CALIFORNIA COASTAL COMMISSION
CENTRAL COAST DISTRICT
725 FRONT STREET, SUITE 300
SANTA CRUZ, CA 95060
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WEB: WWW.COASTAL.CA.GOV

Th12a

A-3-SCO-20-0027 (SISNEY, SANTA CRUZ CO.)
MAY 11, 2023 HEARING
EXHIBITS

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North
Capitola
Project Site
Opal Cliff Drive
City of
Santa Cruz
Live Oak
Beach Area
Pleasure
Point
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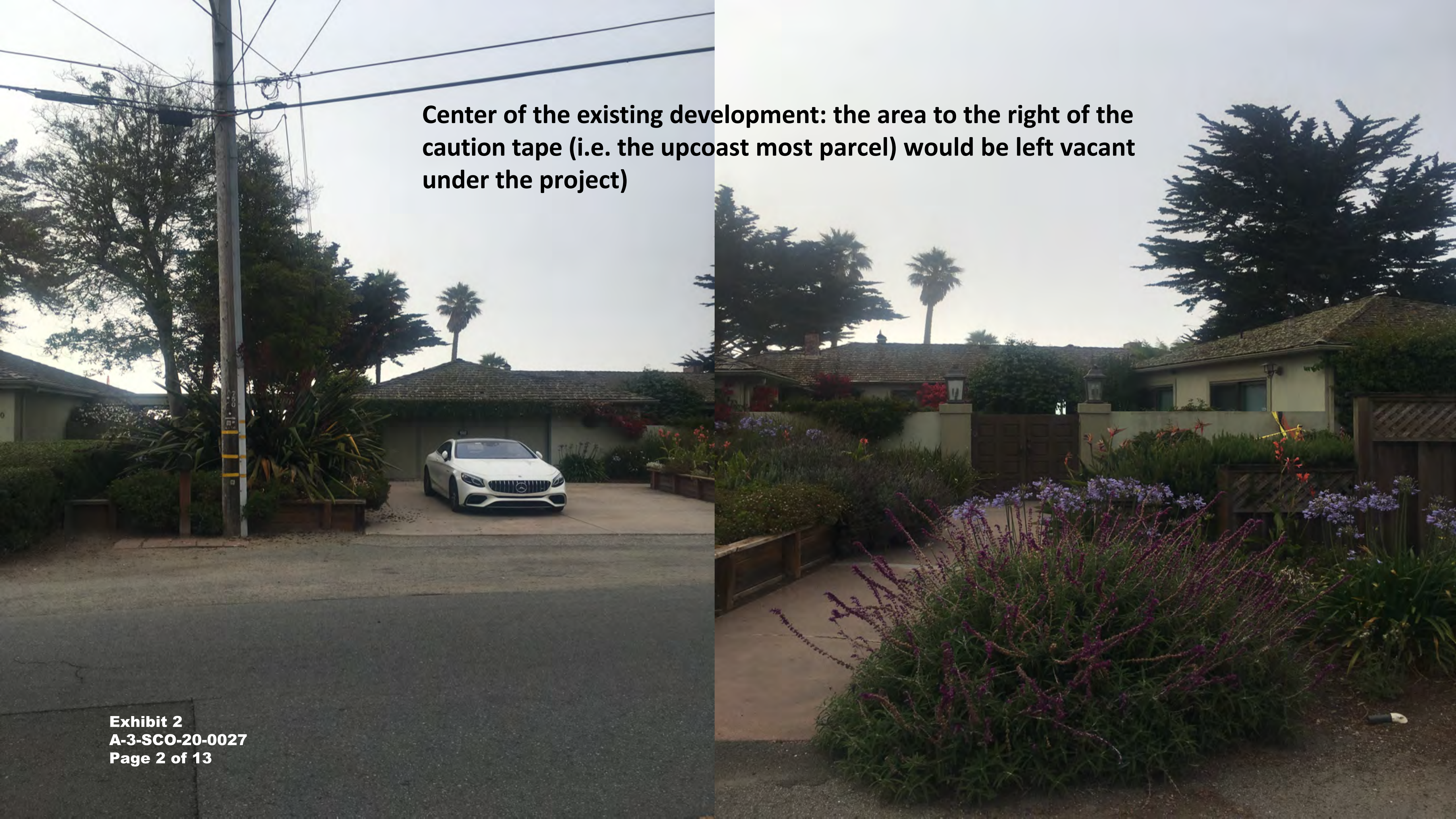
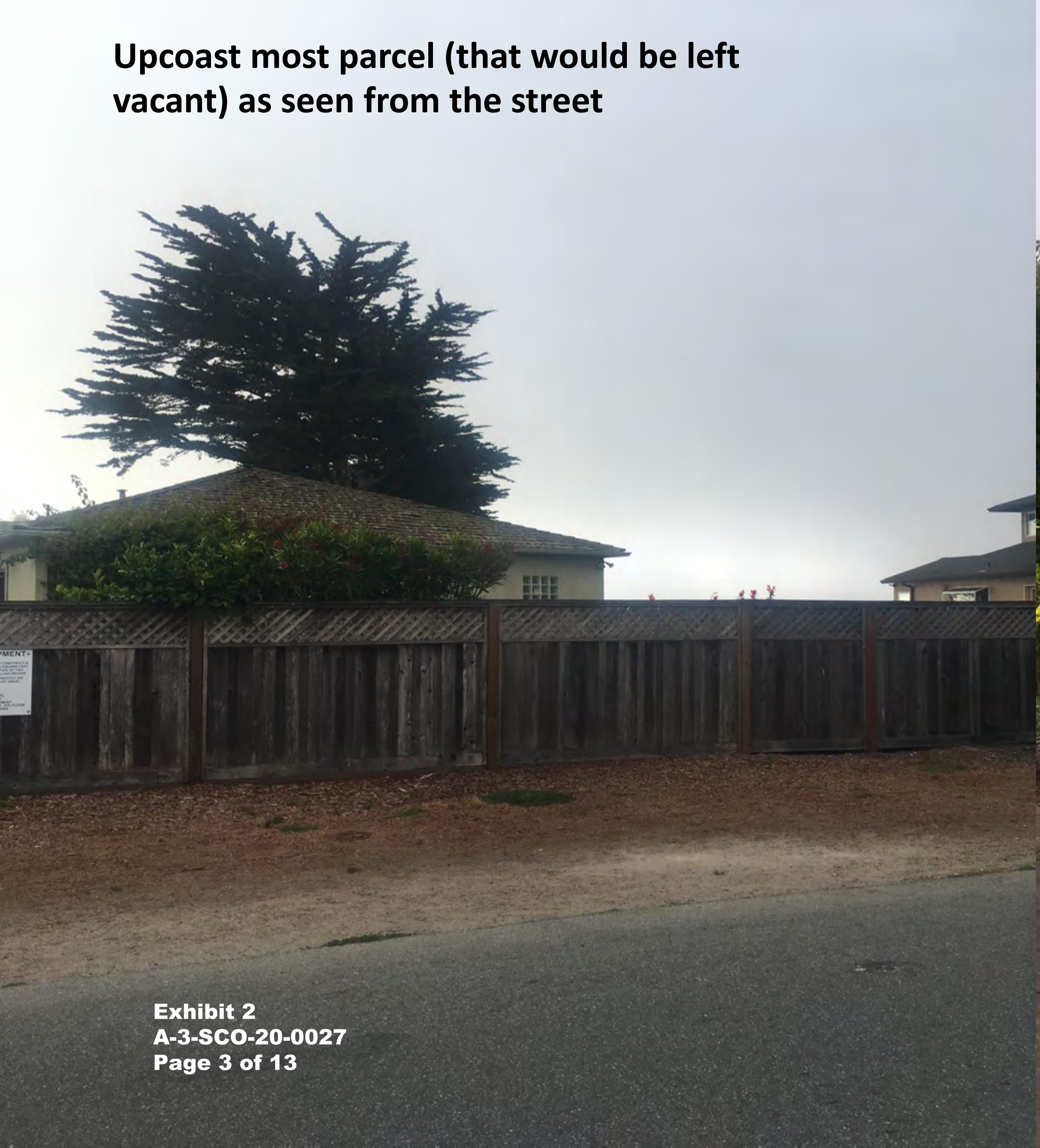
Page 1 of 1

The area left of the caution tape would be left vacant under the project (i.e. the downcoast most parcel).

Existing view of the single-story home from Opal Cliff Drive

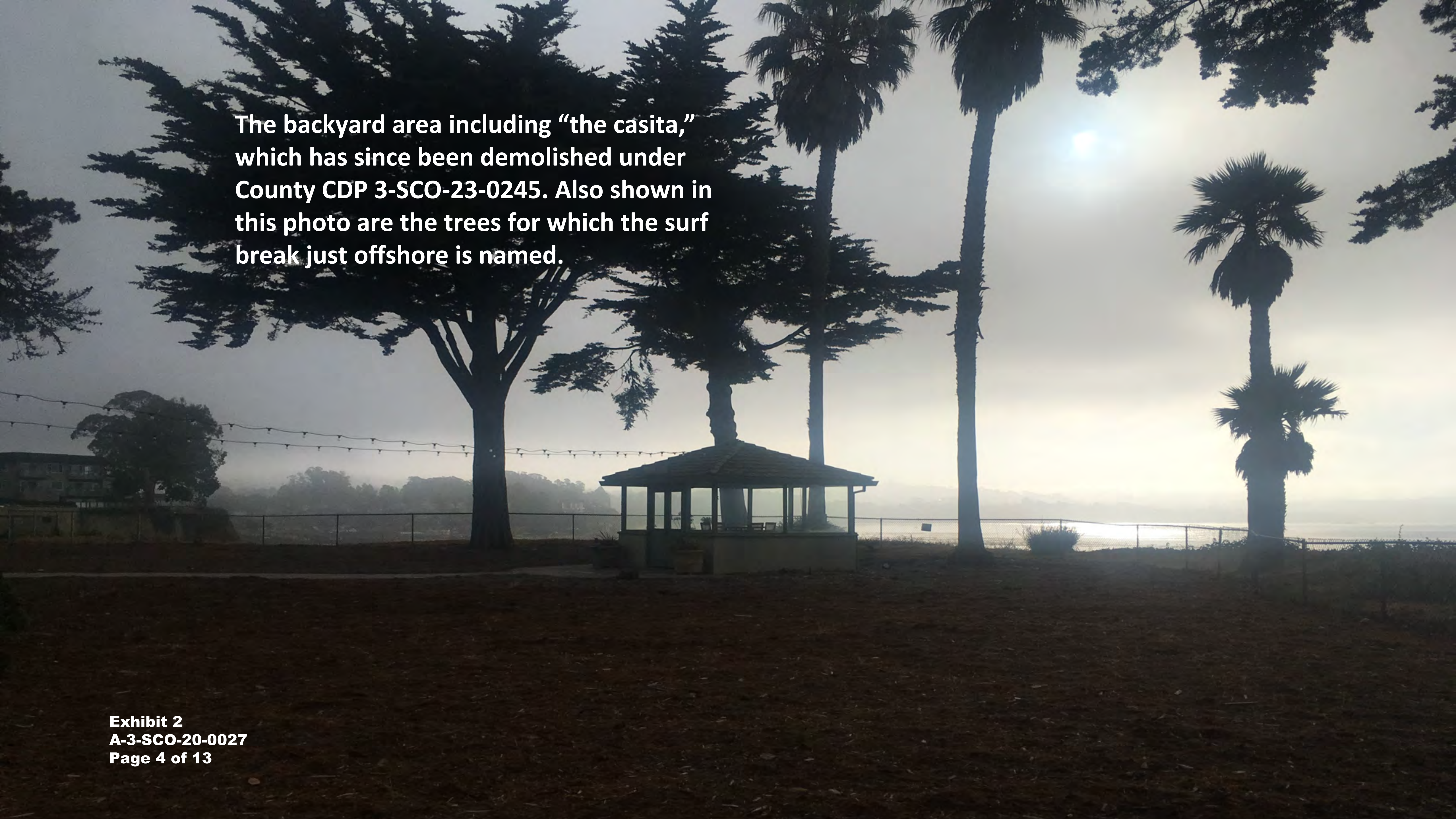


Center of the existing development: the area to the right of the caution tape (i.e. the upcoast most parcel) would be left vacant under the project)



Upcoast most parcel (that would be left vacant) as seen from the street

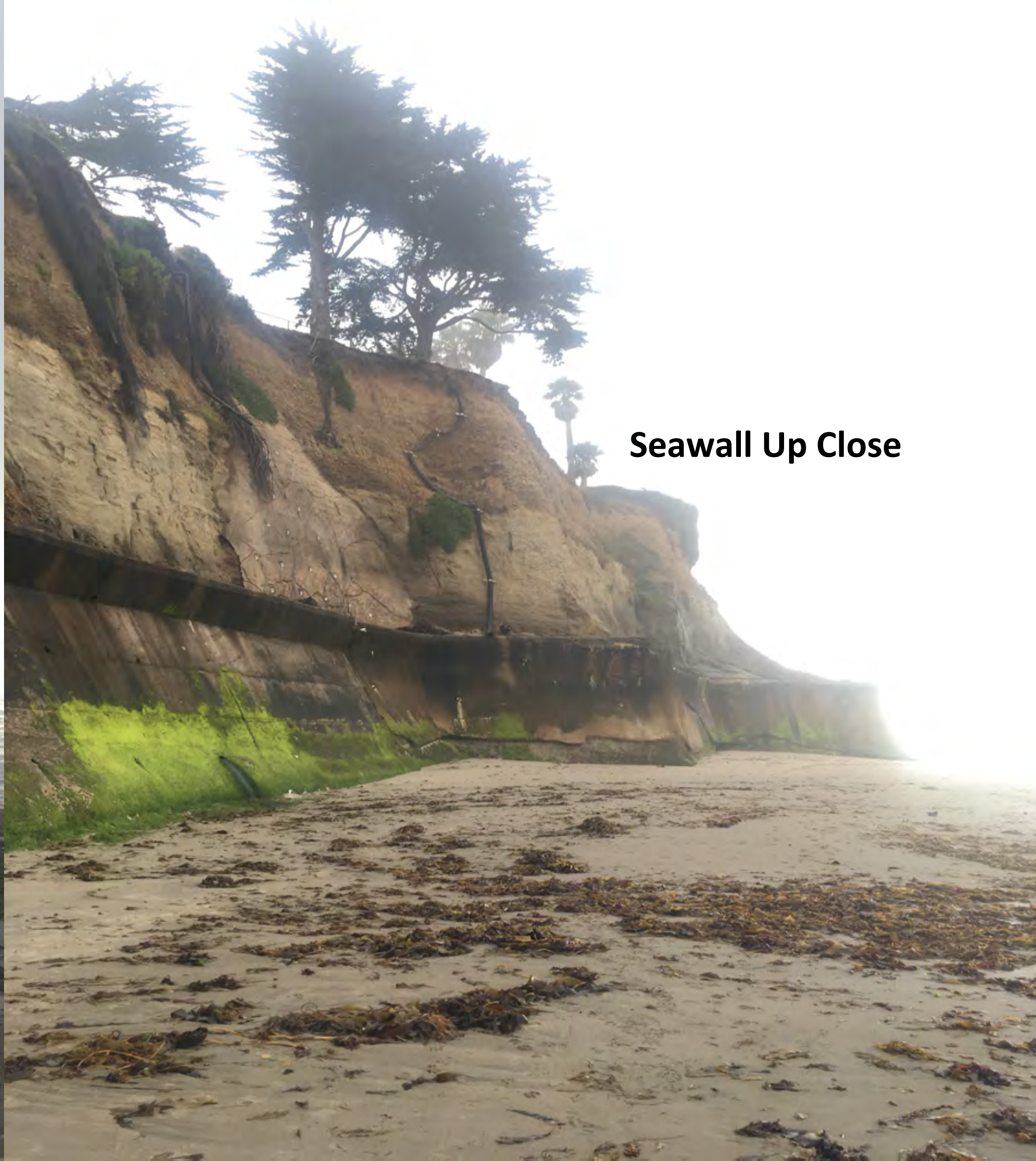
The area right of the caution tape would be left vacant (seen from inside the property lines).



