table H3 also shows that in the generic mounds shown in Figures H1 and H2 (identical contaminated mound shapes), the total volume of cap material material required is reduced by nearly 60 percent, from 847,200 m^3 (1,108,100 yd^3) to 347,800 m^3 (454,900 yd^3) when the required cap thickness over the apron is reduced from 1 to 0.3 m. The volume required to cover the contaminated apron reduces from 16.4 to 4.3 percent of total cap volume. The dredging and cap placement over the wide area covered by the apron will, for most projects, significantly increase the project costs. In rare instances where an abundance of cap material is being dredged as part of an authorized dredging project, the cap material can be considered "free." However, the capping project must still cover the additional cost of precisely placing the cap.

For low levels of contaminants, bioturbation-induced mixing of the cap-contaminated material and native sediment may be sufficient to reduce the resulting level of contamination to an acceptable level. McFarland (in preparation)[1] describes procedures that can be used to determine the effects of reduced cap thicknesses over the apron based on bioaccumulation studies. For the sediments used on the Port Newark/Elizabeth 1993 project, McFarland (in preparation) found that a cap thickness to apron thickness ratio of 2:1 was sufficient to reduce bioaccumulation of the contaminant of concern (dioxin) to acceptable levels. The apron thickness for the Port Newark/Elizabeth mound ranged from 1 to 10 cm with a 5 cm averge thickness. Thus using McFarland's results, a cap thickness over the apron of 10 to 20 cm would have been sufficient. Most of the capped mounds created as part of the New England Division's capping program have cap thicknesses over the apron of 20 to 50 cm.

Another issue impacting the amount of cap required is how far beyond the known contaminated mound boundary to place cap material. Because the edge of the cap will normally be located with a sediment profiling camera, the edge of the contaminated material will normally be defined to a precision of about 50 m. Therefore, it seems reasonable to place cap material such that the cap material

---

[1] References cited in this appendix are listed in the References at the end of the main test.

Table H3
Contaminated and Cap Material Volumes and Mound Dimensions

Project	Tot Vol, m^3 (yd^3)	Apron Vol, M^3 (yd^3)	% Total	Footprint, m^2, (acres)	Max thick, m (ft)
Contaminated					
Port Elizabeth/ Newark	448,000 (586,000)	52,000 (68,000)	11.6	1,470,000 (363)	2.40 (8.0)
Generic No. 1 (Figure H1)	96,600 (126,300)	49,900 (65,300)	51.7	785,400 (194)	0.9 (3.0)
Generic No. 2 (Figure H2)	96,600 (126,300)	49,900 (65,300)	51.7	785,400 (194)	0.9 (3.0)
Cap					
Port Elizabeth/ Newark (1 m cap over entire project)	1,870,000 (2,445,900)	1,040,000 (1,360,300)	55.6	1,470,000 (363)	1.8 (5.91)
Generic No. 1 (Figure H1) (0.9 m cap over entire project)	847,200 (1,108,100)	140,400 (183,600)	16.6	1,097,000 (271)	0.9 (2.95)
Generic No. 2 (Figure H2) (0.9 m cap over main mound, 0.3 m cap over apron)	347,800 (454,900)	15,100 (19,750)	4.3	885,800 (219)	0.9 (2.95)

extends a distance of 15 to 30 m beyond the expected edge of the contaminated material.

For sites with significant currents (say 30-50 cm/sec and greater) some loss of cap material will probably be experienced. The Seattle District has documented that for small sites (100 to 150 m overall dimensions) this "volume lost," which is a actually cap material that is moved beyond the edge of the contaminated sediment, can be from 10 to 20 percent of the estimated volume required based on a flat cap over the contaminated sediment footprint (Parry 1994).

For a fine-grained cap, the volume lost to consolidation will have to be taken into account for the erosion layer. An estimate of the amount of consolidation over time will be required and the additional thickness added to account for potential erosion. Note that the reduced cap thickness from consolidation may not be a problem from a chemical isolation standpoint due to advection of contaminants. The reduced cap thickness from consolidation is somewhat compensated for by the reduced void ratio and permeability, creating more tortuous paths for the contaminants to diffuse through.

However, the reduction in cap thickness due to consolidation should be considered from the standpoint of advection of pore water. Consolidation will reduce the void ratio and thus will force pore water further out into the cap.

Effect on Volume Due to Change in Void Ratio

The volume of material to be dredged for the cap must be calculated to determine if potential sources of capping material, say from an available maintenance dredging project, will be adequate. The potential changes in volume due to dredging and placement must be considered. The required volume of capping material (in situ in the channel) can be calculated as follows:

$$V_{ci} = V_c\left(\left[\frac{(e_o - e_i)}{(1 = e_i)}\right] + 1\right) \tag{H6}$$

where

V_{ci} = volume of cap material in situ in channel

V_c = volume of cap material initially placed

e_o = average void ratio of cap material initially placed

e_i = average void ratio of cap material in situ in channel

For projects in which the capping material is hydraulically placed, the value of e_o can be determined in the same way as that used in design of confined disposal facilities (USACE 1987, EM 1110-2-5027). For mechanically dredged sediments, an approach to determine the minimum cap volume required is to assume no difference in e_o and e_i (i.e., $V_{ci} = V_c$). It is recommended that those with experience dredging a particular project (USACE District Operations Division staff, dredging contractors, etc.) be contacted for suggestions on bulking factors. SAIC (1995) reports that the assumption of no difference in e_o and e_i is reasonable.

Options if Required Volume is Too Large

The information from the prior section along with the information in Chapter 6 (main text) on expected contaminated mound footprint should be used to compute required cap volume. If the estimated cap volume is too large, either because insufficient cap material is available or the cost is too high, the following options are available. As noted earlier, the most obvious is to reduce the volume of contaminated material. A second option may be to delay dredging until additional cap material becomes available, perhaps combining several small projects that collectively can afford the cap required. Other options involve creating a contained aquatic disposal (CAD) site, either by creating berms from clean material (perhaps dredged from the disposal site creating additional capacity) or potentially using geotextile fabric containers. Use of geosynthetic fabric containers (GFCs) to contain the contaminated sediments is also an option to reduce the amount of cap required. However, this is a fairly recent development, and specific guidelines for this application are not yet available. Clausner et al. (1996) summarize the present state of knowledge and critical issues for geotextile container use with contaminated dredged material.

Good advance planning can be used to create a "natural" CAD site. As described in Chapter 6, over a several-year time period, the New England Division created a series of capped mounds in a circle. The de facto CAD site in the center was then used for a rather large project. This technique greatly reduced the potential spread of the contaminants and allowed a low cap volume to contaminated sediment volume ratio. Fredette (1994) describes this project in detail.

Appendix I
Consolidation Testing

Consolidation Testing Procedures

Consolidation analysis of soft dredged material requires that laboratory compressiblity data be obtained across the entire, wide range of void ratios that are commonly encountered in these soft materials as they consolidate. Void ratios in dredged materials can vary much more than those of normal soils. In typical (nonsediment) soils in the natural state, void ratios normally vary between 0.25 and 2.0, with some soft organic clays reaching 3.0. Recently deposited in situ sediments often have void ratios as high as 5 or 6, double or triple the values of most soils. When dredged by hopper or hydraulic dredges, the initial void ratios after disposal may reach as high as 10 to 12; in a few clayey sediments; the maximum values may reach even higher. Mechanical dredging does not dramatically alter the void ratio of the mass of dredged material; however, there will be clumps of material at about the in situ void ratio with much softer (slurry consistency) material between the clumps.

Laboratory consolidation testing of soft materials often requires use of at least two types of consolidation tests. Both a modified version of the standard oedometer consolidation test and a self-weight consolidation test must normally be conducted; these tests provide data for the low and high ends of the anticipated range of void ratios, respectively. However, on relatively firm dredged materials that are mechanically dredged, use of oedometer testing alone may suffice.

Several additional consolidation test devices and procedures have been developed and evaluated in recent years, but none are currently available or recommended for routine dredged material testing. Some of these devices were intended to supplement the self-weight and oedometer test by providing more continuous void ratio-effective stress (e-σ) and void ratio-permeability (e-k) throughout the middle ranges of interest, while some devices were intended to provide all of the necessary data, thus eliminating the need for any other tests (e.g., Poindexter 1988). Because of continued widespread interest in slurry consolidation in the dredging, mining, and phosphate industries, it is anticipated that the American Society for Testing and Materials (ASTM) will develop a standard (or standards) for consolidation testing of very soft materials in the near future.

The modified oedometer test procedure is outlined in Appendix D of EM 1110-2-5027 (U.S. Army Corps of Engineers (USACE) 1987). The self-weight consolidation test and its interpretation and use have been described by Poindexter (1988) and Poindexter-Rollings (1990). Both of these consolidation tests will be briefly discussed below. For additional information and exact testing procedures, the reader is referred to the following documents: ASTM D 2435, USACE (1986), USACE (1987), Cargill (1986).

Standard Oedometer Test

The standard oedometer (consolidometer) test can be used to conduct consolidation tests on dredged materials and foundation soils, as shown in Figure I1 (USACE 1986). Due to the soft, often fluidlike consistency of the sediment samples normally tested, the fixed ring consolidometer should be used, instead of the floating ring device, since extrusion of the sample from the device will be less likely in the fixed ring consolidometer. Sample preparation and loading method constitute the only modifications necessary for testing of dredged material in this device. Consolidation test procedures for use with soft dredged materials are outlined below; more detailed procedures are provided in USACE (1987), Poindexter (1988), Poindexter-Rollings (1990), and Palermo, Montgomery, and Poindexter (1978), and troubleshooting tips are provided in Rollings and Rollings (1996). Although the foundation soils under dredged

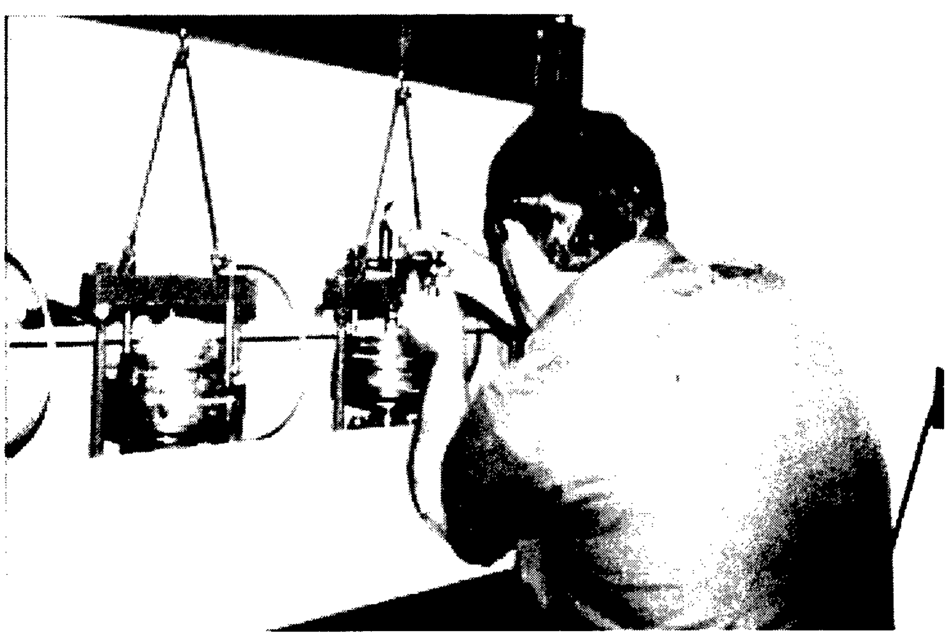


Figure I1. Standard oedometer testing device material mounds are generally stiffer than dredged sediments, they are usually still categorized as soft soils within the geotechnical community. Therefore, it is prudent to test the foundation soils in the fixed ring device, although the standard loading sequence may be used.