The backyard area including “the casita,” which has since been demolished under County CDP 3-SCO-23-0245. Also shown in this photo are the trees for which the surf break just offshore is named.

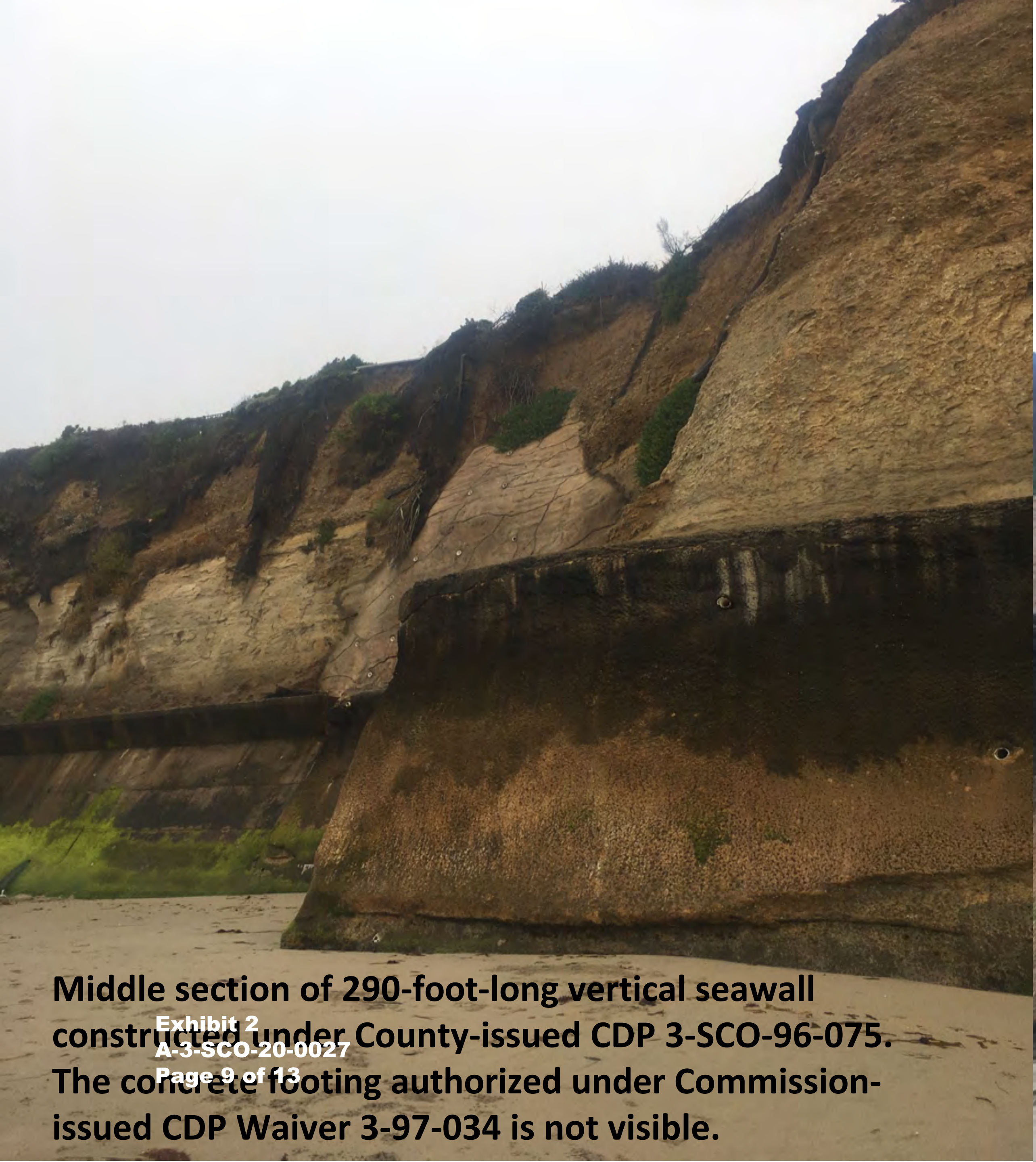
Casita, Backyard, and Existing Residence


View of the property from Opal Cliff Park Stairway
(at very low tide)
Subject Property
Existing seawall


Seawall Up Close

Seawall as viewed from the beach

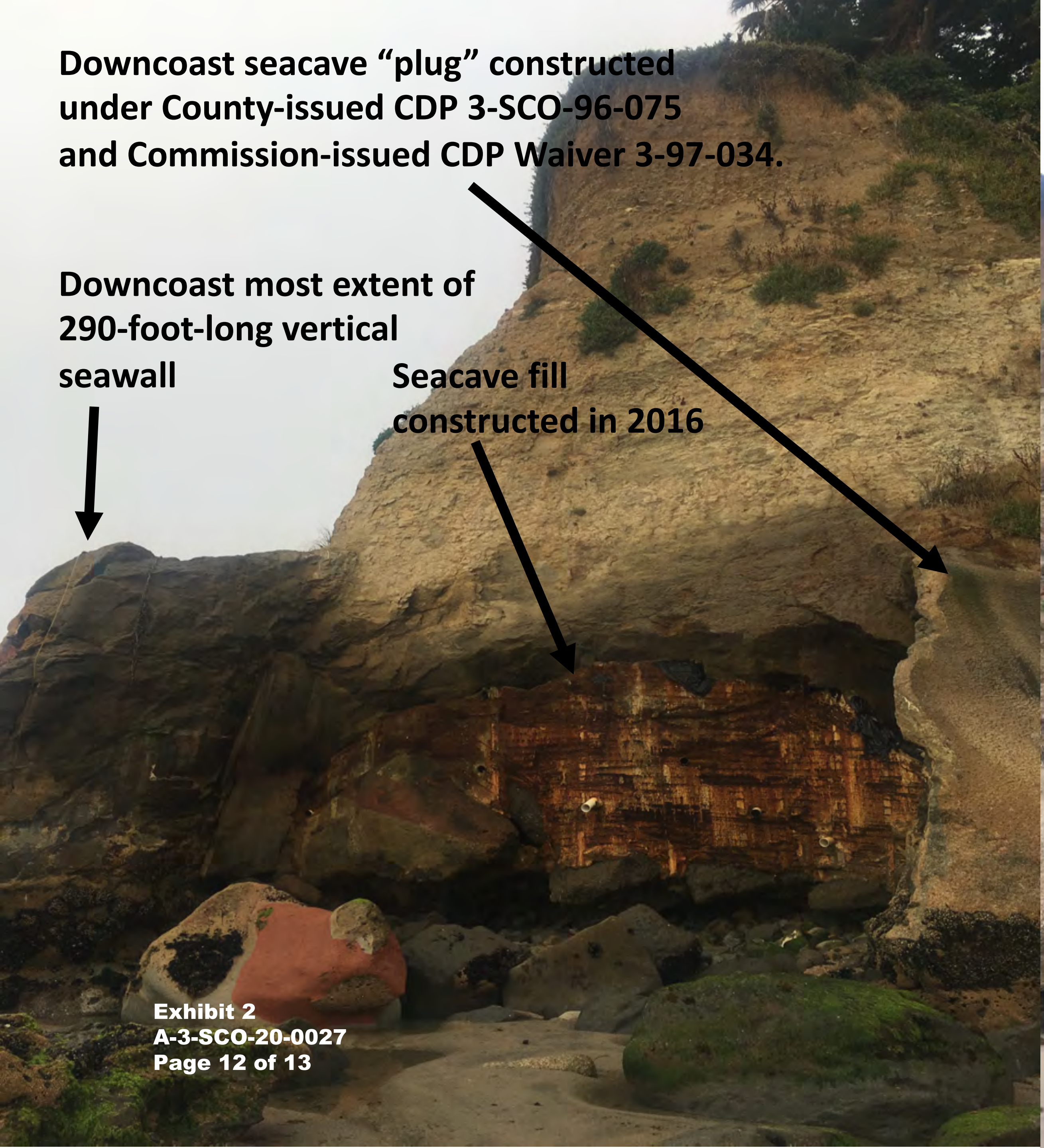
Upper bluff retaining wall and upcoast seacave fill constructed under County-issued CDP 3-SCO-18-041



Middle section of 290-foot-long vertical seawall constructed under County-issued CDP 3-SCO-96-075. The concrete footing authorized under Commission-issued CDP Waiver 3-97-034 is not visible.

Middle section of 290-foot-long vertical seawall constructed under County-issued CDP 3-SCO-96-075. The concrete footing authorized under Commission-issued CDP Waiver 3-97-034 is not visible.

Seacave fill constructed in 2016 that is the subject of the Commission enforcement case and litigation/ settlement agreement between the Applicants and the Commission.


Downcoast seacave "plug" constructed under County-issued CDP 3-SCO-96-075 and Commission-issued CDP Waiver 3-97-034.
Downcoast most extent of 290-foot-long vertical seawall
Seacave fill constructed in 2016
Exhibit 2
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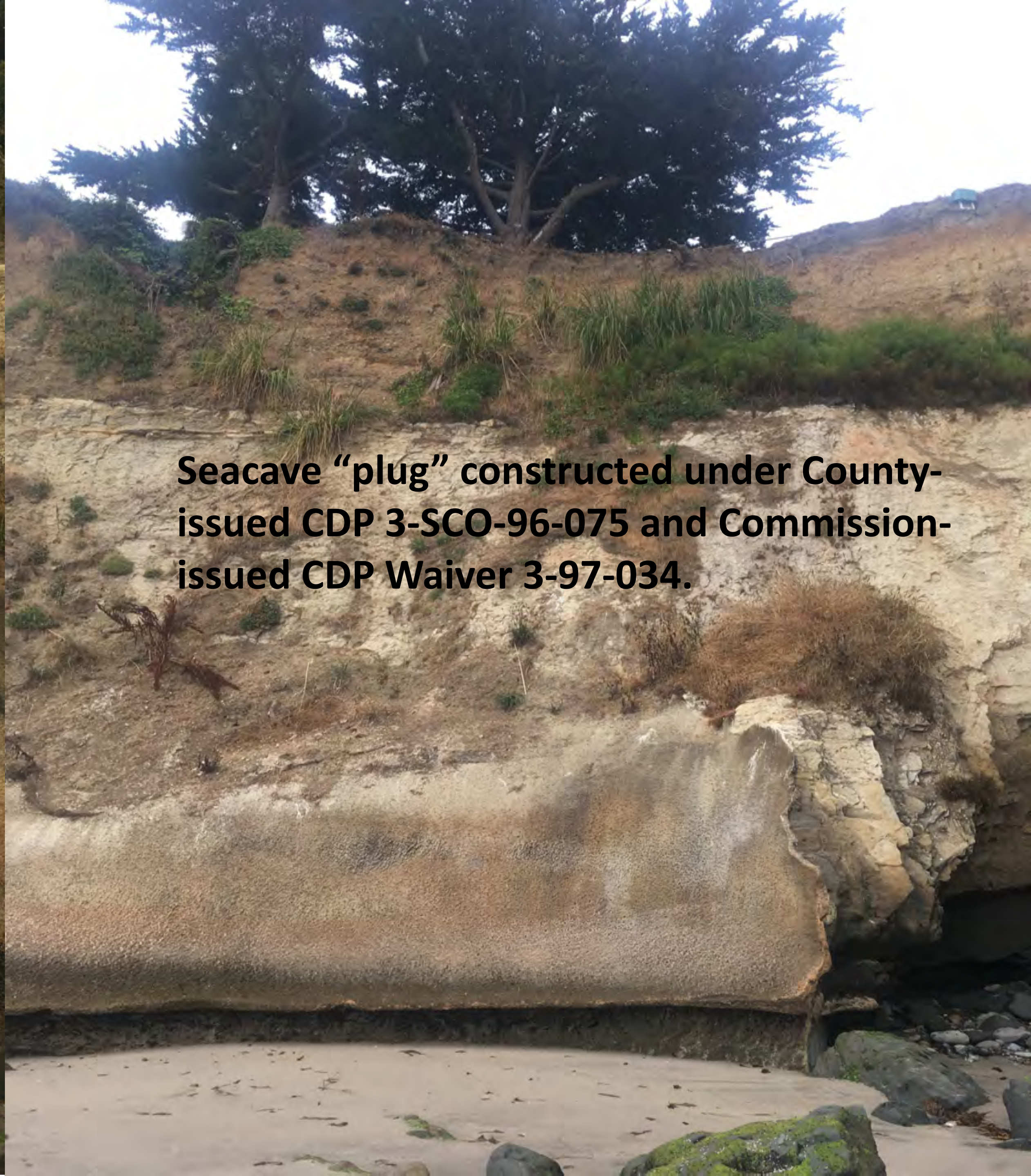
Seacave "plug" constructed under County-issued CDP 3-SCO-96-075 and Commission-issued CDP Waiver 3-97-034.


Downcoast most extent of seacave "plug" constructed under County-issued CDP 3-SCO-96-075 and
Commission-issued CDP Waiver 3-97-034.