A representative sample of the fine-grained (minus No. 40 sieve) portion of sediments to be dredged should be used for the standard oedometer test. Since sediments have typically been remolded during the dredging process and any internal structure existing in situ in the channel has been destroyed, a remolded sample can be used for this test. The samples of foundation soils for consolidation testing, however, should be undisturbed.

When soft disturbed sediment samples are used, they are often spooned into the consolidation device. In this case, the dredged material must be placed carefully into the consolidometer to prevent inclusion of air bubbles that would invalidate the test results. After the sample is placed in the consolidation ring in the oedometer, the initial load is applied. The seating load consisting of the porous stone, loading plate, and ball bearings plus the compression load caused by the dial indicator is considered as the initial load increment for the test. This load should not exceed 0.005 tsf. If the sample consistency is extremely fluid-like, a lower initial load may be necessary to prevent extrusion of the soft material from the consolidation ring.

Succeeding load increments may be placed using the normal beam and weight or pneumatic loading devices. The following loading schedule is typically used for dredged material testing: 0.005, 0.01, 0.02, 0.05, 0.10, 0.25, 0.50, and 1.0 tsf. A maximum load of 1.0 tsf should be adequate for most applications. However, the maximum effective stress anticipated to occur at the bottom of the dredged material deposit during its existence should be estimated and the loading sequence extended, if necessary, to cover the full range of potential effective stresses.

Time-consolidation data should be examined while the test is in progress to ensure that 100-percent primary consolidation is reached for each load increment. In some cases, it may be necessary to allow each load increment to remain for a period of several days. Rebound loadings are not normally required since the dredged material will not typically be excavated after placement at a disposal site (USACE 1987).

Self-Weight Consolidation Test

A test device and testing procedure were developed by Cargill (1985 and 1986) to allow determination of the compressibility characteristics of dredged material at high void ratios. This test represents a modification to a testing procedure developed by Bromwell and Carrier (1979) for use in analyzing phosphate mining wastes. It is used to supplement the standard consolidation test in order to provide e-σ' and e-k data over the full range of anticipated void ratios and is especially useful for hopper or hydraulically dredged materials.

This test is useful for determining the upper portion of the void ratio-effective stress and void ratio-permeability relationships; it is presently the only method available to determine this needed information.

The self-weight testing device is shown in Figure I2. This device consists of an outer plexiglass cylinder that encircles a second plexiglass column composed of either 0.25- or 0.50-in.-thick rings. The device allows consolidation testing and subsequent incremental sampling of a specimen 6 in. in diameter and up to 12 in. high. The material tested in this device should consist of only the fine-grained portion of the sediment, i.e., that portion passing the No. 40 sieve. Use of only minus No. 40 material is necessary to prevent, or minimize, segregation of the coarser fraction from the high void ratio slurry being tested.

The sediment is mixed with water from the dredging site to form a slurry. In order to develop the entire e-σ' relationship, this slurry should always be at a void ratio greater than the void ratio at zero effective stress, e_{00}, which is the void ratio of the dredged material after sedimentation and before consolidation. The initial void ratios usually used in this test range from approximately 10.0 to 16.0.

The slurry is placed in the consolidometer, and it is allowed to undergo self-weight consolidation. Deformation versus time data are collected during the consolidation process. After the completion of primary consolidation, the test device is disassembled and the specimen is sampled at 0.25- or 0.50-in. intervals throughout its depth to obtain the necessary data to calculate void ratio, effective stress, and permeability values for the upper portion of the e-σ' and e-k curves.

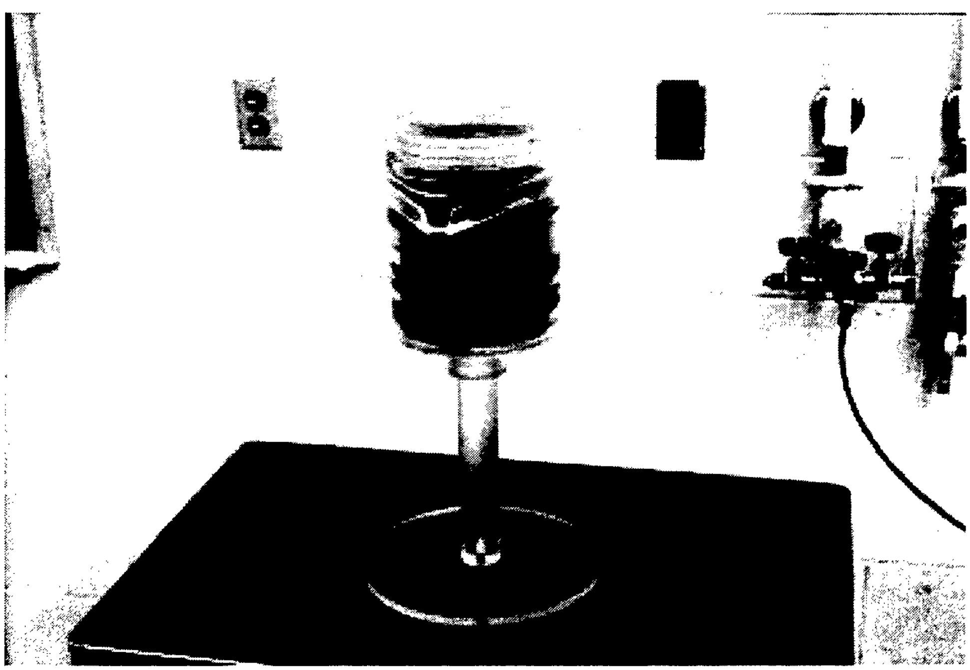


Figure I2. Self-weight consolidation test device

(Only one average value of k is obtained from this test.) Typical void ratios encountered in the specimen after completion of this test range from 5 to 12 (from bottom to top of specimen).

The self-weight consolidation test was developed to provide compressibility and permeability data for material that had been hydraulically dredged and placed in the disposal site as a slurry; thus the initial void ratios used in this test were required to be greater than the zero effective stress void ratio. Despite the fact that dredging methods other than hydraulic dredging will commonly be used for material placement at subaqueous disposal sites, continued use of this procedure will ensure that the e-σ' and e-k relationships developed for a particular material will cover the entire possible range of conditions.

Test Results

Both void ratio-effective stress and void ratio-permeability relationships must be developed from laboratory test results for each material (cap, contaminated dredged material, and foundation soil). These relationships should extend across the entire range of void ratios that may exist in each material. For dredged material, results obtained from the self-weight and oedometer tests (described in the previous section) must be combined to yield composite e-σ' and e-k relationships. For the stiffer foundation soils and some mechanically dredged materials, standard oedometer tests will typically provide adequate data. Tests needed for capping material will depend upon the type of material and its consistency; if sand is used for capping, no consolidation test will be required. Example compressibility and permeability curves are shown in Figures I3 through I8.

References

Bromwell, L. G., and Carrier, W. D., III. (1979). "Consolidation of fine-grained mining wastes," *Proceedings of the Sixth Pan American Conference on Soil Mechanics and Foundation Engineering, Lima, Peru.*

Cargill, K. W. (1985). "Mathematical model of the consolidation/desiccation process in dredged material," Technical Report D-85-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cargill, K. W. (1986). "The large strain, controlled rate of strain (LSCRS) device for consolidation testing of soft, fine-grained soils," Technical Report GL-86-13, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Gibson, R. E., England, G. L., and Hussey, M. J. L. (1967). "The theory of one-dimensional consolidation of saturated clays, I. Finite, non-linear consolidation of thin homogeneous layers," *Geotechnique* 17, 261-273.

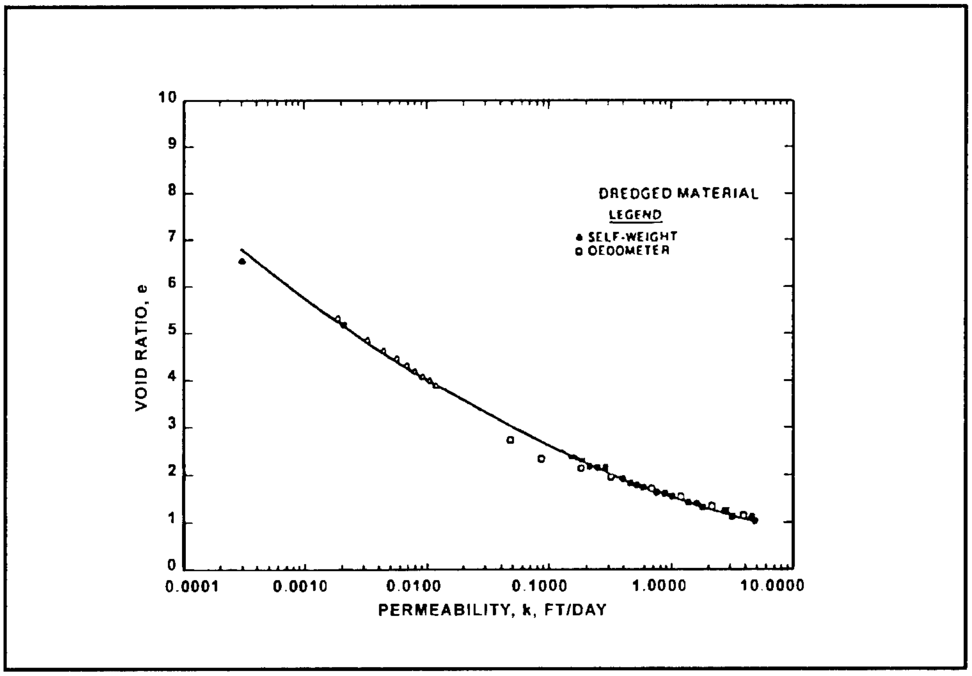


Figure I3. Void ratio-effective stress relationship for contaminated dredged material

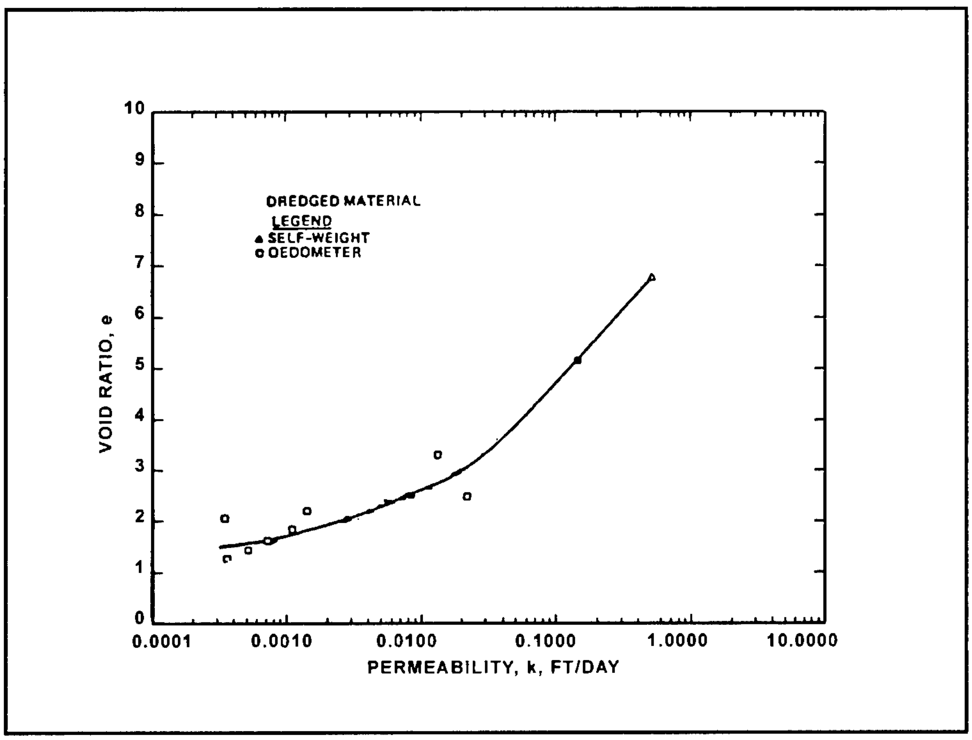


Figure I4. Void ratio-permeability relationship for contaminated dredged material

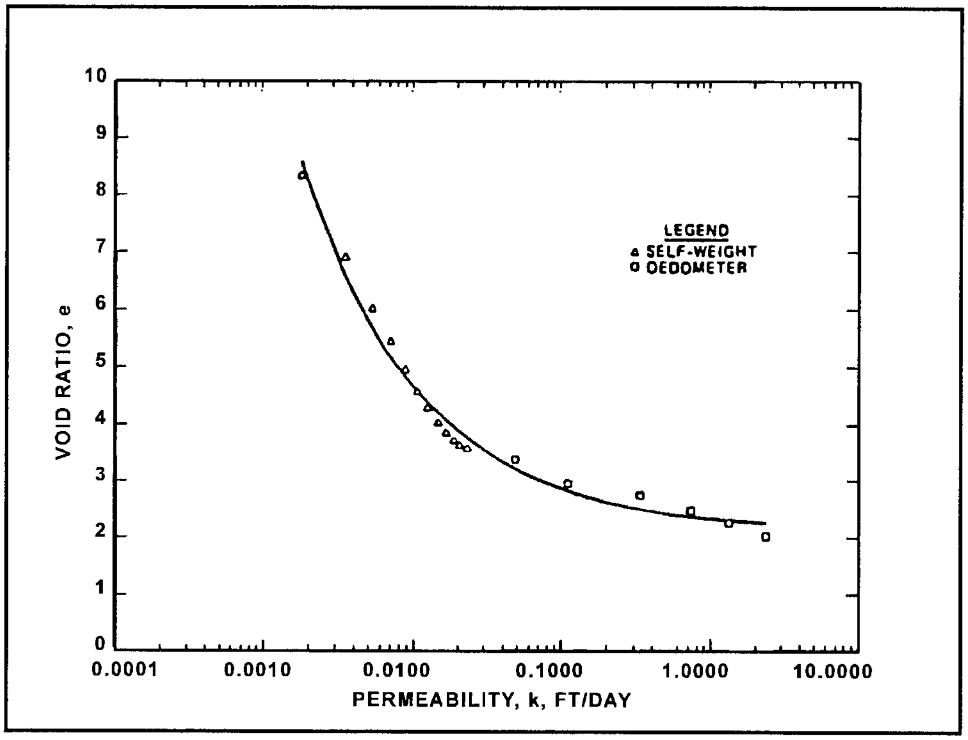


Figure I5. Void ratio-effective stress relationship for capping material

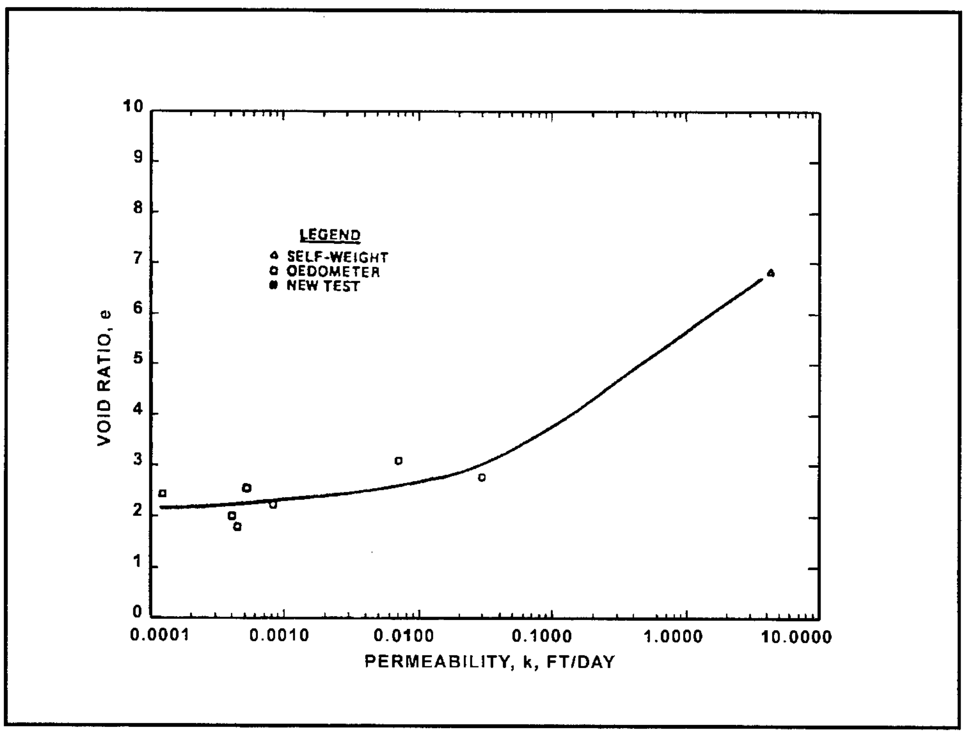


Figure I6. Void ratio-permeability relationship for capping material

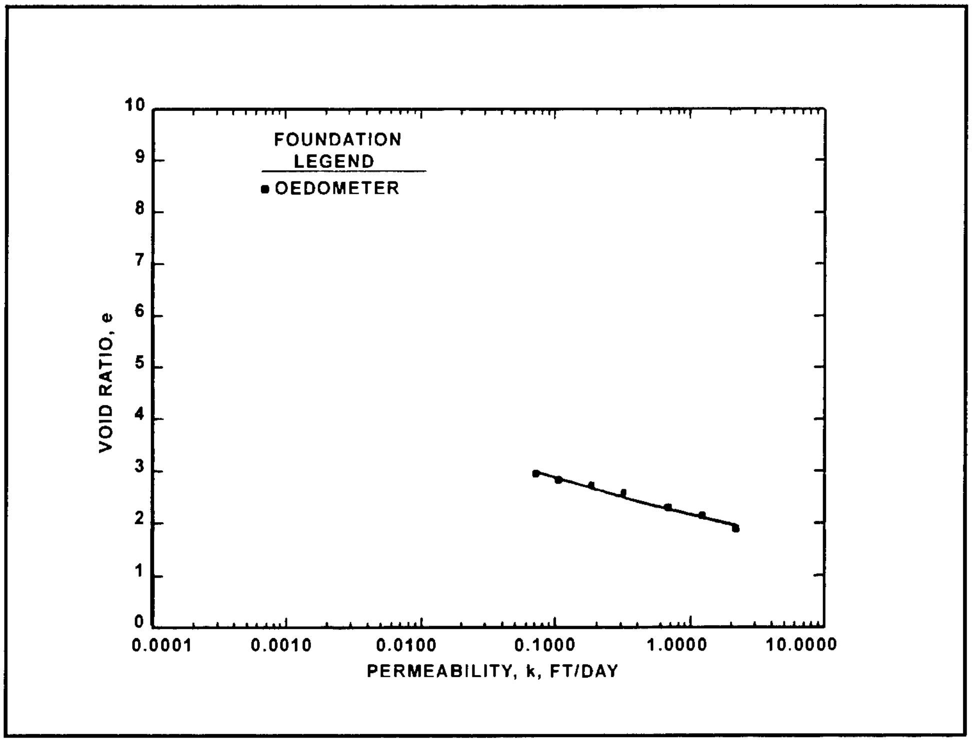


Figure I7. Void ratio-effective stress relationship for foundation soil

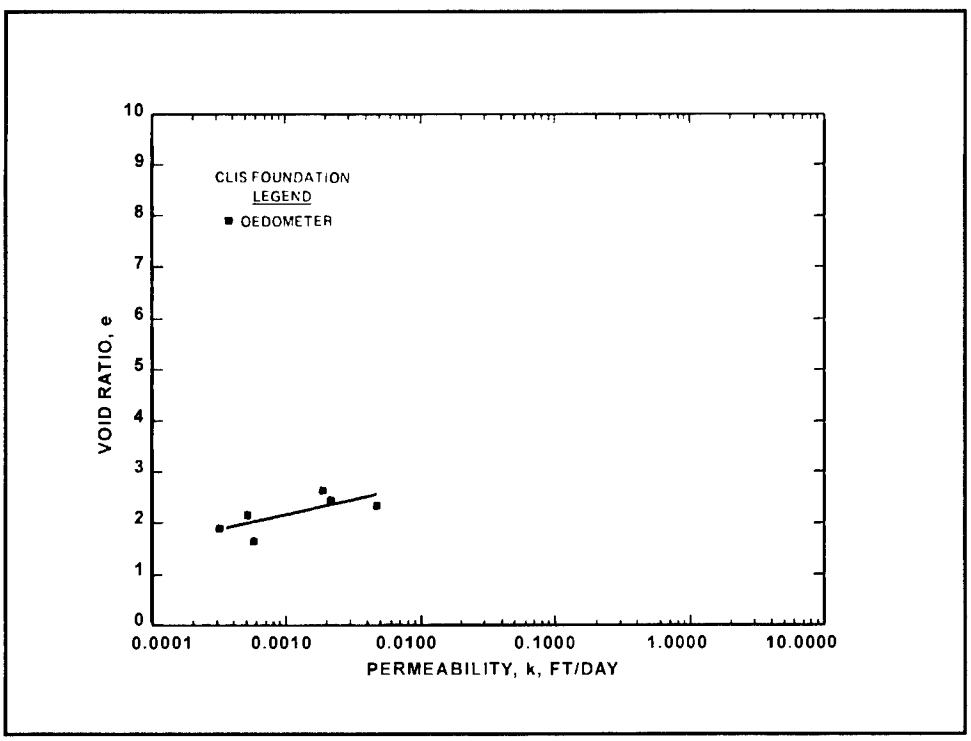


Figure I8. Void ratio-permeability relationship for foundation soil

Gibson, R. E., Schiffman, R. L., and Cargill, K. W. (1981). "The theory of one-dimensional consolidation of saturated clays, II. Finite, non-linear consolidation of thick homogeneous layers," *Canadian Geotechnical Journal* 8, 280-293.