FRANKS & BRENKWITZ, L.L.P.
ARCHITECTURE • PLANNING • HISTORICAL

P.O. Box 597
Aptos, CA 95001
(831) 662-8800

SISNEY RESIDENCE
OPAL CLIFF DRIVE
033-132-05,13

PROPOSED SITE PLAN

LICENSED ARCHITECT
BRETT W. BRENKWITZ
No. C 25131
REN. 9-30-19
STATE OF CALIFORNIA

REVISION:

DATE: 6-27-18

SCALE: 1"=16'

SHEET NO.
A-2
OF 25SHEETS

Exhibit 3
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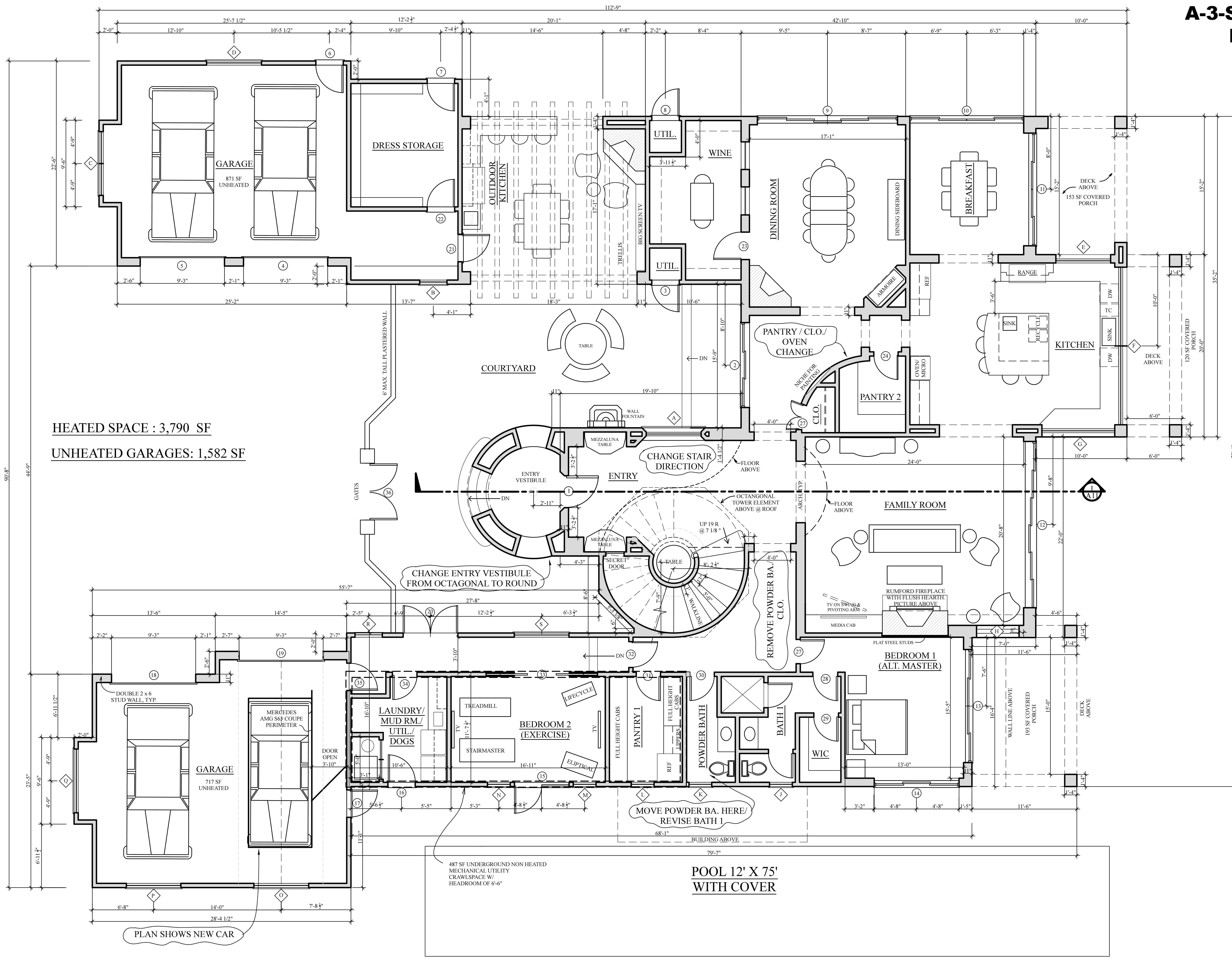

1 | 3/16"=1'-0" | LOWER FLOOR PLAN

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SISNEY RESIDENCE
033-132-05, -13

PROPOSED
LOWER FLOOR PLAN
ALTERNATE # 4

REVISION:

DATE: 12-22-18

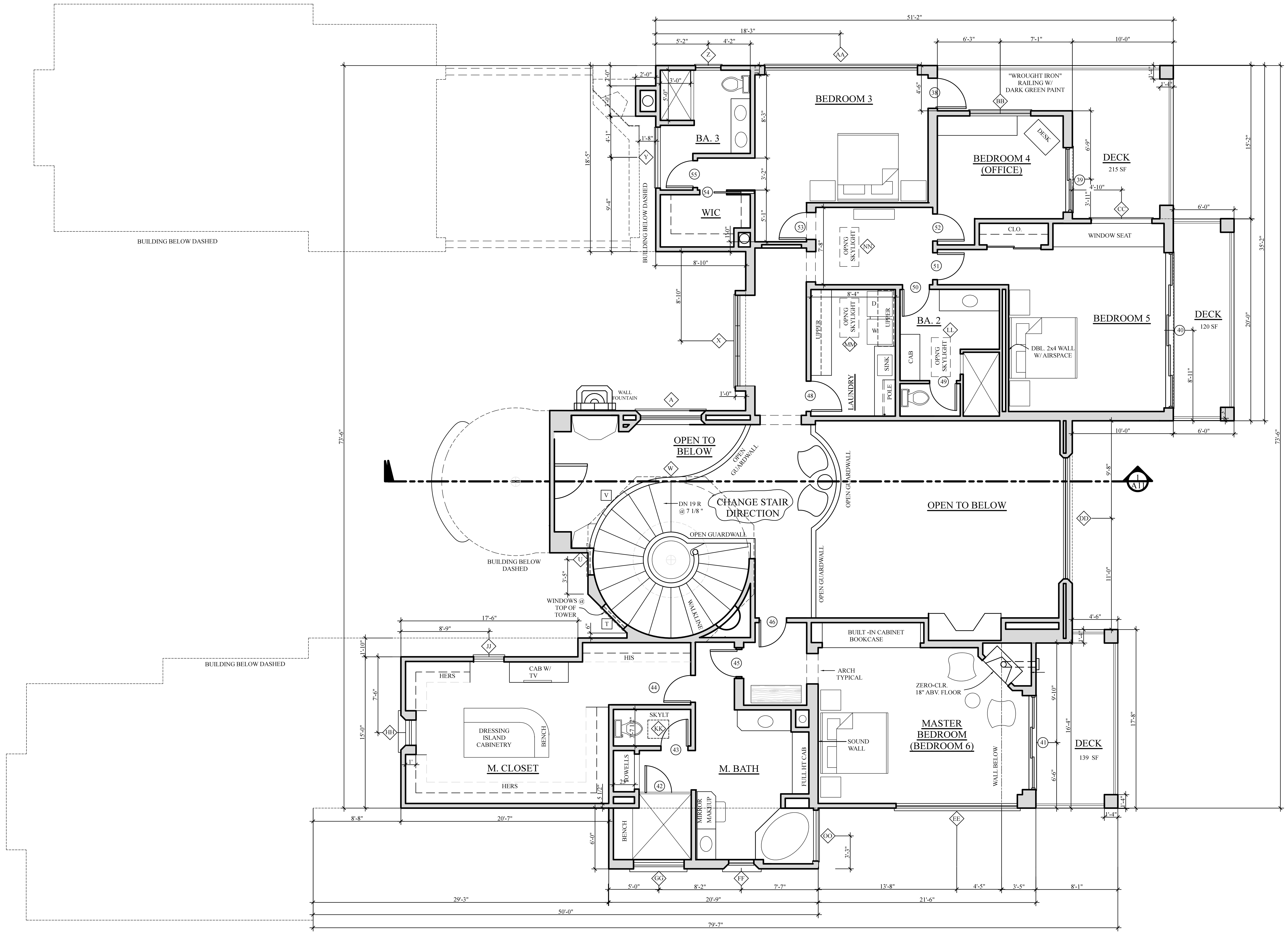
LICENSED ARCHITECT
BRETT W. BRENKWITZ
No. C 25131
REN. 9-30-19
STATE OF CALIFORNIA

SCALE: 3/16"=1'-0"

SHEET NO.

A-4

OF X SHEETS



HEATED: 2,840 SF

DECK: 474 SF

1	3/16"=1'-0"	UPPER FLOOR PLAN

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SISNEY RESIDENCE
033-132-05, -13

PROPOSED
UPPER FLOOR PLAN
ALTERNATE 4

REVISION:

DATE: 12-22-18

LICENSED ARCHITECT
BRETT W. BRENKWITZ
No. C 25131
REN. 9-30-19
STATE OF CALIFORNIA

SCALE: 3/16"=1'-0"

SHEET NO.

A-5

OF X SHEETS

PROPOSED CONDITION

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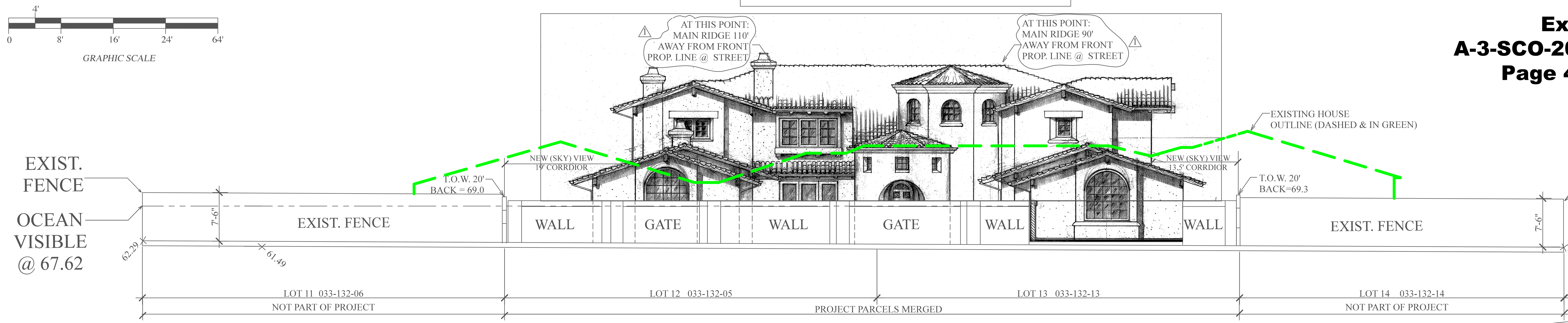
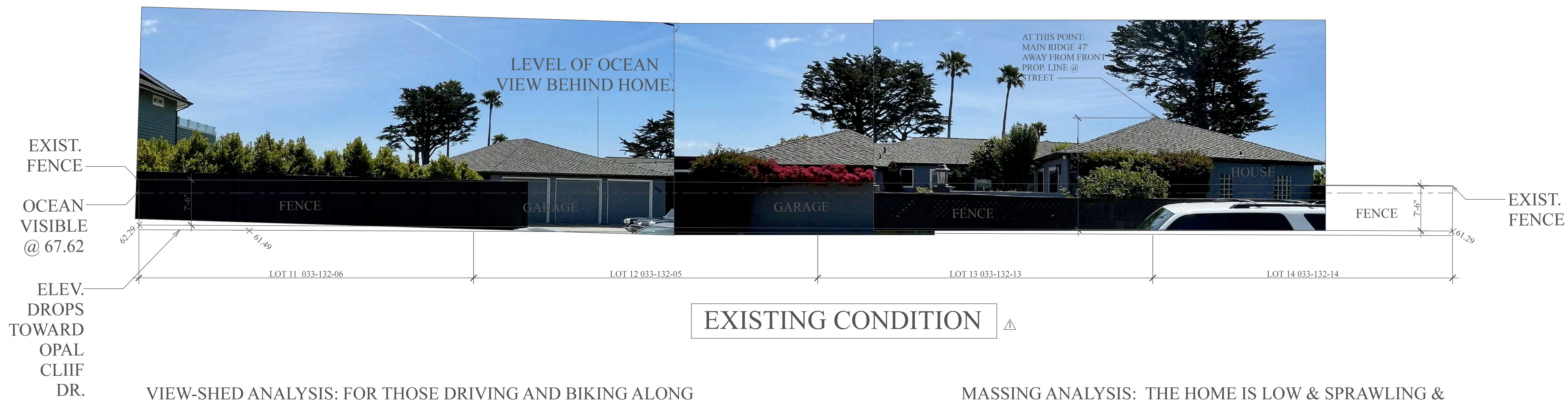


VIEW-SHED ANALYSIS: FOR THOSE DRIVING, BIKING AND WALKING ALONG THE STREET, THE OCEAN VIEWS ARE UNCHANGED FROM THE EXISTING CONDITION, HOWEVER, MORE "SKY" VIEW WILL BE CREATED BETWEEN THE HOUSE AND SIDE PROPERTY LINES BY REMOVING THE EXISTING (WIDER) HOUSE.

⚠ MASSING ANALYSIS: THE HOME IS CONCENTRATED IN THE MIDDLE 2 LOTS AND INCORPORATES A STEPPED MASSING OF LOWER HEIGHT GARAGES CLOSEST TO THE STREET. THE UPPER STORY OF THE HOUSE IS 30' AT THE CLOSEST POINT TO 96' AWAY AT THE FARTHEST POINT FROM THE FRONT PROPERTY LINE AT THE STREET. THE MAIN ROOF RIDGE IS 90' AWAY AT THE CLOSEST POINT TO THE FRONT PROPERTY LINE AT THE STEET.



EXISTING CONDITION ⚠

VIEW-SHED ANALYSIS: FOR THOSE DRIVING AND BIKING ALONG THE STREET, THE OCEAN VIEWS ARE COMPLETELY BLOCKED DUE TO THE EXISTING FENCING AND STRUCTURES. FOR THOSE WALKING, OCEAN VIEWS ARE ALSO COMPLETELY BLOCKED UNLESS THE WALKER IS APPROX. 7'-3" TALL.

MASSING ANALYSIS: THE HOME IS LOW & SPRAWLING & COVERS ALL 4 LOTS. THE MAIN RIDGE IS 47' BACK FROM THE FRONT PROP. LINE @ THE STREET. THE HOUSE IS "BOXY" AND THE WALL PLANES ARE NOT BROKEN UP AND ARTICULATED.