Palermo, M. R., Montgomery, R. L., and Poindexter, M. E. (1978). "Guidelines for designing, operating, and managing dredged material containment areas," Technical Report DS-78-10, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Poindexter, M. E. (1988). "Behavior of subaqueous sediment mounds: Effect on disposal site capacity," Ph.D. Diss., Texas A&M University, College Station, TX.

Poindexter-Rollings, M. E. (1990). "Methodology for analysis of subaqueous sediment mounds," Technical Report D-90-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Rollings and Rollings. (1996). *Geotechnical materials in construction.* McGraw-Hill, New York.

Townsend, F. C. (1987). "Clay waste pond reclamation by sand/clay mix or capping," *ASCE Journal of Geotechnical Engineering* 115(11), New York.

Townsend, F. C., and McVay, M. C. (1990). "State-of-the-art: Large strain consolidation predictions," *ASCE Journal of Geotechnical Engineering* 116(2), New York.

U.S. Army Corps of Engineers. (1986). "Laboratory soils testing," Engineer Manual 1110-2-1906, Washington, DC.

__________. (1987). "Confined disposal of dredged material," Engineer Manual 1110-2-5027, Washington, DC.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY ***(Leave blank)***

2. REPORT DATE
June 1998

3. REPORT TYPE AND DATES COVERED
Final report

4. TITLE AND SUBTITLE
Guidance for Subaqueous Dredged Material Capping

5. FUNDING NUMBERS

6. AUTHOR(S)
Michael R. Palermo, James E. Clausner, Marian P. Rollings, Gregory L. Williams, Tommy E. Myers, Thomas J. Fredette, Robert E. Randall

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
See reverse.

8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report DOER-1

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

When dredged materials proposed for open-water placement are found to require isolation form the benthic environment due to the presence of contaminants, capping may be appropriate for consideration as a management action. This report is intended to provide technical guidance for evaluation of capping projects. From a technical perspective, this guidance is applicable to dredged material capping projects in ocean waters as well as inland and near-coastal waters.

Subaqueous dredged material capping is the controlled, accurate placement of contaminated dredged material at an appropriately selected open-water placement site, followed by a covering or cap of suitable isolating material. A number of capping operations under a variety of placement conditions have been accomplished. Conventional placement equipment and techniques are frequently used for a capping project, but these practices must be controlled more precisely than for conventional placement. Level bottom capping (LBC) is defined as the placement of a contaminated material in a mounded configuration and the subsequent covering of the mound with clean sediment. Contained aquatic disposal is similar to LBC but with the additional provision of some form of lateral confinement (e.g., placement in natural bottom depressions, constructed subaqueous pits, or behind subaqueous berms) to minimize spread of the materials on the bottom.

(Continued)

14. SUBJECT TERMS

Capping	Dredged material Open-water disposal
Contaminated sediments	Dredging

15. NUMBER OF PAGES
302

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

7. (Concluded).

U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, MS 39180-6199;
U.S. Army Engineer District, New England
696 Virginia Road, Concord, MA 01742-2751;
Texas A&M University, College Station, TX 77843

13. (Concluded).

The main body of this report describes specific procedures for all aspects of capping project evaluation and design. A recommended sequence of design activities is presented, and specific design steps are organized into flowcharts as necessary. A number of appendixes are also included in this report that provide detailed information on specific testing procedures, predictive models, etc.

A capping operation must be treated as an engineered project with carefully considered design, construction, and monitoring to ensure that the design is adequate. There is a strong interdependence between all components of the design for a capping project. By following an efficient sequence of activities for design, unnecessary data collection and evaluations can be avoided, and a fully integrated design is obtained. The major components of the project design and evaluation process include site selection, equipment and placement techniques, geotechnical considerations, mixing and dispersion during placement, required capping sediment thickness, material spread and mounding during placement, cap stability, and monitoring. Processes influencing the cap design include bioturbation, consolidation, erosion, and potential for advection or diffusion of contaminants. The basic criterion for a successful capping operation is simply that the cap thickness required to isolate the contaminated material from the environment be successfully placed and maintained.

The cost of capping is generally lower than alternatives involving confined (diked) disposal facilities. The geochemical environment for subaqueous capping favors long-term stability of contaminants as compared with the upland environment where geochemical changes may favor increased mobility of contaminants. Capping is therefore an attractive alternative for disposal of contaminated sediments from both economic and environmental standpoints.

City Testing and Analysis

Testing for Nearshore Placement

Composite Sampling
(included 80-90% Clean Material)

Testing for Open Ocean Disposal

Suitability= Is the material sandy and clean

Yes
suitable for
nearshore disposal

No
unsuitable for
nearshore disposal

Suitability= Not sand, non-toxic, and will not cause adverse effects when disposed offshore

No
unsuitable for
Open-ocean disposal

Yes
suitable for
Open-ocean disposal

Point where City Stopped Analysis

CAD Placement

Suitability: Water Quality Impacts from contaminated material ONLY

No
unsuitable for
CAD

Yes
suitable for
CAD

Analysis Not Completed by City

Upland

USACE Upland Testing Manual

USACE Subaqueous Capping
Technical Guidance

USACE Evaluation for Open Ocean Disposal
of Dredge Material

Revell, Mandy@Coastal

From: val-lyon@sbcglobal.net
Sent: Tuesday, October 4, 2022 12:26 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: RE: Support for Dredging & CAD Project--City of Newport Beach Application no. 5-21-0640

Staff and members of the California Coastal Commission:

My wife and I would like to express our unqualified **support** for the dredging and confined aquatic disposal project for Newport Harbor contained in the City of Newport Beach Application no. 5-21-0640.

Sincerely,

Edward and Barbara Lyon
427 San Bernardino Avenue
Newport Beach, California 92663

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 11:44 AM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Jim Connelly <jim.connelly@creativeteaching.com>
Sent: Monday, October 3, 2022 9:03 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>; Dennis Durgan (ddurgan@att.net) <ddurgan@att.net>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.
Thank you
Jim Connelly
321 Pirate Road
Newport Beach, CA

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 11:44 AM
To: Revell, Mandy@Coastal
Subject: FW: Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

From: Alan Andrews <alan@andrewsyacht.com>
Sent: Monday, October 3, 2022 8:47 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Alan Andrews <alan@andrewsyacht.com>
Subject: Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

I have been a citizen of California all of my life and Newport for many years, use the bay frequently and believe this is the one feasible way available to remove the contaminated bottom sediment from active contact with the bay while maintaining the harbor for use by the public.

Respectively submitted,

Alan Andrews

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 11:20 AM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

-----Original Message-----
From: Alan Airth <alan.airth@airth.com>
Sent: Monday, October 3, 2022 8:45 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach; Item 17a - Application No. 5-21-0614

> I am in agreement with The Commission staff recommending that the Commission Approve Coastal Development Permit application 5-21-0640 as conditioned.

Thanks,

Alan Airth

Sent from my iPhone

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 11:19 AM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

-----Original Message-----
From: Inga Beder <ingabeder@me.com>
Sent: Monday, October 3, 2022 8:38 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

I support and approve!!!

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Tuesday, October 4, 2022 11:18 AM
To: Revell, Mandy@Coastal
Subject: FW: Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Hi Mandy,
Here you go!

From: Celina Doka <cdoka@outlook.com>
Sent: Monday, October 3, 2022 8:30 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Celina Wang Doka
1031 Bayside Cove
Newport Beach CA

Sent from Mail for Windows

Revell, Mandy@Coastal

From: Robert Kinney <robert@alcommarine.com>
Sent: Tuesday, October 4, 2022 9:16 AM
To: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

Hi Mandy:

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

Robert Kinney
Alcom Marine Electronics
711 West 17th Street
Unit C12
Costa Mesa, California 92627
949 515 1727 office
949 279 5048 mobile

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Tuesday, October 4, 2022 8:26 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Jana Forrest

Date: October 4, 2022
Time: 3:26 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 23.124.253.95
Powered by: Elementor

Revell, Mandy@Coastal

From: Linda Merrifield <lmerrifield120@gmail.com>
Sent: Tuesday, October 4, 2022 7:44 AM
To: Revell, Mandy@Coastal
Subject: Oppose Newport Beach CAD

Linda Merrifield
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

Dear Coastal Commission,

I am OPPOSED to the idea of putting dredged sediment "unsuitable" for open ocean disposal in a CAD in Newport Harbor. This "unsuitable" sediment could drift to many popular public beaches adjacent to the anchorage and lining the harbor. The location is a popular spot for sailing and boats anchoring in Newport Harbor. The force of anchor dragging caused the recent Huntington Beach pipeline leak that spilled tens of thousands of gallons of crude oil into the ocean. Sediment is also disturbed by propeller thrust during anchoring and idling. This "unsuitable" sediment needs to be disposed of on land not by putting it back in the water!

Regards,

Linda Merrifield

Revell, Mandy@Coastal

From: Peter Kinney <peterakinney@gmail.com>
Sent: Tuesday, October 4, 2022 12:08 AM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project - City of Newport Beach Application NO. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

Thank you,
Peter Kinney
Newport Beach, CA

Peter Kinney
(949)735-9582 - Cell
peterakinney@gmail.com
peter@alcommarine.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 7:04 PM
To: Revell, Mandy@Coastal
Subject: FW: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

From: Dennis Baker <dennis.baker@diandden.net>
Sent: Monday, October 3, 2022 6:58 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Chris Miller <cmiller@city.newport-beach.ca.us>
Subject: Public Comment on October 2022 Agenda Item Friday 17a - Application No. 5-21-0640 (City of Newport Beach, Newport Beach)

Re: Application No. 5-21-0640

Hello Commissioners and Staff,

Please note the following. I am:

- Resident of Newport Beach for 50 years
- Active in water sports both on and in the water
- On the bay/ocean 2 to 3 days a week all year round
- Served on the City of Newport Beach Water Quality/Coastal Tidelands Committee for 13 years
- Volunteer docent for OC Parks / Newport Bay Conservancy for 22 years
- Board Member and Officer, SPON (Stop Polluting Our Newport) for 20 years

I strongly support the approval of Application No. 5-21-0640

Dennis Baker
Corona del Mar, CA
949.274.3226

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Monday, October 3, 2022 6:00 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Kris Mungo

Date: October 4, 2022
Time: 1:00 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 104.0.81.201
Powered by: Elementor

Revell, Mandy@Coastal

From: John Clement <john.clement@venturepointinc.com>
Sent: Monday, October 3, 2022 5:55 PM
To: Revell, Mandy@Coastal
Subject: Opposed - Application #5-21-0640; Agenda 17a

RE: Application #5-21-0640; Agenda 17a

Hello Mandy

I write to express my strong opposition to the CAD project in the Newport Bay and to urge you to take a long, hard look at the many problems with the project and it's approach.

I am a degreed mechanical engineer from UCSB with over 40 years experience in land use and environmental issues. I have read all the documentation associated with this project and there are serious flaws in the assumptions based on minimal, often just one, similar projects.

The likelihood of negative impact on the health of our residents, primarily our youth due to physical contact with the bay is very strong. The best approach of sending the polluted material to an EPA approved dump location has been dismissed as too expensive. I believe this is the only safe solution and no one has presented the cost for this approach.

So far, this project has been approved in the City process without serious review or debate.

Thank you for taking more time and truly examining this very serious issue.

John Clement
Resident – Newport Beach, CA

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 5:48 PM
To: Revell, Mandy@Coastal
Subject: FW: CAD / dredging app #5-21-0640

-----Original Message-----
From: Sandi Hill <tugwillyb@gmail.com>
Sent: Monday, October 3, 2022 5:47 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: CAD / dredging app #5-21-0640

Dear Commissioners,
I am in full favor of this project being done. We live by a beautiful harbor which makes Newport Beach so special. Many people enjoy our harbor as well as making a living off it. We must take care of it.
In living here since 1968 I have seeing many dredging go on, all befitting the safety of our harbor. During these dredging projects few problems arose and the outcome was well worth it. We have a boat in the mooring field that would be moved and don't mind the inconvenience for the benefit of our harbor. I want my grandchildren to be able to enjoy the bay as much as I have.
It would be shame to loose the federal funding for this project.
Let's get it done!

Sandi Barker Hill
503 Kings Road
Newport Beach, CA 92663

Sent from my iPad

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 5:32 PM
To: Revell, Mandy@Coastal
Subject: FW: Application No. 5-21-0640 (City of Newport Beach)

From: Svrcek, Rudy <RSvrcek@newportbeachca.gov>
Sent: Monday, October 3, 2022 5:00 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Application No. 5-21-0640 (City of Newport Beach)

Dear California Coastal Commission Board and Staff Members,

Approval of the City of Newport Beach Application No. 5-21-0640 will allow dredging of Newport Harbor to its design depth which will significantly enhance its flushing capability and water quality. I have been a resident for decades and have observed how much healthier the bay has become due to efforts in dredging and water management. I have enjoyed watching the sea life come alive in our bay over the last 20 years – fishing is better, dolphins and porpoises visit the harbor more than ever before due to dredging, monitoring water quality and additional management efforts. This confined aquatic disposal (CAD) facility will provide long term water quality improvements, enhancing the eel grass environment which will in turn bring an even healthier harbor to California. I ask the California Coastal Commission to approve Application No. 5-21-0640.

Rudy Svrcek
Harbor Commissioner

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 4:42 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Clark Cashion <clarkcashion@gmail.com>
Sent: Monday, October 3, 2022 3:32 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Team,

I wanted to drop you all a note and with how busy you are, I will keep it brief. As a lifelong resident of Newport Beach and active paddle boarder and occasional boater in the harbor, I STRONGLY support the CAD and dredging project in Newport Beach (Item 17a - Application No. 5-21-0640).

Some highlight that I am sure you will receive are:

- The proposed Newport Beach disposal site for the clean sand is the least damaging feasible alternative and the proposed CAD facility is the least damaging feasible alternative for disposal of contaminated sediments (Staff Report page 3).
- The project is consistent with the allowable use, alternatives, and mitigation tests contained in Coastal Act Section 30233 (Staff Report page 3).
- The contaminated sediments proposed for dredging and disposal in the proposed CAD facility would remain permanently isolated in the CAD facility and the project would not adversely affect water quality and marine resources of Newport Harbor and the adjacent waters of the coastal zone. The project, as conditioned, would be consistent with the marine resources and water quality policies of the California Coastal Act Sections 30230, 30231, 30232 (Staff Report page 3).
- The project would also significantly improve public access and recreational opportunities due to the placement of approximately 282,400 cy of clean and grain-size compatible sand along a stretch of eroding beach immediately upcoast of the Newport Harbor entrance. The project is consistent with the public access, recreation, and sand supply policies of the California Coastal Act (Staff Report page 3).
- The long-term water quality improvement of sequestering contaminated sediment will result in a net reduction in contaminated sediment that is currently located at various depths within the harbor (Staff Report page 5).
- The project construction would actually result in an increase of the available area for boats to pass through compared to existing conditions with an occupied anchorage in place (Staff Report page 6).
- This project is an allowable use pursuant to Section 30233(a)(2), -(4), and -(6), as components of the project achieve numerous goals for the overall functionality of Newport Harbor (Staff Report page 22).
- The Commission finds that the proposed dredging and fill associated with the proposed project is associated with allowable uses and is the least environmentally-damaging feasible alternative for disposal of Lower Newport Harbor contaminated sediments, which includes feasible mitigation measures. Environmental and human health risk assessment of the CAD cell alternative has shown that it can provide one of the lowest risk options compared with other alternatives because relative to upland disposal, there is less rehandling of the material and fewer contaminant transfer pathways because upland disposal can result in greater dermal contact, volatile emissions (Greenhouse gas emissions from truck or train trips) and groundwater pathways (Staff Report page 24).

- The proposed project includes the following characteristics which supported the Navy, USACE, and Oxnard Harbor District's consideration of CAD technology to remedy the current sediment contamination problems in Lower Newport Harbor:
- Construction of the CAD in lower Newport Harbor and deposition of beach quality sand in nearshore waters just west of the Newport Harbor mouth is not expected to cause significant adverse impacts to non-listed or sensitive bird species that nest, roost, and forage in the area (Staff Report page 34).
- Eelgrass impacts are not anticipated to occur as a result of the proposed project (Staff Report page 34).
- The project is not expected to cause a significant adverse impact to populations of these marine invertebrate species (Staff Report page 34).
- Therefore, as conditioned for revised plans limiting the locations for sand disposal to avoid contiguous sand dollar beds as shown in Exhibit 5, in addition to avoiding nighttime sand deposition to avoid potential negative impacts to grunion, Commission staff finds the project consistent with Sections 30230 and 30231 of the Coastal Act (Staff Report page 36).
- In other words, the existing water quality of Newport Bay is already negatively affected by the presence of DDx compounds and is not predicted to appreciably change as a result of the proposed placement of DDx containing sediments into the CAD. Further, by collecting, concentrating and burying contaminant laden sediments below a clean cap within the proposed CAD that are currently dispersed across Newport Bay, the proposed project may result in water quality improvements (Staff Report page 38).
- As conditioned, Commission staff has determined that the removal, placement, and permanent containment of DDT-contaminated Lower Newport Bay sediments at the proposed CAD facility would not adversely affect water quality over the short term and may ultimately help enhance water quality within the Bay (Staff Report page 38).
- The proposed beach replenishment would maintain and improve recreational use of State Tidelands. Sand replenishment around public beaches is consistent with the City's Tidelands grant (Staff Report pages 46).
- As conditioned, the Commission finds that with these measures, the proposed project would not adversely affect visual resources of the coastal zone, and therefore, the project is consistent with the policies of the Coastal Act (Staff Report pages 47).
- The majority of communities adjacent to the proposed CAD site (except for downtown Costa Mesa), on the other hand have low overall CalEnviroScreen scores. Additionally, areas nearby with higher pollution burden scores that are above 60% in the northern part of Newport Beach would not be affected by the proposed project or any of the alternatives. Therefore, the proposed project of keeping the contaminated sediment in the harbor near the source(s) of contamination does not result in environmental justice impacts compared to the project alternatives, which would relocate contaminated sediments to communities of concern in other regions and require transport of sediments through additional communities of concern. In addition, as conditioned, the project would minimize adverse environmental impacts that may occur locally (Staff Report pages 50).
- The Commission finds that the project, as conditioned, is consistent with Coastal Act requirements and will not cause new adverse impacts to the environment. Feasible mitigation measures which will minimize all adverse environmental impacts have been required. Therefore, the Commission finds that the proposed project, as conditioned, complies with the applicable requirements of the Coastal Act to conform to CEQA (Staff Report pages 51).

V/R,

Clark Cashion
949.322.9080
clarkcashion@gmail.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 4:42 PM
To: Revell, Mandy@Coastal
Subject: FW: Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: lee olsen <lbird20@gmail.com>
Sent: Monday, October 3, 2022 3:46 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

NEWPORT BEACH APPLICATION FOR CONFINED AQUATIC DISPOSAL

FACILITY
OCTOBER 14, 2022

TALKING POINTS FOR COASTAL COMMISSION COMMUNICATIONS
• By approving the City of Newport Beach Application No. 5-21-0640 the Coastal Commission has the opportunity to move forward the long awaited dredging of Newport Harbor, remove unsuitable materials currently lying on the floor of the harbor, finally bring the harbor back to its design depth, and make significant improvements to the water quality.
• Coastal Commission staff has reviewed this application and is recommending approval of the same.
• The City of Newport Beach has conducted significant research, held many public hearings, prepared and reviewed a myriad of studies and environmental reports, and certified the EIR for the project.
• The City of Newport Beach is near the end of the road. With the California Coastal Commissions approval of this Application for the Confined Aquatic Disposal facility, the City will move forward with the dredging of the bay to its design depth thus significantly enhancing its flushing capability and water quality and removing unsuitable materials that today are lying on the bottom of the bay.
• If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.
• This Application furthers the mission of the California Coastal Commission to protect and enhance California's coast and ocean for present and future generations by removing unsuitable materials from Newport Harbor's floor.