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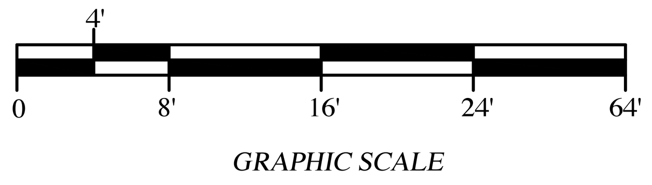
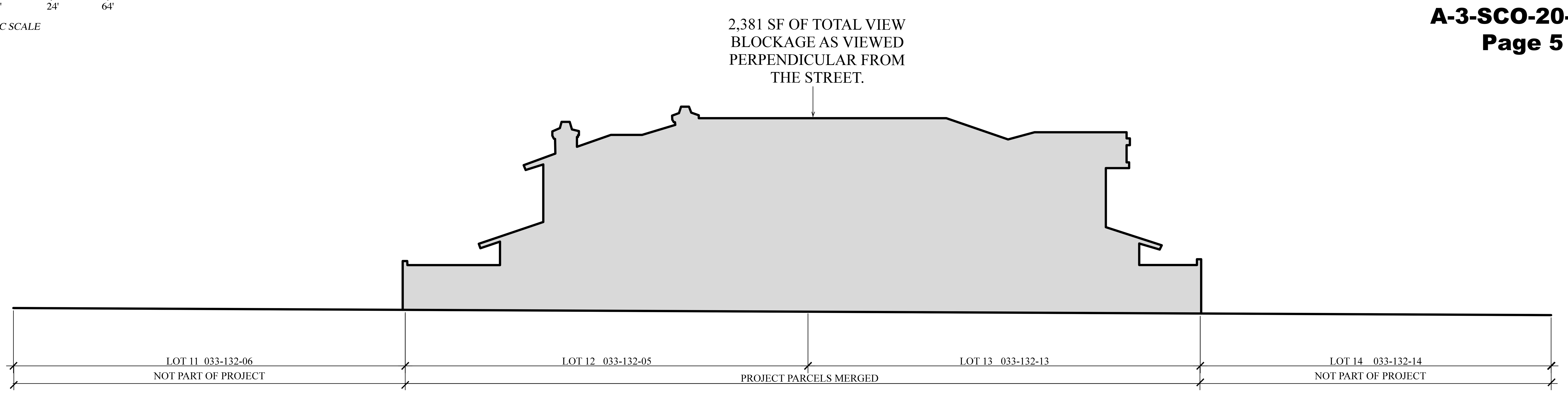
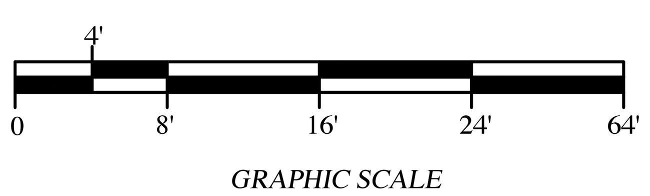
SISNEY RESIDENCE OPAL CLIFF DRIVE 033-132-05,13	OCEAN VIEW-SHED & BUILDING MASS COMPARISONS EXISTING VS. PROPOSED	LICENSED ARCHITECT BRETT W. BRENKWITZ No. C 25131 REN. 9-30-23 STATE OF CALIFORNIA	REVISION: ⚠ 5-21-22 DATE: 1-26-22 SCALE: 1/8"=1'	SHEET NO. OVM-1 OF 1 SHEETS

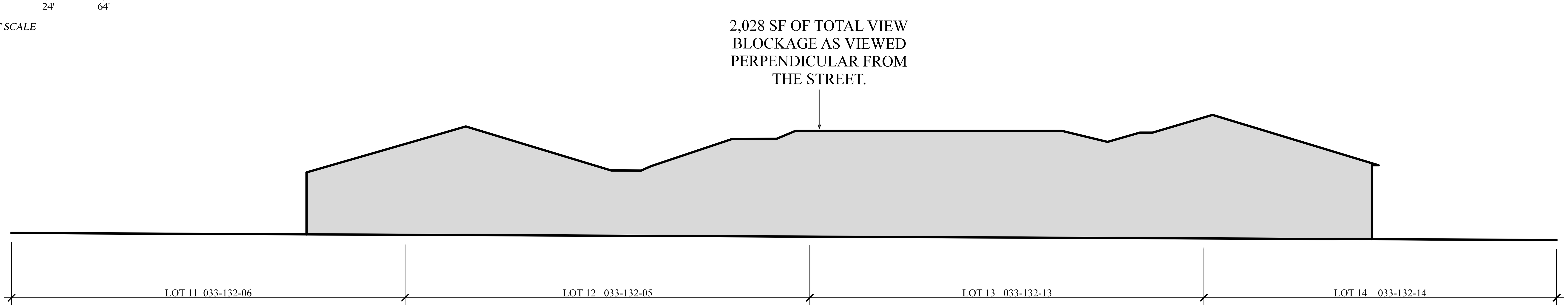




PROPOSED CONDITION

VIEW-SHED ANALYSIS: THE NEW HOME REPRESENTS AN 17% INCREASE IN SURFACE AREA COMPARED TO THE EXISTING HOME.





EXISTING CONDITION

FRANKS & BRENKWITZ, L.L.P. ARCHITECTURE • PLANNING • HISTORICAL P.O. Box 597 Aptos, CA 95001 (831) 662-8800	SISNEY RESIDENCE OPAL CLIFF DRIVE 033-132-05,13	OCEAN VIEW-SHED & BUILDING MASS COMPARISONS EXISTING VS. PROPOSED	LICENSED ARCHITECT BRETT W. BRENKWITZ No. C 25131 REN. 9-30-19 STATE OF CALIFORNIA	REVISION: DATE: 6-28-19 SCALE: 1/8"=1'	SHEET NO. OVM-2 OF 3 SHEETS

AN EARLIER RENDERING OF THE HOUSE IN THE DESIGN STAGE SHOWS HOW THE MASSING STEPS BACK FROM THE STREET WITH THE LOWER HEIGHT GARAGES IN FRONT, AND THE TALLER PORTION OF THE HOUSE FAR BACK FROM THE STREET. ALSO SHOWN IS HOW THE VARIOUS WALL PLANES ARE BROKEN UP TO PROVIDE A MORE ARTICULATED AND LESS "BOXY" ENSEMBLE.

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SISNEY RESIDENCE
OPAL CLIFF DRIVE
033-132-05,13

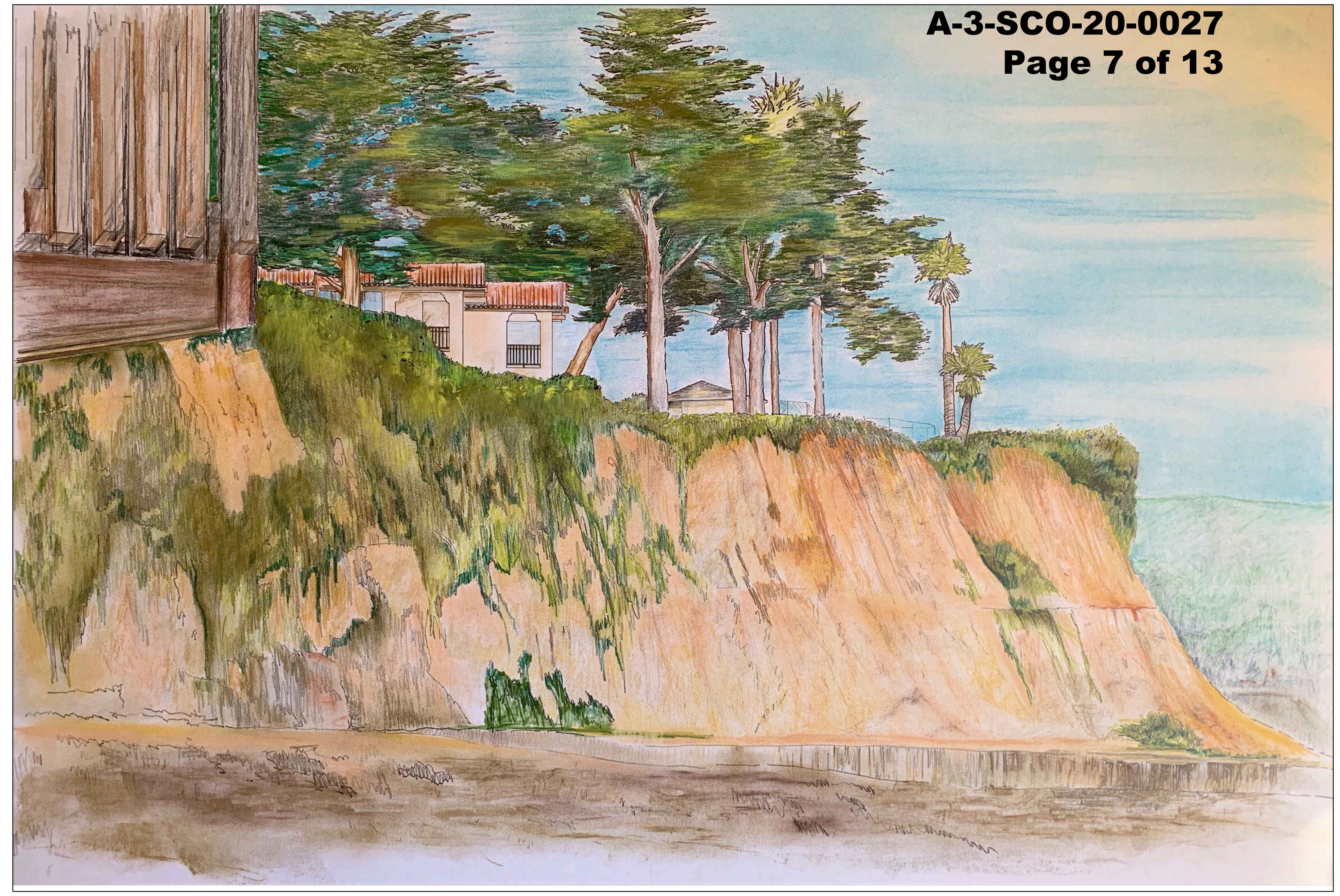
OCEAN VIEW-SHED & BUILDING MASS COMPARISONS
BUILDING RENDERING

LICENSED ARCHITECT BRETT W. BRENKWITZ No. C 25131 REN. 9-30-19 STATE OF CALIFORNIA

REVISION:
DATE: 6-28-19
SCALE: NTS

SHEET NO.
OVM-3
OF 3 SHEETS

3 | NTS | VISUAL RENDERING EXISTING PHOTO



2 | NTS | VISUAL RENDERING OF PROJECT

1 | NTS | PHOTO LOCATIONS

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P.O. Box 597
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(831) 662-8800

SISNEY RESIDENCE
OPAL CLIFF DRIVE
033-132-05,13

VISUAL RENDERING FROM "PRIVATES" BEACH

LICENSED ARCHITECT BRETT W. BRENKWITZ No. C 25131 REN. 9-30-19 STATE OF CALIFORNIA

REVISION:
DATE: 9-3-19
SCALE: NTS

SHEET NO.
R-1
OF 32 SHEETS


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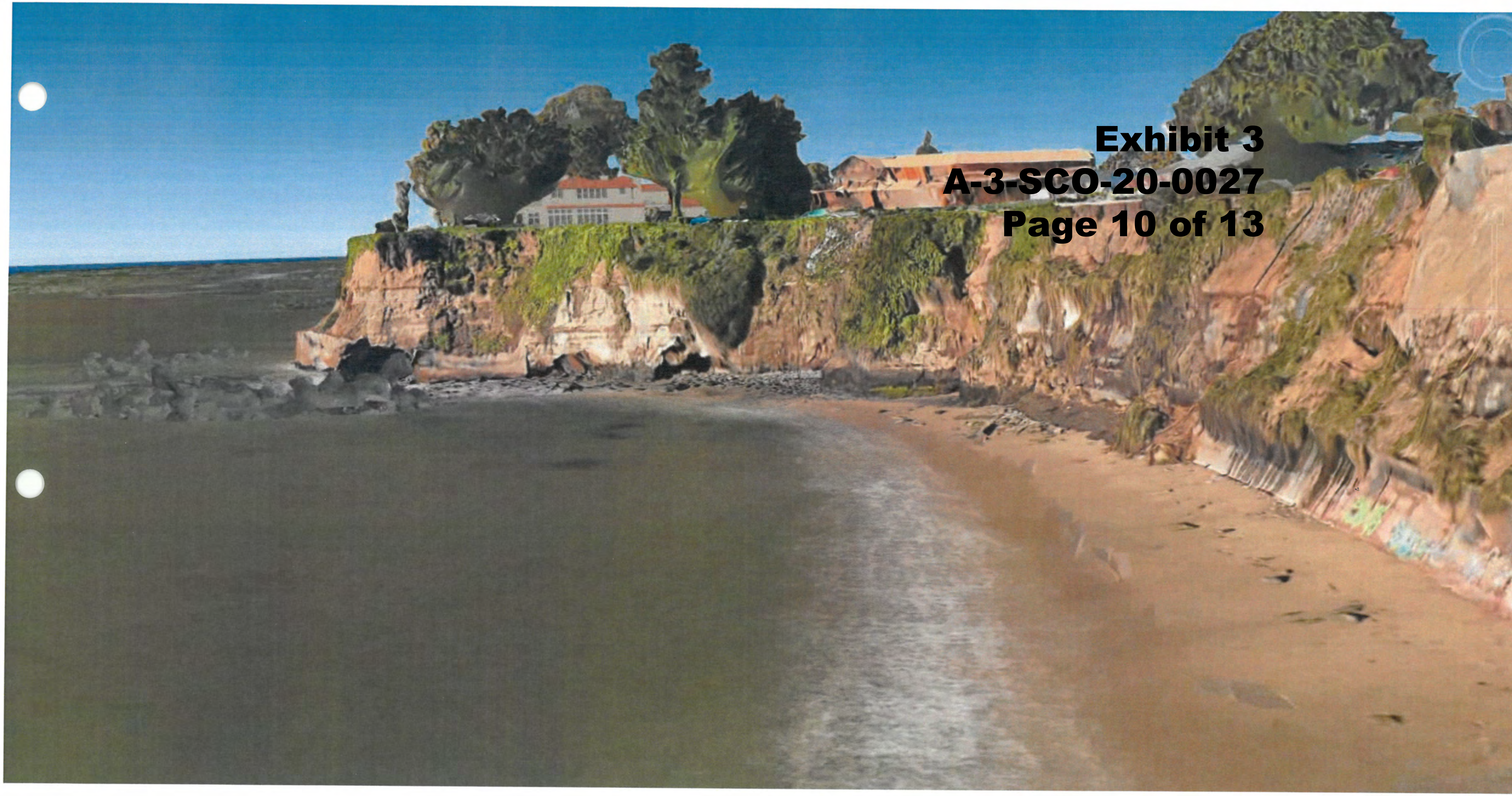