• (I, we, my family, my organization) ask you the Commissioners of the California Coastal Commission to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 4:42 PM
To: Revell, Mandy@Coastal
Subject: FW: I support of harbor dredging

From: Eve Lowey <elowey@chameleonoc.com>
Sent: Monday, October 3, 2022 2:42 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support of harbor dredging

Hello,

I wanted to reach out because I was not in support of the harbor dredging and I recently got a lot more educated about what this entails exactly and why and my mind is completely changed. I definitely support the long term health of the bay and I sounds like this process is long overdue. Please approve☺

Best regards,

Eve Lowey, ASID
President

714.708.3505 ext. 300
elowey@chameleonoc.com

JOIN OUR E-NEWSLETTER

CELEBRATING 30 YEARS

CHAMELEON DESIGN
3188 Airway Ave Suite B | Costa Mesa, Ca 92626 | 714.708.3515 fx | www.chameleonoc.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 4:41 PM
To: Revell, Mandy@Coastal
Subject: FW: I Support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Travis Duffield <travis@duffyboats.com>
Sent: Monday, October 3, 2022 4:40 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I Support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Good Afternoon,

As a lifelong resident and boater in Newport Harbor, I strongly support the CAD and Dredging project.

Best Regards,
Travis Duffield
Duffy Boats
Office: 949 645-6811
Cell: 949 293-5593
e-mail: travis@duffyboats.com

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Monday, October 3, 2022 4:30 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Liz Barman

Date: October 3, 2022
Time: 11:30 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Safari/605.1.15
Remote IP: 72.219.100.239
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Monday, October 3, 2022 4:27 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Linda Merrifield

Date: October 3, 2022
Time: 11:27 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_6) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Safari/605.1.15
Remote IP: 108.184.68.69
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Monday, October 3, 2022 3:58 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Marissa DuBois

Date: October 3, 2022
Time: 10:58 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 108.85.197.47
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Monday, October 3, 2022 3:58 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Marissa DuBois

Date: October 3, 2022
Time: 10:57 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 108.85.197.47
Powered by: Elementor

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:16 PM
To: Revell, Mandy@Coastal; Roman, Liliana@Coastal
Subject: FW: I support of harbor dredging

Hi,
Is this one of yours

From: Eve Lowey <elowey@chameleonoc.com>
Sent: Monday, October 3, 2022 2:42 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support of harbor dredging

Hello,

I wanted to reach out because I was not in support of the harbor dredging and I recently got a lot more educated about what this entails exactly and why and my mind is completely changed. I definitely support the long term health of the bay and I sounds like this process is long overdue. Please approve☺

Best regards,

Eve Lowey, ASID
President

714.708.3505 ext. 300
elowey@chameleonoc.com

JOIN OUR E-NEWSLETTER

CELEBRATING 30 YEARS

CHAMELEON DESIGN
3188 Airway Ave Suite B | Costa Mesa, Ca 92626 | 714.708.3515 fx | www.chameleonoc.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:16 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Keith Jarrett <membership@thehousenewportbeach.com>
Sent: Monday, October 3, 2022 3:11 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

To whom it may concern:

I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640.

I have been a long time resident in Newport Beach and currently own a private club on the harbor called thehouse Newport Beach.

The health of the harbor is important and the dredging project needs to happen!

Thanks!

Keith

Keith Jarrett
Founding Member and Owner
(949) 689-5186
thehousenewportbeach.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:06 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach

-----Original Message-----
From: Rhonda Knipp <rjknipp13@gmail.com>
Sent: Monday, October 3, 2022 1:28 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach

Application No 5-21-0640

Rhonda Knipp
949.887.6917

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:06 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Application No 5-21-0640

-----Original Message-----
From: Knipp Family <4knippfam@gmail.com>
Sent: Monday, October 3, 2022 1:29 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Application No 5-21-0640

R Knipp

Rhonda Knipp

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:05 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

From: Alexander Popof <alpopof@gmail.com>
Sent: Monday, October 3, 2022 1:56 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

To the Coastal Commission and Mandy Revell,

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640.

Alexander Popof
Menlo Park, California

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:05 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD and dredging project in Newport Beach - Application No. 5-21-0640

From: sabrina ketchum <sabrinaketchum@me.com>
Sent: Monday, October 3, 2022 2:06 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD and dredging project in Newport Beach - Application No. 5-21-0640

I was born, raised and have lived in Newport Beach my entire life (53 years).

I am avid sailor and boater, and consider Newport Harbor a true treasure!! **I strongly support the CAD and dredging project in Newport Beach - Application No. 5-21-0640**

Thank you
Sabrina Combs Ketchum

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:05 PM
To: Revell, Mandy@Coastal
Subject: FW: Newport Beach CAD & Dredging Project

From: Jim Carmack <Jim@carmackinsurance.com>
Sent: Monday, October 3, 2022 2:38 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Newport Beach CAD & Dredging Project

Ladies & Gentlemen,

I have been a full-time resident of Newport Beach since 1979 and have been a user of Newport Harbor even longer.

I support the CAD & Dredging project as proposed.

I understand there has been extensive "Robo-mailing" in opposition to this project, so I welcome you to contact me to confirm I am a real person.

Thank you,

Jim Carmack

(949) 246-4071

CARMACK INSURANCE

James M. Carmack | President
Established 1925 | (800) 228-6630
CA License #0508650
www.carmackinsurance.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:04 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Sharf, Royce <RSharf@savills.us>
Sent: Monday, October 3, 2022 2:49 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

As a long time resident, and boat enthusiast, in Newport Beach, I would like to go on record to provide my family's (The Sharf family, 2012 Tahuna Terrace, Corona del Mar) strongest support for the approval of Costal Development Permit application 5-21-0640. I have read your staff report and find it to be accurate and thoughtful for the proper next steps to address this pressing issue in Newport Harbor. If the Coastal Commission doesn't approve the Application, the unsuitable materials will remain on the floor of the bay and be disturbed by each passing boat, the bay will continue to silt up causing navigational problems, and the bay won't properly flush resulting in deteriorating water quality.

The Sharf family politely urges you, the Commissioners of the California Coastal Commission, to approve this Application for the Confined Aquatic Disposal Facility today and move this project forward.

Thank you for your consideration. - RAS

Royce Sharf
Vice Chairman, Branch Manager

Savills, 520 Newport Center Drive, 8th Floor, Newport Beach, CA 92660

Tel : +1 949 660 3545
Mobile : +1 714 404 3091
Website : www.savills.us

License 00993432 Corporate License 00388260

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:03 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

From: Cathy Kinney <kinney406@gmail.com>
Sent: Monday, October 3, 2022 2:55 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640. I am a lifelong resident of Newport Beach who has enjoyed boating in Newport Harbor since I was very young.

Gratefully,
Cathy Kinney
Newport Beach, CA 92661

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 3:03 PM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

From: Marshall, Timothy P. <timothy.p.marshall@ubs.com>
Sent: Monday, October 3, 2022 2:58 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Item 17a - Application No. 5-21-0640

Thank you

Timothy P. Marshall
Senior Vice President –Wealth Management
Senior Portfolio Manager

UBS Financial Services Inc.
888 San Clemente Drive, Suite 300
Newport Beach, CA 92660-6301
Tel. 949-717-3940, Fax 855-216-1952
timothy.p.marshall@ubs.com

Our Team: http://financialservicesinc.ubs.com/team/pricegroup

Main Website:www.UBS.com

Revell, Mandy@Coastal

From: Cathy Kinney <kinney406@gmail.com>
Sent: Monday, October 3, 2022 2:55 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640. I am a lifelong resident of Newport Beach who has enjoyed boating in Newport Harbor since I was very young.

Gratefully,
Cathy Kinney
Newport Beach, CA 92661

From: barbaravoigtriggs@gmail.com
Sent: Monday, October 3, 2022 2:46 PM
To: Revell, Mandy@Coastal
Subject: Newport Harbor Dumping

Barbara Riggs
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

No dumping in the harbor please!!

Revell, Mandy@Coastal

From: Alexander Popof <alpopof@gmail.com>
Sent: Monday, October 3, 2022 1:56 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640

To the Coastal Commission and Mandy Revell,

I support the Dredging and CAD Project – City of Newport Beach Application NO. 5-21-0640.

Alexander Popof
Menlo Park, California

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 1:22 PM
To: Revell, Mandy@Coastal
Subject: FW: Support for Dredging & CAD Project--City of Newport Beach Application no. 5-21-0640

From: William G. Swigart <wswigart@santanaship.com>
Sent: Monday, October 3, 2022 12:46 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Cc: Revell, Mandy@Coastal <Mandy.Revell@coastal.ca.gov>
Subject: Support for Dredging & CAD Project--City of Newport Beach Application no. 5-21-0640

To Whom It May Concern:-

I would like to express my unqualified support for the dredging and confined aquatic disposal project for Newport Harbor contained in the City of Newport Beach Application no. 5-21-0640.

Sincerely,
William G. Swigart
830 Harbor Island Drive,
Newport Beach, California 92660

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 1:22 PM
To: Revell, Mandy@Coastal
Subject: FW: For CAD in Newport Beach Harbor

From: Scott McFetters <smcfetters@outlook.com>
Sent: Monday, October 3, 2022 1:07 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: For CAD in Newport Beach Harbor

Dear Coastal Commission,

I hope all is well! I am a Newport Island resident in Newport Beach, and I am writing to support the CAD project for many reasons including the continued health and function of the harbor/related channels and sand replenishment especially at the wedge. Any other jetty modifications approvals needed at the wedge to bring back that special wave would be much appreciated.

Thank You,

Scott McFetters

Revell, Mandy@Coastal

From: William G. Swigart <wswigart@santanaship.com>
Sent: Monday, October 3, 2022 12:46 PM
To: SouthCoast@Coastal
Cc: Revell, Mandy@Coastal
Subject: Support for Dredging & CAD Project--City of Newport Beach Application no. 5-21-0640

To Whom It May Concern:-

I would like to express my unqualified support for the dredging and confined aquatic disposal project for Newport Harbor contained in the City of Newport Beach Application no. 5-21-0640.

Sincerely,
William G. Swigart
830 Harbor Island Drive,
Newport Beach, California 92660

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Monday, October 3, 2022 12:24 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Pamela Hostetler

Date: October 3, 2022
Time: 7:23 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) GSA/231.0.475926209 Mobile/15E148 Safari/604.1
Remote IP: 172.116.145.173
Powered by: Elementor

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 12:06 PM
To: Revell, Mandy@Coastal
Subject: FW: Application No. 5-21-0640

From: Gary Hill <garzophill@gmail.com>
Sent: Saturday, October 1, 2022 6:41 PM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Application No. 5-21-0640

Dear Commissioners

My name is Gary Hill, I have lived in Newport Beach for over sixty five years. I have been using and swimming in Newport Harbor for that time. I also have a Marine Fuel Business that my family has been involved in since 1954.
I very much support the CAD & Dredging Project in Newport Beach
Application No. 5-21-0640
This is very important for future boating in Newport Harbor

Thank You

Gary P. Hill
503 Kings Road
Newport Beach, Ca. 92673
949-795-3486

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 11:53 AM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD and Dredging Project in Newport Beach, Application No. 5-21-0640

From: Gary Stevens <gary@stevensyachtgroup.com>
Sent: Monday, October 3, 2022 8:51 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD and Dredging Project in Newport Beach, Application No. 5-21-0640

To whom it may concern,

I support the CAD & Dredging Project in Newport Beach - Application No. 5-21-0640. My family has been in Newport Beach for 50 years and heavily involved in boating and harbor activities.