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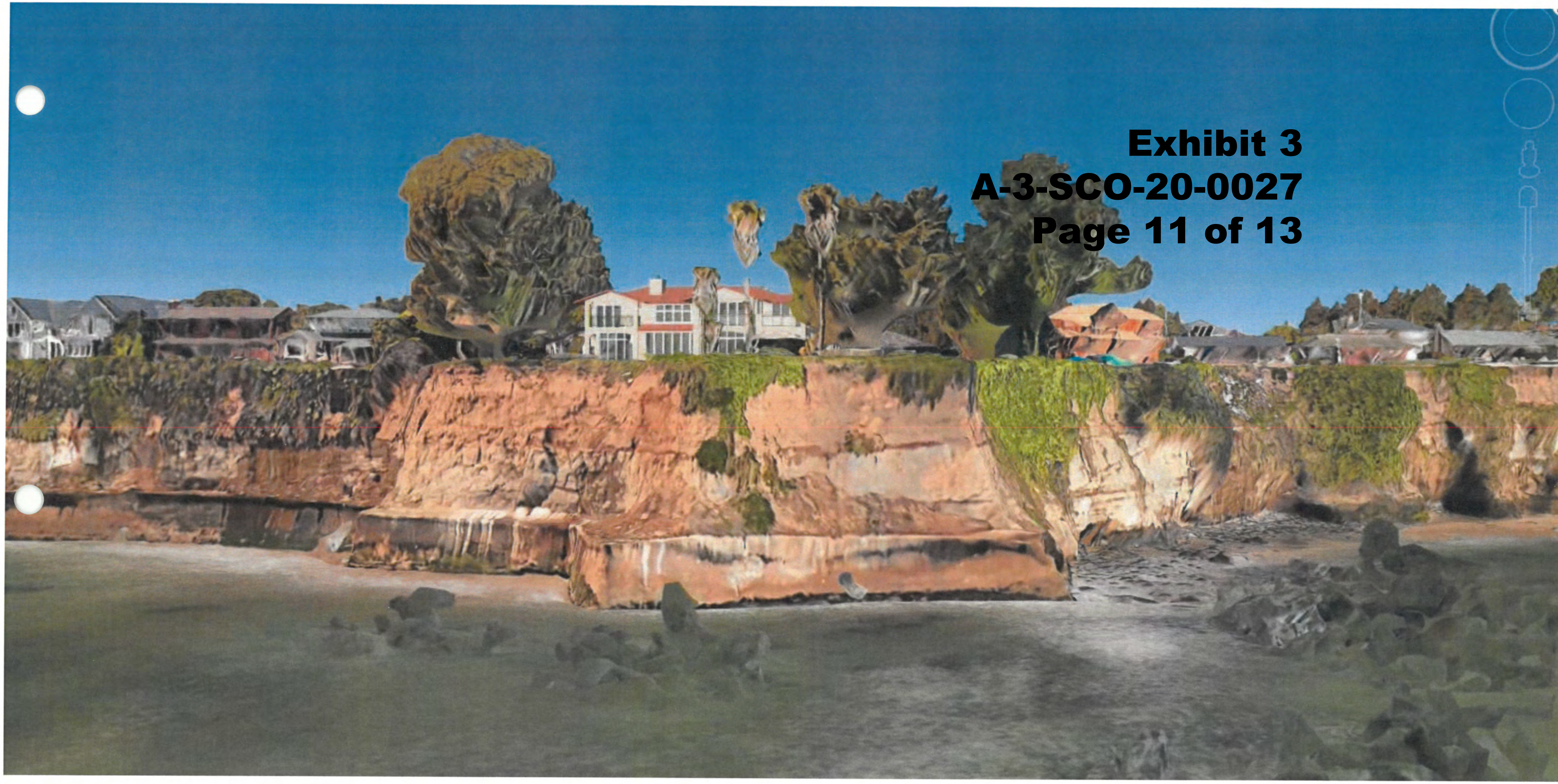

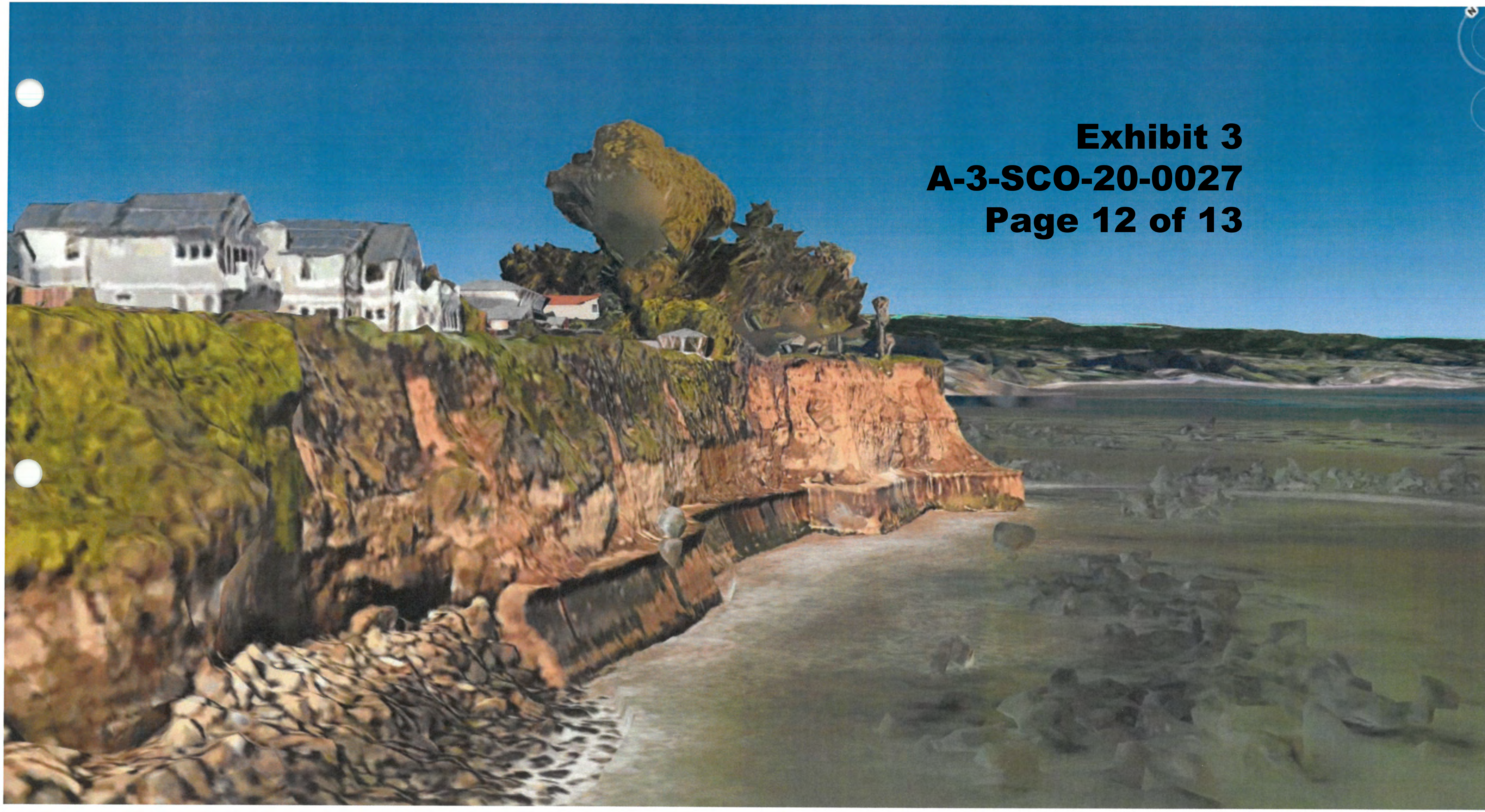
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CALIFORNIA COASTAL COMMISSION
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January 22, 2020

Nathan MacBeth, County Planner
Santa Cruz County Planning Department
701 Ocean Street, 4th Floor
Santa Cruz, CA 95060

Derric Oliver
Fenton & Keller
2801 Monterey-Salinas Highway
P.O. Box 791
Monterey, CA 93942

Subject: Application 191246 (4660 Opal Cliff Drive, Sisney Residence)

Dear Mr. MacBeth and Mr. Oliver:

We received the application materials for County Application # 191246. First, we would like to note that the currently proposed project is similar to the project proposed in County Application # 181217[1], with the exception that the house is proposed to be sited eight feet further landward (albeit still seaward of the existing residence), the pool has been temporarily eliminated (i.e., a separate Coastal Development Permit application will be submitted for the proposed pool at a later undetermined date), and minor aesthetic alterations have been incorporated including: removal of the six-foot-tall side fence located within the front yard setback; a lighter/softer shade of white paint for the exterior of the house; the detached garage is now further from the residence in an effort to break up massing; and the landscaping plan has been enhanced. Nevertheless, the primary issues that were raised in the previous application remain, including with respect to geologic hazards, visual resources, and ongoing public access/recreational impacts stemming from the existing shoreline armoring system (which was installed to protect the *existing* development that is proposed to be demolished as a part of the subject application), all as is described in more detail in the attached letters (August 10, 2018 and letter dated May 2, 2019). Accordingly, Commission staff's ongoing recommendation is that the project be modified to comply with the LCP requirements as outlined in previous correspondence.

Finally, with regard to the Applicant's submitted materials, including the letters from Derric Oliver dated September 5, 2019 and December 12, 2019, Commission staff does not agree with many of the assertions or characterizations presented in those materials; however, we do not intend to respond to each assertion at this time given that this stage of the application process is

[1] One of the attached letters incorrectly identifies the application as #181243 instead of #181217.

intended to address application completeness and LCP compliance – again, see our previous letters in this regard.

Thank you for your consideration.

Sincerely,

Rainey Graeven

Rainey Graeven
Coastal Planner
Central Coast District Office

Attachments

CALIFORNIA COASTAL COMMISSION
CENTRAL COAST DISTRICT OFFICE
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May 2, 2019

Jocelyn Drake, Zoning Administrator
Santa Cruz County Planning Department
701 Ocean Street, 4th Floor
Santa Cruz, CA 95060

Subject: Zoning Administrator Hearing 5/3/19 (Application 181243: 4660 Opal Cliff Drive)

Dear Ms. Drake:

Application # 181243 is scheduled for the Zoning Administrator hearing on May 3, 2019. The proposed project includes the demolition of an existing 4,000-square-foot single-family dwelling, the merging of two parcels, and the construction of a two-story and approximately 6,702-square-foot dwelling with 1,536 square feet of garage area, and a swimming pool. We previously commented on this project and raised concerns regarding the project's consistency with the Santa Cruz County Local Coastal Program's (LCP) policies related to geologic hazards and the protection of visual resources (see attached comments dated August 10, 2018). We have reviewed the staff report and the additional materials provided by Les Strnad on April 29, 2019 (including Greg's Easton's "Response to County Comments" dated August 29, 2018 and the Amended Monitoring and Maintenance Agreement recorded April 17, 2018). After reviewing these materials we continue to have significant concerns with the proposed application's consistency with the Santa Cruz County LCP, particularly the project's proposed geologic hazards setback, including how the shoreline armoring at the base of the bluff affects the required setback distance.

Specifically, pursuant to Land Use Plan (LUP) Policy 6.2.16 and Implementation Plan (IP) Section 16.10.070(H)(3)(a), new development *cannot* rely on shoreline armoring for purposes of ensuring long-term stability. As a result, the proposed new home must be set back far enough to meet the LCP's minimum 100-year stability test *without the protection afforded by any existing armoring*. In this case, the 100-year setback was derived based on the assumption that the existing shoreline armoring would remain in place. However, such armoring cannot be countenanced for determining this setback because new development (e.g., the new proposed home) *cannot* rely on shoreline armoring, and any armoring that was placed in the past to protect existing structures would need to be removed. Greg Easton's letter dated August 29, 2018 notes that "the CCC continues to misinterpret and misquote County code" and that LUP Policy 6.2.16 (and IP Section 16.10.070(H)(3)(a)) refer to new shoreline protection structures. Commission staff respectfully disagrees with Mr. Easton's comments that the LCP sections refer to new shoreline protection structures; rather these sections are intended to refer to *all* shoreline protection structures.

Furthermore, even if there were questions of interpretation regarding the LCP's hazards avoidance and shoreline armoring policies, the LCP specifically provides that in the event there is a dispute regarding LCP policy interpretation, the Coastal Act shall supersede (see LUP Chapter 1, Interpretation, page 1-20.)[1] And further, the courts have previously found that an LCP must be understood in relation to the relevant Coastal Act Section (i.e., the Coastal Act Section from which a specific LCP provision derives its authority) [see *McAllister v. Coastal Commission* (2008)]. In this case the Coastal Act Section from which LUP Policy 6.2.16 and IP Section 16.10.070(H)(3)(a) are derived limits shoreline armoring devices to protect *existing* (i.e., not new or redeveloped) structures and beaches in danger of erosion or when required to serve coastal-dependent uses, none of which is the case here. Finally, it is worth noting that the Commission has acted on numerous applications (including appeals from local jurisdictions) where removal of shoreline armoring was required once the existing structures that were entitled to armoring were redeveloped and thus were no longer entitled to armoring. These applications include, but are not limited to, the Katz Residence (CCC-18-CD-02) and the Honjo Residence (A-3-STC-16-0345).

Fortunately, in this case, it appears the property is ample enough in size to allow for a redeveloped residence to be accommodated in a manner that meets the LCP's required 100-year stability test without shoreline armoring. As such, we respectfully request that this house redevelopment project be conditioned to require a modified geologic setback that is derived without reliance on any existing shoreline armoring, and that all existing armoring be required to be removed, thereby affording protection and enhancement to our coastal beach commons by eliminating the adverse impacts such armoring causes to this resource.[2]

Further, we would note that we have concerns regarding the construction of a swimming pool on a coastal bluff and within a known geologically hazardous area (e.g.: how the construction of a pool may affect the bluff's stability), and questions regarding why the conditions of approval exclude the typical coastal hazards risk and response conditions on this permit application, including a condition that the new residence would not be entitled to shoreline armoring. Coastal hazards risk and response conditions are typically included on all coastal permits for projects located on coastal bluffs or within geologically hazardous areas including most recently on April 5, 2019 (see Application # 171178 for the demolition of an existing single-family residence and the construction of a new single-family residence at 525 Seacliff Drive). We respectfully request that these issues be discussed, and would further recommend that the coastal hazards risk and response conditions be included as conditions of approval.