--

Best Regards,

Gary Stevens
949.422.9960
www.stevensyachtgroup.com

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 11:51 AM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Application No. 5-21-0640

From: Laurie Eastman <laurieeastman3@gmail.com>
Sent: Monday, October 3, 2022 8:51 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Application No. 5-21-0640

To whom it may concern,

I support the CAD & Dredging Project in Newport Beach - Application No. 5-21-0640.

Laurie Eastman

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 11:48 AM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach - Application No. 5-21-0640

From: Gary Stevens <gary@stevensyachtgroup.com>
Sent: Monday, October 3, 2022 9:39 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach - Application No. 5-21-0640

To whom it may concern;

I support the CAD & Dredging Project in Newport Beach - Application No. 5-21-0640. Our family and friends are involved in all harbor and boating related activities and we firmly believe in this project for the health of the harbor. My husband has managed local shipyards and has been a yacht broker for thirty years.

Best Regards,

Anne Stevens
32 Mainsail Drive
Corona Del Mar, CA.
949.422.9970

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 11:44 AM
To: Revell, Mandy@Coastal
Subject: FW: I support the CAD & Dredging Project in Newport Beach

---

From: Katie Dickerson <katiedickerson79@gmail.com>
Sent: Monday, October 3, 2022 11:18 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: I support the CAD & Dredging Project in Newport Beach

To Whom It May Concern:

I support the CAD & Dredging Project in Newport Beach - Application
No. 5-21-0640.

As a resident of Newport Beach for over 40 years and an avid boater, I fully support the need to dredge to keep our bay running, and healthy and for the continued use and enjoyment of all those that visit our bay and live on or around it.

Sincerely,

Katie Werner Dickerson
Lido Lisle Resident

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 11:44 AM
To: Revell, Mandy@Coastal
Subject: FW: App #5-21-0640

From: Dana Ritchie <ritchie.dana@gmail.com>
Sent: Monday, October 3, 2022 11:33 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: App #5-21-0640

To: Maher Zaher

Maher.Zaher@waterboards.ca.gov

I support the CAD & Dredging Project in Newport Beach App #5-21-0640

I support the CAD & Dredging Project in Newport Beach. App#5-21-0640

I was on the wrong side of this issue and after further review I have seen the light!

Thank you, Dana Ritchie

____

Revell, Mandy@Coastal

From: SouthCoast@Coastal
Sent: Monday, October 3, 2022 11:43 AM
To: Revell, Mandy@Coastal
Subject: FW: Support CAD & Dredging Project in Newport Beach - Item 17a-Application 5-21-0640

From: David Ellis <dle@delta-partners.com>
Sent: Monday, October 3, 2022 11:09 AM
To: SouthCoast@Coastal <SouthCoast@coastal.ca.gov>
Subject: Support CAD & Dredging Project in Newport Beach - Item 17a-Application 5-21-0640

The vast majority of Newport Harbor users support Harbor dredging and the CAD. I am one of them. The City is an amazing steward of the Harbor and has studied this issue ad nauseum. Environmentalists, boaters, residents, businesses, recreational users all support dredging and the CAD. A few well-healed bayfront homeowners have stirred up folks with a campaign of misinformation with the goal of killing the project.

Best,

Dave

Delta Ventures Inc.
4040 MacArthur Blvd. Ste. 240
Newport Beach, CA 92660
Office: 949.447.5350 Ext. 101
Fax: 714.242.6747
Cell: 949.230.2110

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Monday, October 3, 2022 11:26 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Randall Hause

Date: October 3, 2022
Time: 6:26 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 104.48.244.213
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Monday, October 3, 2022 10:25 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Gina Vincent

Date: October 3, 2022
Time: 5:24 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (X11; CrOS x86_64 14816.131.0) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/103.0.0.0 Safari/537.36
Remote IP: 172.7.140.190
Powered by: Elementor

Revell, Mandy@Coastal

From: gina vincent <ginavin@msn.com>
Sent: Monday, October 3, 2022 10:24 AM
To: Revell, Mandy@Coastal
Subject: please oppose #5-21--640

Kmre$Zmrgirx

Sttswih$

Ettpmgexmsr$9165144:84$

Ekirhe$J5;e$

Sgxsfiv$58$6466$

Revell, Mandy@Coastal

From: Paul Ludgate <kiwipaulludgate@gmail.com>
Sent: Monday, October 3, 2022 6:49 AM
To: Revell, Mandy@Coastal
Subject: CAD

Paul Ludgate

Sttswih
Ettpgexmsr$'916514:84
Ekirhe$J5;e$
Sgxsfiv$580$466

Sent from my iPhone
I am 100% against this ridiculous proposal

Revell, Mandy@Coastal

From: Sandi Warneke <sandiwarneke@gmail.com>
Sent: Sunday, October 2, 2022 7:29 PM
To: Revell, Mandy@Coastal
Subject: CAD site in Newport Harbor

The proposed CAD site in our bay is dangerous to our water environment and all who utilize the waters in our harbor. PLEASE support the Alternate Plan for putting these contaminants on dry land.
Thank you,
Sandi Warneke
209 Via Ravenna
Newport Beach, CA 92663'
949-500-7318

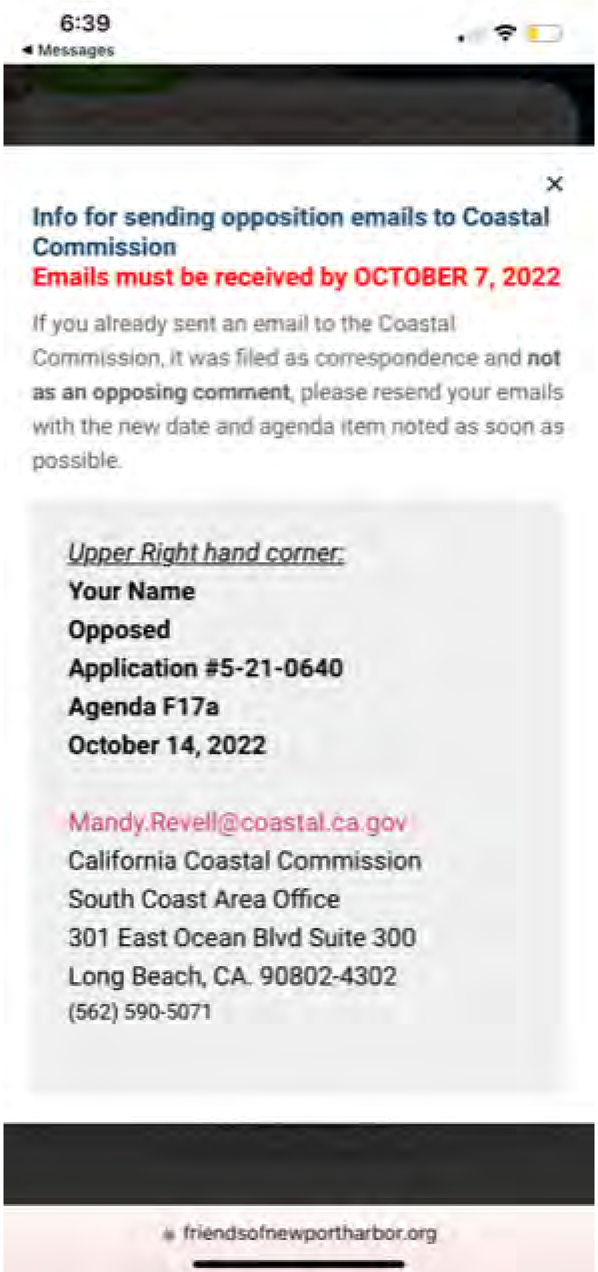
Revell, Mandy@Coastal

From: MARK PAZ <marpaz@aol.com>
Sent: Sunday, October 2, 2022 6:43 PM
To: Revell, Mandy@Coastal
Subject: Mark Paz CDM resident oppose the dumping of dug sludge for back bay contaminated into our beautiful neeport beach Harbor.

Hi Mandy,

This is mark Paz and my wife Karla Paz and we oppose the below application to dump sludge into our harbor. Please stop the same.

Thanks,
Mark Paz and Karla Paz
Paris Paz and Capri Paz



Sent from my iPhone

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Sunday, October 2, 2022 6:37 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Mark Paz

Date: October 3, 2022
Time: 1:36 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6 Mobile/15E148 Safari/604.1
Remote IP: 172.116.129.228
Powered by: Elementor

Revell, Mandy@Coastal

From: Marsha Ferrall <marshaferrall@gmail.com>
Sent: Sunday, October 2, 2022 6:31 PM
To: Revell, Mandy@Coastal
Cc: Marsha Ferrall
Subject: opposed to CAD project in newport bay

Marsha Ferrall

Opposed

Application #5-21-0640

Agenda 17a

i have lived in the newport beach area for many years. i understand the necessity for dredging but i am opposing the CAD project in the middle of our bay.

please, for the sake of the generations to come, dismiss the CAD and look to the land solution.

i thank you in advance for your cooperation.

Revell, Mandy@Coastal

From: kris mungo <krismungo@gmail.com>
Sent: Sunday, October 2, 2022 5:29 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640

Dr. & Mrs. Richard Mungo

Opposed

Application #5-21-0640

Agenda 17a

We are very opposed to Application #5-21-0640 plan to dump Mercury and DDT into Newport Harbor East Turning Basin of the Newport Harbor Bay. This area is the main channel of the harbor for recreation. Everyone uses it for boating, sailing, kayaking, SUP, swimming, day/overnight anchorage, raft up's, regattas and more. There are other ways to get rid of the contaminants.

Thank you!