---

1 "In any case in which the interpretation or application of an LCP is unclear, as that policy may relate to a particular development application or project, the application or interpretation of the policy which most clearly conforms to the relevant Coastal Act policy shall be utilized."

2 We would also note that the Applicant has a pending application to the Commission to modify the existing shoreline armoring which would not appear approvable also on this basis (i.e., that the structure at issue would be new as opposed to "existing" and thus not be entitled to shoreline armoring.)

Finally, in terms of aesthetics and public views, Opal Cliff Drive primarily consists of larger, redeveloped two-story residences that completely block ocean views as seen from Opal Cliff Drive. In contrast, the existing property consists of a modest one-story home that spans four lots and offers a few glimpses of coastal views and some visual relief from the residential density and massing identified above. The proposed project, which entails a large dwelling permit to accommodate an approximately 6,702 square foot house and a 1,536 square foot garage and plastered side fencing that reaches up to 8 feet in height would significantly increase the visual massing and would likely eliminate any ocean views from Opal Cliff Drive. Pursuant to IP Section 13.10.525(D), an over-height fence certification may only be authorized in the coastal zone if the finding can be made that public views and scenic character will not be adversely impacted. In this case, we recommend that the size of the house be reduced to better blend in with the surrounding character and that the side fencing be eliminated to preserve the ocean views from Opal Cliff Drive.

Thank you for your consideration.

Sincerely,

Rainey Graeven

Rainey Graeven
Coastal Planner
Central Coast District Office

cc: Nate MacBeth
Brett Brenkwitz
Les Strnad
Greg Easton

Graeven, Rainey@Coastal

From: Graeven, Rainey@Coastal
Sent: Friday, August 10, 2018 2:59 PM
To: 'Nathan MacBeth'
Cc: 'brenkwitz@sbcglobal.net'; 'greg@eastongeology.com'
Subject: Comments on Application No. 181217

Dear Nate,

Thank you for the opportunity to comment on the above-referenced CDP application. Please include these comments as part of the administrative record for this project, and distribute them to the appropriate staff. The project proposes to: combine two parcels; demolish the existing single-family residence and related development, and; construct an approximately 6,700-square-foot house with an approximately 1,500-square-foot garage and a swimming pool and related residential development, all on the blufftop at 4660 Opal Cliff Drive. The proposed project raises significant Local Coastal Program (LCP) consistency issues that will need to be addressed as a part of the application. Please find our preliminary compliance and completeness comments below:

Comments:

1. Geologic Hazard Report. The project appears to propose extensive new development in an area of potential coastal hazards. The LCP requires that a coastal bluff building site be stable for a minimum of 100 years in its pre-development application condition, and that any development be set back an adequate distance to provide stability for the development's lifetime, and at least 100 years. The minimum 100 years of stability must be established through the use of appropriate setbacks and siting, and without reliance on engineering measures "such as shoreline protection structures, retaining walls, or deep piers" (Implementation Plan (IP) Section 16.10.070(H)(3)). Also, the LCP allows shoreline protection structures only "to protect existing structures from a significant threat" (LCP Policy 6.2.16). Thus, the LCP has a two-part minimum 100-year stability requirement: first, there must be a portion of the site in question that itself will be stable for at least 100 years in a pre-development (i.e., no project) scenario, without reliance on structural development (although please also note that the Applicants have applied to the Commission to add new footings to two existing seawalls (one of which extends onto the neighboring upcoast property), which will extend the lives of these seawalls (CDP Application No. 3-18-0742)) to make it so; and second, any development then introduced onto the site must also be stable for its lifetime measured for at least 100 years without reliance on engineering measures. As such, please modify the existing geologic hazards report to identify the 100-year bluff erosion line determined without any armoring (i.e. please identify the erosion rate at the site pre-armoring using historical data coupled with any available data related to current erosion rates for unarmored areas of Opal Cliff Drive such as 4760 Opal Cliff Drive or Application No. 181205) and as influenced by sea level rise. Once the report has been updated, please provide a copy to Coastal Commission staff, and please identify any updated 100-year bluff erosion setback lines on the project plans, and ensure that no new development encroaches into either the minimum 25-foot or the 100-year setback (including the proposed swimming pool). Finally, the updated geologic hazard report must also describe how removal of the existing armoring may impact up- and downcoast properties.

2. Visual Resource Protection. The proposed residence is greater than 5,000 square feet in size and thus needs to be consistent with the LCP's "Large Dwelling Permit Requirements and Design Guidelines (as set forth in IP Sections 13.10.325(B) and 13.10.325(D)). These IP sections set forth numerous ways to reduce the appearance of significant bulk and massing, including by: selecting more natural colors and materials that blend in; varying roof heights; breaking up large wall expanses with bay windows; using a combination of horizontal and vertical architectural elements; and via landscaping (including retention of existing blufftop trees and the planting of additional trees as appropriate and feasible). The proposed project is rather boxy in design and does not include these required elements. Therefore, please request that the Applicants revise the project to ensure that the proposed project meets the LCP's large dwelling requirements.

Please let me know if you have any questions regarding the comments above.

Sincerely,

Rainey Graeven
Coastal Planner
Central Coast District Office

Easton Geology, Inc.
P.O. Box 3533, Santa Cruz, CA 95063
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GEOLOGIC INVESTIGATION

Sisney Property

4660 Opal Cliff Drive
Santa Cruz, California
Santa Cruz County APNs 033-132-05, 06, 13, 14

This report details the findings from our geologic investigation of the above-referenced property.

Easton Geology Job No. C15023
Updated 6 December 2019

EASTON GEOLOGY, INC.
P.O. Box 3533, Santa Cruz, CA 95063
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Updated 6 December 2019

Bret and Carol Sisney
100 De Bernardo Lane
Aptos, California 95003

Job No. C15023

Re: Geologic Investigation
Sisney Property
4660 Opal Cliff Drive
Santa Cruz, California
Santa Cruz County APNs 033-132-05, 06, 13, 14

Dear Mr. and Mrs. Sisney:

We are pleased to present this updated geologic report detailing the findings from our geologic investigation for your residential property located at 4660 Opal Cliff Drive, in Santa Cruz, California. We understand you wish to raze an existing 80-year old residence and garage at the site and construct a new single-family residence on parcels 5 and 13. The chief purpose of our work was to provide an evaluation of the stability of the coastal bluff at the site and provide a 100-year blufftop setback for the proposed improvements, as required by the certified Santa Cruz County Local Coastal Program (LCP). The LCP requires that new development be sited behind the projected 100-year position of the blufftop or a minimum of 25 feet from the edge of the coastal bluff, whichever is greater, based on current site conditions. Based on our review and analysis of the current site conditions, it is our opinion that the proposed residential project is geologically feasible, provided the existing seawall system at the base of the subject bluff is maintained as required by permit, and our recommendations, and those of the project geotechnical engineer, are closely followed.

Please contact us if you have any questions regarding this report.

Sincerely,

EASTON GEOLOGY, INC.

Gregory Easton

PROFESSIONAL GEOLOGIST
GREGORY EASTON
No. 2502
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Gregory Easton
Principal Geologist
C.E.G. No. 2502

Copies: Addressee (1 and pdf copy)
Franks Brenkwitz & Assoc., attn: Brett Brenkwitz (3 and pdf copy)
Haro Kasunich & Associates, attn: Moses Cupril (pdf copy)

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INTRODUCTION

This update report presents the findings from our geologic investigation of the subject property, located at 4660 Opal Cliff Drive, in Santa Cruz, California. The contiguous parcels comprising the subject property (parcels 033-132-05, 06, 13, and 14) are situated atop a steep coastal bluff along the Opal Cliffs shoreline (Figure 1; Site Location Map). The project proposes to raze the existing home and garage built on the property in or around 1939 and construct a new single-family residence on parcels 5 and 13.

The primary geologic hazards at the subject site are seismic shaking and coastal erosion. The bluff supporting the subject property and residence forms a broad bedrock headland along the Opal Cliffs shoreline, with several deep undercuts or seacaves existing within the headland prior to construction of a seawall along the base of the subject bluff. The coastal development permit to construct and maintain the existing 288-foot long seawall and seacave plug along the subject bluff was approved by Santa Cruz County in 1996, the approved shoreline protection measures were constructed in 1998, and maintenance work was performed in 2016 and 2017. At its upcoast end the subject seawall joins with another permitted and maintained seawall constructed in 1994 which spans the three adjacent upcoast properties.

Prior engineering geologic analysis has been completed for the subject site by LRA (1992), Rogers Johnson & Associates (2009), and Easton Geology (2015).

The scope of work performed for this investigation included: 1) review of published and unpublished literature relevant to the site and vicinity; 2) analysis of stereo-aerial photographs; 3) geologic mapping of the site; 4) co-logging of five exploratory borings; 5) numerous site visits to evaluate existing conditions and to assess the condition of the seawall’s footing and cave plugs; 6) coordination and meetings with the project team; 7) compilation and analysis of the resulting data; and 8) preparation of this report and accompanying illustrations, including a geologic map and cross-sections.

Development at or landward of the 100-year blufftop setback line, as depicted on Plate 1, is geologically feasible provided the seawall is maintained as required by the 1996 coastal development permit (CDP No. 95-0621). The 100-year blufftop setback, as determined by our firm and as required by Santa Cruz County Local Coastal Program (LCP) Policy 6.2.12 and Santa Cruz County Code Section 16.10.070 (H)(1), takes into account: 1) the current, pre-development application condition of the site; 2) a minimum setback distance of 25 feet from the top edge of the bluff or the extent of landward erosion in 100 years as calculated by our firm, whichever is greater; and 3) does not take into consideration the effect of any proposed shoreline protection structures, retaining walls, or deep piers.

SUMMARY OF CONCLUSIONS

The coastal blufftop property is located along Opal Cliff Drive in Santa Cruz County, California. The primary geologic hazards at the subject site are seismic shaking and coastal erosion.

Current development plans consist of razing the existing 80-year-old residence and constructing a new single-family dwelling on the property. The development plans do not include any proposed shoreline protection measures.

The majority of the subject bluff on the property is protected by a seawall system permitted by Santa Cruz County in 1996 and constructed in 1998. As a condition of seawall permit (95-0621), the structural integrity of the seawall system is required to be maintained, and consistent with that requirement, maintenance work was performed in 2016 and 2017.

The Santa Cruz County LCP requires new development to be sited such that it will be stable for a minimum of 100-years. Development at or landward of the 100-year blufftop setback line, as depicted on Plate 1, is geologically feasible.

Consistent with Santa Cruz County LCP Policy 6.2.12 and Santa Cruz County Code Section 16.10.070(H)(1), we determined the 100-year setback for the proposed development based on the existing pre-development application condition of the property and did not take into consideration any proposed shoreline protection measures. Our 100-year blufftop setback for the site is based on existing site conditions and incorporates: 1) a calculated erosion rate of 0.3 feet per year, calculated from the change in the mapped position of the bluff-edge at the site between 1928 and 2015 along the unprotected portion of the bluff; 2) a 25% increase in the rate of potential erosion of the unprotected portion of bluff resulting from sea level rise; and 3) a ten foot buffer to account for any uncertainty in the erosion rate along the unprotected portion of the bluff resulting from the recent (2015) collapse of an adjacent bedrock promontory. The 100-year setback depicted on Plate 1 assumes the existing seawall system will be maintained as required by the approved permit and maintenance agreement, as was done in 2016 and 2017.

REGIONAL GEOLOGIC SETTING

The subject site is situated atop a stretch of steep coastal bluff known as Opal Cliffs, approximately midway between Soquel Point to the southwest and New Brighton Beach to the northeast (Figure 1). This seacliff is one of many such cliffs along the northern coast of Monterey Bay characterized by gently dipping, late Tertiary marine sedimentary rocks that are generally overlain by nearly horizontal, Quaternary terrace deposits chiefly of terrestrial origin. The coastal bluffs have formed as a result of surf erosion in conjunction with changes in sea level and relatively steady tectonic uplift.

Regional tectonism not only has given rise to the seacliff in the vicinity of the subject site but has created the Santa Cruz Mountains themselves. The Santa Cruz Mountains are formed by a series of rugged, linear ridges and valleys following the pronounced northwest to southeast structural grain of central California geology. Contrasting basement rock types which underlie the Santa Cruz Mountains are separated by the northwest-trending San Andreas fault zone. Underlying the mountains southwest of the San Andreas fault is a large, elongate prism of granitic and metamorphic basement rocks, known collectively as the Salinian Block. Northeast of the fault, the mountains are underlain by several structural blocks of metamorphosed basement rock consisting of either the Franciscan Complex, Coast Range Ophiolite, or parts of the Great Valley Sequence. The basement rock southwest of the San Andreas fault is overlain by a sequence of Mesozoic and Cenozoic era marine sedimentary rocks (Figure 2; Regional Geologic Map).

Throughout the Cenozoic Era, this portion of California has been dominated by tectonic forces associated with lateral or "transform" motion between the North American and Pacific crustal plates, producing long, northwest-trending faults such as the San Andreas and San Gregorio faults, with horizontal displacements measured in tens to hundreds of miles. Accompanying the northwest-southeast trending, dextral strike-slip movement of the plates were episodes of compressive stress, causing repeated uplift, deformation, erosion, and subsequent redeposition of sedimentary rocks. Near the crest of the Santa Cruz Mountains, this tectonic deformation is most evident in sedimentary rocks older than the middle Miocene and consists of steeply dipping folds, overturned bedding, faulting, jointing, and fracturing. Along the coast, the ongoing tectonic activity is most evident in the formation of a series of uplifted marine terraces. The Loma Prieta earthquake of 1989 and its aftershocks are the most recent reminders of the geologic unrest in the region.

The seismicity of the area is influenced primarily by the northwest-trending San Andreas fault located northeast of the subject property (Figure 2). The seismicity of the site will be discussed in more detail below.

REGIONAL SEISMIC SETTING

California's broad system of strike-slip faulting has a long and complex history. Several regional faults present seismic hazards to the subject property. The most important of these are the San Andreas, San Gregorio, Monterey Bay, and Zayante-Vergeles fault zones (Figure 2). These faults are either active or considered potentially active (Buchanan-Banks et al., 1978; Burkland and Associates, 1975; Greene, 1977; Hall et al., 1974; Jennings et al., 1975; Schwartz et al., 1990; Wallace, 1990; Working Group on Northern California Earthquake Potential [WGNCEP], 1996; and Working Group on California Earthquake Probabilities, 2008. Each fault is discussed below. The intensity of seismic shaking that could occur at the site in the event of a future earthquake on one of these faults will be discussed in a later section.

San Andreas Fault

The San Andreas fault is active and represents the major seismic hazard in northern California (Jennings et al., 1975; Hall et al., 1974; and Bryant and Lundberg, 2002). The main trace of the San Andreas fault trends northwest-southeast and extends over 700 miles from the Gulf of California through the Coast Ranges to Point Arena, where the fault extends offshore.

Geologic evidence suggests that the San Andreas fault has experienced right-lateral, strike-slip movement throughout the latter portion of Cenozoic time, with a cumulative offset of hundreds of miles. Surface rupture during historical earthquakes, fault creep, and historical seismicity confirm that the San Andreas fault and its branches, the Hayward, Calaveras, and San Gregorio faults, are all active today.

Historical earthquakes along the San Andreas fault and its branches have caused significant seismic shaking in the Santa Cruz County area. The two largest historical earthquakes on the San Andreas to affect the area were the moment magnitude (M_w) 7.9 San Francisco earthquake of April 18, 1906 (actually centered near Olema) and the M_w 6.9 Loma Prieta earthquake of October 17, 1989. The San Francisco earthquake caused severe seismic shaking and structural damage to many buildings in Santa Cruz County. The Loma Prieta earthquake appears to have caused more intense seismic shaking than the 1906 event in localized areas of the Santa Cruz Mountains, even though its regional effects were not as extensive. There were also significant

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earthquakes in northern California along or near the San Andreas fault in 1838, 1865, and possibly 1890 (Sykes and Nishenko, 1984; WGNCEP, 1996).

Geologists have recognized that the San Andreas fault system can be divided into segments with earthquakes of different magnitudes and recurrence intervals (Working Group on California Earthquake Probabilities, 1988 and 1990). A study by the WGNCEP in 1996 redefined the segments and the characteristic earthquakes for the San Andreas fault system in northern and central California. Two overlapping segments of the San Andreas fault system represent the greatest potential hazard to the subject property. The first segment is defined by the rupture that occurred from Cape Mendocino to San Juan Bautista along the San Andreas fault during the great 1906 M_w 7.9 earthquake. The WGNCEP (1996) has hypothesized that this "1906 rupture" segment experiences earthquakes with comparable magnitudes in independent cycles about two centuries long.

The second segment is defined by the rupture zone of the M_w 6.9 Loma Prieta earthquake, despite the fact that the oblique slip and depth of this event does not fit the ideal of a typical, right-lateral strike-slip event on the San Andreas fault. Although it is uncertain whether this "Santa Cruz Mountains" segment has a characteristic earthquake independent of great San Andreas fault earthquakes, the WGNCEP (1996) assumed an "idealized" earthquake of M_w 7.0 with the same right-lateral slip as the 1989 Loma Prieta earthquake and a multi-segment recurrence interval of 400 years, and the WGCEP (2008) has determined that the San Andreas – Santa Cruz Mountains Section has a recurrence interval of about 190 years. Field et al. (2014) determined that the Santa Cruz Mountains Section of the San Andreas fault has about a 16% probability of generating an M_w 6.7 or greater earthquake in the next 30 years.

Aagaard, et al., (2016) determined that a given segment of the San Andreas fault within the San Francisco Bay region has a 22% probability of generating an M_w 6.7 or greater earthquake in the next 30 years.

San Gregorio Fault

The San Gregorio fault, as mapped by Greene (1977), Weber et al. (1979), Weber and Lajoie (1974), and Weber et al. (1995), skirts the coastline of Santa Cruz County northward from Monterey Bay and trends onshore at Point Año Nuevo. Northward from Año Nuevo, it passes offshore again, touching onshore briefly at Seal Cove just north of Half Moon Bay, and eventually connects with the San Andreas fault near Bolinas. Southward from Monterey Bay, it may trend onshore north of Big Sur (Greene, 1977) to connect with the Palo Colorado fault, or it may continue southward through Point Sur to connect with the Hosgri fault in south-central California. Based on these two proposed correlations, the San Gregorio fault zone has a length of at least 100 miles and possibly as much as 250 miles.

The on-land exposures of the San Gregorio fault at Point Año Nuevo and Seal Cove show evidence of late Pleistocene displacement (Jennings, 1975; Buchanan-Banks et al., 1978) and Holocene displacement (Weber and Cotton, 1981; Simpson et al., 1997). Although stratigraphic offsets indicate a history of horizontal and vertical displacements, the San Gregorio is considered predominantly right-lateral strike slip by most researchers (Greene, 1977; Weber and Lajoie, 1974; and Graham and Dickinson, 1978).

In addition to stratigraphic evidence for Holocene activity, the historical seismicity in the region is partially attributed to the San Gregorio fault (Greene, 1977). Due to inaccuracies of epicenter locations, even the magnitude the 6+ earthquakes of 1926 (tentatively assigned to the Monterey Bay fault zone), may have actually occurred on the San Gregorio fault (Greene, 1977).

The WGNCEP (1996) divided the San Gregorio fault into the "San Gregorio" and "San Gregorio, Sur Region" segments. The segmentation boundary is located west of Monterey Bay, where the fault appears to have a right step-over (Figure 2). The San Gregorio segment is assigned a slip rate that results in a M_w 7.3 earthquake with a recurrence interval of 400 years. This value was assigned based on the preliminary results of a paleoseismic investigation at Seal Cove by Lettis and Associates (see Simpson et al., 1997) and on regional mapping by Weber et al. (1995). Simpson et al. (1997) discovered prior displacements consistent with a moment magnitude of 7 to 7¼ in their paleoseismic study at Seal Cove. The Sur Region segment is assigned a slip rate that results in a M_w 7.0 earthquake with an effective recurrence interval of 411 years. Within the Sur Region many geologists, including Greene (1977), map the San Gregorio fault zone as continuing along the Palo Colorado fault. Graham and Dickinson (1978) show the San Gregorio fault continuing along the Sur fault zone. Field et al. (2014) has determined that the probability of the San Gregorio fault generating a M6.7 or greater earthquake in the next 30 years is about 4%.

Monterey Bay-Tularcitos Fault Zone

The Monterey Bay fault zone is a 6 to 9-mile-wide, 25-mile-long zone of short, northwest-striking en echelon faults trending between the San Gregorio fault zone and the Seaside-Monterey area in the southern Monterey Bay (Bryant, 2001). The Monterey Bay fault zone is part of the larger Monterey Bay-Tularcitos fault zone which extends 50 miles southeast from the San Gregorio fault to near the crest of the Sierra de Salinas range. Other faults within the greater fault zone include the Navy, Reliz, Tularcitos, and Chupines faults. These faults exhibit evidence of possible late Quaternary and Holocene age right-lateral slip. Geomorphic expression of the Monterey Bay fault zone is revealed by fault strands offsetting the seafloor of southern Monterey Bay.

Seismically, the Monterey Bay-Tularcitos fault zone may be historically active. The largest historical earthquakes *tentatively* located in the Monterey Bay-Tularcitos fault zone are two events, estimated at 6.2 on the Richter Scale, in October 1926 (Greene, 1977). Because of possible inaccuracies in locating the epicenters of these earthquakes, it is possible that they actually occurred on the nearby San Gregorio fault zone (Greene, 1977).

Petersen et al. (1996) calculated an M_w 7.1 earthquake for the Monterey Bay-Tularcitos fault zone with a recurrence interval of 2,841 years and a slip rate of about 0.5 millimeters per year. Field et al. (2014) determined that the Monterey Bay-Tularcitos fault zone has about a 1% probability of generating an M_w 6.7 or greater earthquake in the next 30 years.

Zayante-Vergeles Fault

The Zayante-Vergeles fault extends between the San Gregorio and San Andreas faults. The Zayante fault branches from the San Gregorio fault just north of Año Nuevo and trends about 55 miles southeast where it merges with the San Andreas fault south of San Juan Bautista (Bryant, 2000).

The Zayante fault has a long, well-documented history of vertical movement (Clark and Reitman, 1973), probably accompanied by right-lateral, strike-slip movement (Hall et al., 1974; Ross and Brabb, 1973). Stratigraphic and geomorphic evidence indicates the Zayante fault has undergone late Pleistocene and Holocene movement and is potentially active (Buchanan-Banks et al., 1978; Coppersmith, 1979).

Some historical seismicity may be related to the Zayante fault (Griggs, 1973). For instance, the Zayante fault may have undergone sympathetic fault movement during the 1906 earthquake centered on the San Andreas fault, although this evidence is equivocal (Coppersmith, 1979). Seismic records strongly suggest that a section of the Zayante fault approximately 3 miles long underwent sympathetic movement in the 1989 earthquake. The earthquake hypocenters tentatively correlated to the Zayante fault occurred at a depth of 5 miles; no instances of surface rupture on the fault have been reported.

In summary, the Zayante-Vergeles fault should be considered potentially active. Bryant (2000) concludes it capable of generating a magnitude M_w 7.1 earthquake with an effective recurrence interval of about 3,000 years. Field et al. (2014) determined that Zayante-Vergeles fault has about a 0.1% probability of generating an M_w 6.7 or greater earthquake in the next 30 years.

SHORELINE HAZARDS IN THE SANTA CRUZ/CAPITOLA AREA

Overview

The southwest-northeast orientation of the local shoreline is roughly parallel to the dominant direction of approach for refracted waves in the northern portion of Monterey Bay. As a result, littoral drift is rapid along this reach of coastline, inhibiting the formation of a continuous protective beach (Griggs, 1990). Instead, a series of pocket beaches have formed which are sensitive to seasonal changes and human intervention. The oceanographic factors affecting bluff erosion and their implications for coastal development will be discussed in more detail below.

Most of the northern end of Monterey Bay is flanked by a prominent sea cliff 20 to 120 feet high: a clear indication of active surf erosion (in a geological time frame). From Santa Cruz to Capitola, where beaches are generally narrow and discontinuous, the documented rate of cliff retreat due to surf attack has averaged over one foot per year in some areas (Griggs and Johnson, 1979). Of course, this cliff retreat is not a steady process as the quoted rate might seem to imply, but rather occurs episodically every few years in response to large storms and when the undercut base of a section of cliff collapses to the beach below.

Where lacking a broad protective beach or seawall, surf erosion at the base of a cliff causes failure of the bedrock portion of the lower cliff-face. Many of these failures are controlled by near-vertical bedrock joints: when erosional undercutting intersects one of the near-vertical joints, the undercut portion of the cliff fails along the joint and collapses onto the beach, temporarily armoring the base of the cliff. Along unprotected bluffs, these cliff failures often impede lateral access along that portion of the shoreline until wave action gradually removes the debris and the bluff undercutting process starts anew.

Primary failure of the cliff face triggers a time-lagged, secondary failure of the upper cliff, which is comprised of marine terrace deposits. The marine terrace deposits are weaker than the underlying Purisima Formation bedrock and over the long-term cannot maintain a slope much steeper than 1.5:1 (their approximate angle of ultimate stability). Thus, when a portion of the lower cliff fails as previously described, the upper cliff becomes over-steepened and gradually fails by piecemeal sloughing and slumping. Evidence of this process can be seen at various points along the cliff edge in the Santa Cruz-Capitola area. High groundwater levels, saturation, storm runoff, seismic shaking, and loading from human activity are some of the factors that can hasten secondary failure of the marine terrace deposits.

The sequence of events described above represents the most important geologic process operating in the coastal area, with relatively continual surf erosion being responsible for the steady retreat of the coastal cliffs in the Santa Cruz-Capitola area. Because the joints in the Purisima bedrock are located at intervals ranging between 5 and 25 feet, a given segment of the lower cliff-face may remain essentially unchanged for a number of years and then retreat 5 to 25 feet almost instantaneously. Secondary failure of the upper cliff-face commonly lags behind; thus, in the short term, the retreat of the cliff edge tends to occur more regularly than retreat of the cliff toe. Given a long enough period of time, however, the average rate of retreat will be the same for both the top and bottom of the cliff. At the time the seawall was constructed in 1998, the bluff edge was at least 50 feet from the residence, suggesting that multiple bluff retreat events would have been required to threaten the residence. The historical rates of cliff retreat at the subject property will be discussed in a later section.

Storm History of Monterey Bay, 1910 to Present

Review of the storm history of Monterey Bay (Appendix B) leads us to several immediate conclusions:

1. The number of large storms affecting Monterey Bay is relatively large.

2. The storms that produced the greatest damage in the interior of the bay often came from the west or southwest.

3. Structures directly exposed to wave action and designed to protect oceanfront properties from such action have been regularly damaged or destroyed.

For the period of most detailed record, 1910 to 1960, there have been at least 45 storms of some significance (i.e., either high seas, strong winds, and/or damage to at least some portion of the Monterey Bay region). Thus, considering the 50 years of detailed records, this amounts to a major storm every 1.1 years on average. Analysis of the record (Appendix B) reveals that no major storms were recorded for some intervals as long as seven years (1916 to 1923), but in other cases, five significant storms occurred within a single year (1931). If we consider the entire period, 1910 to present, we have a major storm about every 1.5 years on average.

This historical record indicates that the northern half of Monterey Bay (Moss Landing to Santa Cruz) is most susceptible to damage from storms arriving from the west or southwest (Griggs and Johnson, 1983; Johnson and Associates, 1987). Waves from the northwest, which predominate along the central coast (Figure 3; Wave Direction and Frequency), undergo refraction or bending, resulting in a significant energy loss prior to striking beaches along the northern interior of the bay (Figure 4; Monterey Bay Wave Refraction). Thus, although waves from the west-northwest and northwest dominate along the coastline, their effect on the northern interior of the bay appears to have been relatively small. In contrast, the storm waves approaching from the west, west-southwest and southwest pass primarily over the deep water on their way to the shoreline within the bay and lose little energy. These storms have produced the greatest recorded damage at the north end of the bay.

Of the 45 major storms in the study period, 1910 to 1960, 20 have been listed as coming from the southwest or west; only 12 are described as arriving from the north or northwest (the remainder list no direction of approach). Of the 13 storms which have produced significant damage along the bay's interior, only one is described as coming from the northwest; 11 arrived from the southwest, and for two of these storms the direction was not listed. Thus, at least 85 percent of the storms that have caused damage approached from the south or southwest. Looking at the frequency of arrival of these storms, 13 occurred in a period of 69 years. In other words, damaging storms have struck the area every 5.3 years on average. This does not mean, however, that storms will actually occur every 5.3 years.

The record of historical storm damage illuminates some other processes of relevance to the subject property: damage to the Monterey Bay coastal area has often occurred when huge storm waves coincide with high tides.