Dr. and Mrs. Richard Mungo

109 Via Nice, Newport Beach, CA 92663

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Sunday, October 2, 2022 4:41 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

VALAREE WAHLER

Date: October 2, 2022
Time: 11:40 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.6.1 Mobile/15E148 Safari/604.1
Remote IP: 172.116.145.62
Powered by: Elementor

Revell, Mandy@Coastal

From: Cary Singleton <carysingleton1@gmail.com>
Sent: Sunday, October 2, 2022 1:39 PM
To: Revell, Mandy@Coastal
Subject: Opposition to Application #5-21-0640 CAD

Gevsp}r$Wmrkpixsr
Sttswih
Ettpmgexmsr$916514:84
Ekirhe$J5;e
Sgxsfiv$580$466

$
$
Gepmjsvrme$Gsewxep$Gsqqmwwmsr$
Wsyxl$Gsewx$Evie$Sjjmgi$
745$Iewx$Gier$Fpzh$Wymxi744
Psrk$Fiegl0$GE2$=4<461874 6$
,9:6-$=4194;5$

Attention: The Coastal Commision re the CAD Application #5-21-0640

I was diagnosed with a rare form of cancer for a 26 year old - endometrial - in 1982 and given 6-9 months to live with no time for chemo or radiation. Surgery, a hysterectomy, was the only option. after the diagnosis which had been confirmed by four cancer centers around the country since it was so unusual. We learned many years later that **the cancer was likely to have been caused by environmental causes, the dumping of trichloroethylene in the cleaning of circuit boards into the water system** at Hughes Aircraft, Tucson Arizona, where I worked from 1977-79. "Hughes Aircraft and the city of Tucson were accused of dumping TCE in the water table for 29 years, beginning in 1952. **A lawsuit against the city was settled in 1981 for $31 million, and in 1991 a suit against Hughes Aircraft was settled for $84.5 million.** In 1981 the Environmental Protection Agency (EPA) tested water wells on the south side of Tucson and found TCE levels were beyond the EPA limits."* Since I was unaware of this lawsuit having moved out of the area, I didn't participate in the suit, but I can assure that NO AMOUNT OF MONEY would have compensated me for the loss of the opportunity to bear biological children, let alone all of the locals who died or were seriously medically impacted by that.

So, it is incredible that the City of Newport Beach would consider moving potentially cancer-causing material ANYWHERE in our harbor: a harbor where residents and visitors from all over the world swim and enjoy boating activities. This could affect the city's tourist income when this becomes widely known. Furthermore, how can we be ASSURED that an earthquake or other seismic activity won't disturb this site? What if a large boat sinks into the open CAD? or drags an anchor across it, exposing its contents as we recently witnessed off the coast last year. And if it is too dangerous to be dumped in open ocean waters, why do we think that couldn't apply to our own harbor? And if installed and it later leads to lawsuits as a result, who will be responsible financially?

We know other safer venues have been offered that don't involve potential contamination of our harbor. We ask you to please reconsider this plan.

Carolyn Singleton

CarySingleton1@gmail.com
844 Via Lido Nord
Newport Beach, CA 92663

Create Vision > Inspire Action

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Sunday, October 2, 2022 1:32 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

joyce l snyder

Date: October 2, 2022
Time: 8:32 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 70.181.81.66
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Sunday, October 2, 2022 12:52 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Jason Nadeau

Date: October 2, 2022
Time: 7:51 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 108.255.44.234
Powered by: Elementor

Revell, Mandy@Coastal

From: Suzanne Dunlap <suzdunlap11@gmail.com>
Sent: Sunday, October 2, 2022 10:37 AM
To: Revell, Mandy@Coastal
Subject: CAD Newport Beach

Suzanne Dunlap

Opposed
Application #5-21-0640
Agenda F17a
October 14th, 2022

We as a family oppose the CAD dump

Suzanne

Revell, Mandy@Coastal

From: Will Singleton <ws.singleton@gmail.com>
Sent: Sunday, October 2, 2022 10:05 AM
To: Revell, Mandy@Coastal
Subject: Comment on Application #5-21-0640

Will Singleton
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

California Coastal Commission
South Coast Area Office
301 East Ocean Blvd Suite 300
Long Beach, CA. 90802-4302

We are concerned about the use of a CAD to manage toxic material in Newport Beach Harbor. The harbor is a very special place due to its diversity of residential, commercial and recreational activities. Placing a CAD as proposed would be unprecedented in a west coast harbor as beautiful and active as Newport Beach. We believe there are several potential Confined Disposal Facility (CDF) locations that have not been considered that would provide more appropriate solutions.

Sincerely,

Will Singleton
844 Via Lido Nord
Newport Beach, CA 92663

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Sunday, October 2, 2022 9:55 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

FRANCES PULLIN

Date: October 2, 2022
Time: 4:54 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36 Edg/105.0.1343.50
Remote IP: 172.250.210.15
Powered by: Elementor

Revell, Mandy@Coastal

From: Sarah Donovan <sarahxdonovan@me.com>
Sent: Sunday, October 2, 2022 9:30 AM
To: Revell, Mandy@Coastal

Gepmjsvrme$Gsewxep$Gsqqmwwmsr$
Wsyxl$Gsewx$Evie$Sjjmgi$
$
745$Iewx$Sgier$Fpzh$Wymxi744
Psrk$Fiegl0$GE2$=4<4618746$
$
Lipps%$
$
$
MeqWevel$Hsrszer$erh$M$eq$STTSWIH$xsxliGEHmrRi{tsvx$Levfsv$erh${syph$pmoixsvizmi{$sxliv$stxmsrw2$
$
$
Sttswih$
Ettpmgexmsr$'916514:84$
Ekirhe$J5;e$
Sgxsfiv$580$6466$
$$
$
$
$
Sincerely,
Sarah Donovan

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Sunday, October 2, 2022 5:12 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Alexander MacDougall

Date: October 2, 2022
Time: 12:11 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36 Edg/105.0.1343.53
Remote IP: 107.127.0.75
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Sunday, October 2, 2022 2:19 AM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Susan Eaton

Date: October 2, 2022
Time: 9:19 am
Page URL:
https://friendsofnewportharbor.org/?utm_source=social&utm_medium=paid&utm_campaign=save%20the%20bay&hsa_acc=515797409268691&hsa_cam=23851717150640773&hsa_grp=23851717150660773&hsa_ad=23851717150700773&hsa_src=ig&hsa_net=facebook&hsa_ver=3&fbclid=PAAaaLemvwycrgTLNJX_FoFyJ5CEks0U5yZwizf-GsKlKmMpVB1JlIlVu-qMI_aem_AVV6RiKRo2lJy7Lb0rI6xMj6Lj3qyk79cp4n0KVgTpb8T0YSxucJfNXmc0z4RM05ArwiW-1AHahRBtGVJNVp8MALN8Regxe1IatIsx6ae9ulgnYaQ1NTY3DPdw43Y-tCL239hL0qjSwmUtUHk3gjSCxP
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/15E148 Instagram 254.0.0.15.109 (iPhone9,1; iOS 15_6_1; en_US; en-US; scale=2.00; 750x1334; 401726258)
Remote IP: 76.169.229.21
Powered by: Elementor

Revell, Mandy@Coastal

From: LBonas <phoebefufu@yahoo.com>
Sent: Saturday, October 1, 2022 10:26 PM
To: Revell, Mandy@Coastal
Subject: Fw: Application #5-21-0640

To California Coastal Commission

Lynn Bonas
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

I'm very much opposed to the plan to put toxic waste in Newport Harbor, no matter how it is packaged and buried.

Please do not allow this to happen.

Lynn Bonas
Orange, California

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Saturday, October 1, 2022 10:12 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Lynn Bonas

Date: October 2, 2022
Time: 5:12 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.1 Safari/605.1.15
Remote IP: 23.242.32.223
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Saturday, October 1, 2022 10:12 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Lynn Bonas

Date: October 2, 2022
Time: 5:11 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.1 Safari/605.1.15
Remote IP: 23.242.32.223
Powered by: Elementor

Revell, Mandy@Coastal

From: Nicole Nelson <olenicole@gmail.com>
Sent: Saturday, October 1, 2022 8:58 PM
To: Revell, Mandy@Coastal
Subject: Newport Harbor CAD

Nicole Nelson
Opposed
Application #5-21-0640
Agenda F17a
October 14, 2022

I am OPPOSED to the proposal to remove contaminated material which is unsuitable for disposal in the open ocean and bury it in the Newport Beach Harbor.

Sincerely,
Nicole Nelson
Newport Beach, CA

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Saturday, October 1, 2022 8:35 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Jim Aust

Date: October 2, 2022
Time: 3:34 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.2 Safari/605.1.15
Remote IP: 104.0.82.138
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Saturday, October 1, 2022 8:33 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Diane Aust

Date: October 2, 2022
Time: 3:32 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/15.2 Safari/605.1.15
Remote IP: 104.0.82.138
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Saturday, October 1, 2022 8:23 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Puzant Ozbag

Date: October 2, 2022
Time: 3:23 am
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 16_0 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Version/16.0 Mobile/15E148 Safari/604.1
Remote IP: 104.28.85.225
Powered by: Elementor

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Saturday, October 1, 2022 8:23 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Lisa Harrington

Date: October 2, 2022
Time: 3:23 am
Page URL:
https://friendsofnewportharbor.org/?utm_source=social&utm_medium=paid&utm_campaign=save%20the%20bay&hsa_acc=515797409268691&hsa_cam=23851717150640773&hsa_grp=23851717150660773&hsa_ad=23851717150700773&hsa_src=fb&hsa_net=facebook&hsa_ver=3&fbclid=IwAR0PM7liX0i3NscWXJxA0adlQBwq0HPR1b720QX8e4BEcmxm4uohOmN51ic_aem_AWou7sToj20g-mvWgtpjljvmWJ6hs2gqLe9BhWKdDqojvxpgSrvKguXDWSjusosgUBERTl0WEUsS_wv_ff37E9RsXBK4y0XRoJuLspaCvm_iJKTzcl9UM5hGg91SsS2bqN5R4lLP1ajGA6ZzWztukKSI
User Agent: Mozilla/5.0 (iPhone; CPU iPhone OS 15_6_1 like Mac OS X) AppleWebKit/605.1.15 (KHTML, like Gecko) Mobile/19G82
[FBAN/FBIOS;FBDV/iPhone13,3;FBMD/iPhone;FBSN/iOS;FBSV/15.6.1;FBSS/3;FBID/phone;FBLC/en_US;FBOP/5]
Remote IP: 72.211.249.98
Powered by: Elementor

Revell, Mandy@Coastal

From: duncanswh@yahoo.com
Sent: Saturday, October 1, 2022 3:20 PM
To: Revell, Mandy@Coastal
Subject: Application #5-21-0640, Agenda F17a

Lipir$Hyrger$
Sttswih$
Ettpmgexmsr$'916514:84$
Ekirhe$J5;e$
Sgxsfiv$580$6466$

Please note that I am absolutely opposed to the proposed CAD.

Helen Duncan

Revell, Mandy@Coastal

From: Friends of Newport Harbor <info@friendsofnewportharbor.org>
Sent: Saturday, October 1, 2022 3:18 PM
To: Revell, Mandy@Coastal
Subject: Plan to dump Mercury and DDT into Newport Harbor

This is the first time I am hearing of the plan to dump material that is unsuitable for open ocean disposal like Mercury and DDT into the Newport Harbor.

Please register my opposition.

Thank you!

Helen Duncan

Date: October 1, 2022
Time: 10:17 pm
Page URL: https://friendsofnewportharbor.org/
User Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/105.0.0.0 Safari/537.36
Remote IP: 216.24.210.181
Powered by: Elementor