Although there have been numerous significant storms within Monterey Bay between 1984 and 1997, these storms have caused very little damage to structures. The 1997-1998 winter storms, however, did cause some structural damage, especially the storms of January and February 1998, which occurred in conjunction with seasonally high tides. Numerous roads and properties adjacent to the coastal bluffs were threatened. Several rip-rap revetments along the stretch of coast between Natural Bridges State Park, to the west of the site, and Capitola Beach, to the east, were damaged by the large surf generated by these storms. To our knowledge, there were no buildings damaged in the Monterey Bay area, although the Capitola wharf lost several pilings in February 1998. The El Niño winter storms of 2015-2016 caused damage to the Santa Cruz wharf and the Capitola pier. A portion of West Cliff Drive in Santa Cruz also was damaged as a result of pounding surf. In Pacifica, ongoing coastal erosion undermined several homes and apartment buildings during the storms of January 2016.

In general, properly designed, constructed, and maintained coastal protection structures have performed well throughout the historic record.

DESCRIPTION OF SITE AND VICINITY

The Site Location Map (Figure 1), Local Geologic Map (Figure 5), Oblique Aerial Image of Subject Site (Figure 6), Map Showing 100-Year Setback (Plate 1), and Geologic Cross Sections (Plate 2) depict the relevant topographic and geologic information on the subject property.

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Geomorphology

The coastal bluff backing the subject property is incised into the elevated, first emergent marine terrace which locally extends inland beyond Highway 1 (Figure 1). The bluff at the site is about 60 feet high, slopes gently seaward, and was created by the combined processes of sea level fluctuation, tectonic uplift, and coastal erosion over the past tens of thousands of years.

The typical process of coastal bluff formation is as follows: As sea level lowers (as it did during the last ice age), waves erode a relatively smooth, planar surface (termed a wave-cut platform) into the bedrock of the retreating shoreline and upland erosion deposits sediment across the newly emergent coastal plain. During this time, steady tectonic uplift elevates the coastal plain and region, forming a terrace. With a subsequent, post-glacial rise in sea level, a bluff is eroded into the seaward edge of the elevated terrace. The bluff erodes further inland with continued sea level rise.

The subject property occupies a broad bedrock headland along the coastal bluff. The headland has formed due to the presence of several ancient, inactive faults which have offset relatively erosion-resistant bedrock against softer, more erodible bedrock upcoast and downcoast of the site. As a result, the headland erodes at a slower rate than the bluff of the surrounding area. The faults within this headland juxtapose blocks of stronger and weaker bedrock in which deep undercuts have formed in the weaker rock. These undercuts are visible on oblique aerial images of the site which were taken prior to construction of the seawall (Figure 6). The differences in rock strength in addition to the amount of refraction incident waves undergo to reach the site affects the overall rate of bluff erosion, with the downcoast, northeast-facing portion of the bluff retreating the slowest.

The base of the bluff along the majority of the subject property has been protected since 1998 by an approximately 288-foot-long seawall and a concrete plug (Plate 1). The seawall system was permitted by Santa Cruz County in 1996 and the California Coastal Commission (CCC) issued a waiver for the project in 1997; meaning that Santa Cruz County has sole jurisdiction over the seawall. Santa Cruz County's conditions of approval of the permit for the subject seawall include the requirement for a monitoring and maintenance program, with the recorded amended monitoring and maintenance program requiring that the seawall be maintained on an ongoing basis to ensure its stability and structural integrity. The subject seawall spans several deep undercuts within the bedrock bluff, and the concrete plug also spans a deep undercut on the downcoast portion of the parcel. The subject seawall joins with an approximately 215-foot-long seawall constructed in 1994 to protect three upcoast adjacent parcels (APNs 033-132-01, 02, and 03). Portions of the upcoast adjacent seawall were maintained in 2009 and 2017 as required by permit. It was recently determined that the subject seawall and the upcoast adjacent seawall join approximately 12 feet upcoast of the subject property line, indicating that the upcoast seawall was constructed that distance short of the property line.

Our literature review, air photo analysis, and observations at the site indicate that the undercuts were plugged to the extent feasible during construction of the subject seawall; however, erosion of unprotected portions of the subject bluff necessitated maintenance to ensure the structural integrity of the seawall system. Maintenance activities consisting of plugging large voids behind the seawall were carried out in May 2016 and July 2017. These voids occurred where outflanking or undermining of the seawall scoured formerly infilled undercuts. The voids

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enlarged until the overlying bedrock behind or adjacent the seawall collapsed, resulting in a deeply undercut and unstable bluff which jeopardized the stability of the seawall system. The deep undercuts behind the seawall at the collapse areas were subsequently infilled with concrete and the bluff above the seawall stabilized where necessary.

We inspected the footing of the seawall on numerous occasions during the course of our work. The footing is becoming undermined to varying degrees at several locations along the length of the seawall and will require future maintenance as required by the seawall permit and as detailed in the approved and recorded maintenance agreement. Future required maintenance will likely consist of plugging any undercut and/or outflanked portions of the seawall system.

Earth Materials and Geologic Structure

The earth materials comprising the bluff at the subject property consist of Purisima Formation bedrock overlain by marine terrace deposits. A small wedge of talus eroded from the terrace material rests atop the seawall and against the bluff-face. Our observations of the earth materials at the site are in general agreement with the published geologic map of Santa Cruz County (Figure 5).

Exploratory borings advanced on the subject property and co-logged by our firm encountered marine terrace deposits (Qcl) to a depth of 23 feet, underlain by Purisima Formation (Tp) bedrock. The marine terrace deposits generally consist of yellowish brown to brownish gray, poorly consolidated, crudely stratified clay, silt, sand, gravel, and cobbles. The gravel and cobbles are typically more abundant in the lower half of the deposits. The terrace deposits are chiefly of fluvial origin and were deposited on an ancient wave-cut platform. Bedded sands at the base of the deposit have typically been reworked by wave action at the time of their deposition. The basal contact of the marine terrace deposits (the ancient platform) has a slight seaward gradient (Plate 2).

The Purisima Formation which underlies the terrace deposits and comprises the lower 40 or so feet of the bluff is well exposed in the bluff-face. It consists of thinly to thickly bedded, well jointed, fine to very fine-grained sandy siltstone and silty sandstone. Occasional fossiliferous interbeds consisting of shell hash exist throughout the sandstone. Boring B-4, which encountered Purisima Formation bedrock, revealed dark gray, fine to very fine grained micaceous silty sandstone. The bedrock is weathered, friable (breaks easily), and thinly horizontally bedded.

Exploratory boring B-4, drilled to a total depth of 25 feet, encountered perched groundwater at a depth of approximately 18 feet. Borings B-1 and B-2 both encountered groundwater seeps at a depth of about 2 feet.

GEOLOGIC HAZARDS

Seismic Shaking

Seismic shaking at the subject site will be intense during the next major earthquake along local fault systems. Modified Mercalli Intensities of up to VIII are possible at the site (see Table 1), based on the intensities reported by Lawson et al. (1908) for the 1906 earthquake and by Stover et al. (1990) for the 1989 Loma Prieta earthquake. It is important that recommendations regarding seismic shaking be used in the design for the proposed development.

Deterministic Seismic Shaking Analysis

For the purpose of evaluating deterministic peak ground accelerations for the site, we have considered the San Andreas fault zone. While other faults or fault zones in this region are active, their potential contribution to seismic shaking at the site is overshadowed by the relatively short recurrence interval of earthquakes on the San Andreas fault. Table 2 shows the moment magnitude of the characteristic or maximum earthquake, its estimated recurrence interval, and the distance from the causative fault to the site. We took the fault data from “The Uniform California Earthquake Rupture Forecast, Version 2” (WGCEP, 2008), “2008 United States National Seismic Hazard Maps” (Petersen et al., 2008) and “Probabilistic Seismic Hazard Assessment for the State of California” (Petersen et al., 1996).

Also shown on Table 2 are deterministically derived accelerations. These accelerations are based on attenuation relationships developed from the analysis of historical earthquakes. It is important to understand that shaking estimates of potential future earthquakes are based on the statistical analysis of shaking generated by past earthquakes. The calculated accelerations listed in Table 2 are the best estimates given the current methods and their application to the current database of past earthquakes. Therefore, we caution that the listed values are approximations, rather than precise predictions. Actual measured "free-field" accelerations at the site may be larger. Because the historical data can be interpreted in different ways, there are a number of different attenuation relationships available.

We have employed a set of up to five attenuation relationship models compiled by the Pacific Earthquake Engineering Research Center (PEER, 2014) in estimating the acceleration values. The resulting accelerations listed are based upon numerous factors, including magnitude, closest distance to the rupture plane, fault type (strike slip, normal, or reverse), as well as site soil classification. In addition, the regressions are adapted for the specific setting of shallow crustal earthquakes in active tectonic regions (e.g., western North America). The attenuation models therefore provide region-specific flexibility within the tectonic setting of California. We have not performed site-specific seismic shaking evaluations. No on-site or laboratory measurements were made to evaluate site-specific seismic response. The values listed, however, do reflect the site soil classification.

TABLE 1 Modified Mercalli Intensity Scale	
The modified Mercalli scale measures the intensity of ground shaking as determined from observations of an earthquake's effect on people, structures, and the Earth's surface. Richter magnitude is not reflected. This scale assigns to an earthquake event a Roman numeral from I to XII as follows:	
I	Not felt by people, except rarely under especially favorable circumstances.
II	Felt indoors only by persons at rest, especially on upper floors. Some hanging objects may swing.
III	Felt indoors by several. Hanging objects may swing slightly. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	Felt indoors by many, outdoors by few. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing automobiles rock. Windows, dishes, doors rattle. Wooden walls and frame may creak.
V	Felt indoors and outdoors by nearly everyone; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset; some dishes and glassware broken. Doors swing; shutters, pictures move. Pendulum clocks stop, start, change rate. Swaying of tall trees and poles sometimes noticed.
VI	Felt by all. Damage slight. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks and books fall off shelves; pictures off walls. Furniture moved or overturned. Weak plaster and masonry cracked.
VII	Difficult to stand. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings; considerable in badly designed or poorly built buildings. Noticed by drivers of automobiles. Hanging objects quiver. Furniture broken. Weak chimneys broken. Damage to masonry; fall of plaster, loose bricks, stones, tiles, and unbraced parapets. Small slides and caving in along sand or gravel banks. Large bells ring.
VIII	People frightened. Damage slight in specially designed structures; considerable in ordinary substantial buildings, partial collapse; great in poorly built structures. Steering of automobiles affected. Damage or partial collapse to some masonry and stucco. Failure of some chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed pilings broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX	General panic. Damage considerable in specially designed structures; great in substantial buildings, with some collapse. General damage to foundations; frame structures, if not bolted, shifted off foundations and thrown out of plumb. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground; liquefaction.
X	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Landslides on riverbanks and steep slopes considerable. Water splashed onto banks of canals, rivers, lakes. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	Few, if any masonry structures remain standing. Bridges destroyed. Broad fissures in ground; earth slumps and landslides widespread. Underground pipelines completely out of service. Rails bent greatly.
XII	Damage nearly total. Waves seen on ground surfaces. Large rock masses displaced. Lines of sight and level distorted. Objects thrown upward into the air.

TABLE 2 Faults, Earthquakes and Deterministic Seismic Shaking Data						
Fault Segment(s)	Moment Magnitude of Characteristic or Maximum Earthquake (M_w)	Estimated Recurrence Interval (years)	Site Soil Classification	Distance from Site (km)	Estimated Mean Peak Ground Acceleration (g)	Estimated Mean + One Dispersion Ground Acceleration (g)
San Andreas (1906 rupture)	7.9	210	D Stiff Soil	15.4	0.35	0.60
Zayante-Vergeles	7.1	3,000		9.9	0.36	0.63
Monterey Bay - Tularcitos	7.1	2,800		14.5	0.28	0.49
San Gregorio (north-south)	7.3	400		22.4	0.23	0.39

If the deterministically derived accelerations are used for engineering analysis on the subject property, we recommend utilizing the accelerations generated by the San Andreas fault. This is due to the high predicted ground accelerations and the short recurrence interval of the San Andreas fault zone. Based on the results listed in Table 2, the earthquake ground motion (mean peak acceleration plus one dispersion) expected at the subject property will be approximately 0.60g, based on a M_w 7.9 earthquake centered on the San Andreas fault 15.4 kilometers (about 9.5 miles) northeast of the site. The duration of strong shaking is dependent on magnitude. Bray and Rathje (1998) have suggested a relationship between magnitude, distance and duration of strong shaking. On the basis of their relationship, the duration of strong shaking associated with a San Andreas faulting event generating a magnitude 7.9 earthquake and occurring 15.4 km from the site is estimated to be about 31 seconds. This long duration of seismic shaking may be even more critical as a design parameter than the peak acceleration itself.

Coastal Erosion

With the seawall system protecting the majority of the bluff from wave attack, the historic rate of blufftop retreat has slowed at the site. However, the unprotected bedrock bluff-face and overlying terrace deposits will continue to erode through weathering and piecemeal erosion.

Dense tree cover at the site precluded an accurate measurement of the historic erosion rate from the air photo record. Therefore, we calculated the historic erosion rate at the site by comparing the mapped position of the blufftop in 1928 with its position surveyed in 1992, prior to construction of the seawall (Plate 1). Comparing the change in the mapped position of the blufftop between 1928 and 1992, we calculated an erosion rate of up to about 1.1 feet per year along the southwest portion of the subject bluff.

The rate of long-term bluff retreat at the site is governed by erosion of the bedrock comprising the lower portion of the bluff. To determine the position of the 100-year blufftop setback at the site, we constructed four geologic cross-sections depicting the current configuration of the bluff (Plate 2). Three of these cross sections (B, C, and D) were constructed through the portion of bluff where its base is protected by the existing seawall. Where the base of the bluff is protected by the seawall system, the 100-year setback assumes a loss of approximately 5 horizontal feet of sandstone bedrock above the seawall, and retreat of the overlying terrace deposits along a 1.5:1 slope (horizontal:vertical) resulting from strong seismic shaking and subaerial erosion (Plate 2). The potential five-foot loss of bedrock is based on empirical bluff weathering profiles and observations of joint-bounded bedrock bluff failures stemming from the 1989 Loma Prieta earthquake. Cross-section A was constructed through the downcoast portion of the bluff where it lacks a protective structure. To determine the 100-year setback along this portion of unprotected bluff, we applied a bluff retreat rate of 0.3 feet per year, calculated from the change in the mapped position of the bluff-edge at the site between 1928 and 2015, along the unprotected portion of the bluff. Our 100-year setback along this portion of the bluff also incorporates a 25% increase in the rate of potential erosion due to sea level rise, and a 10 foot buffer to account for any uncertainty in the erosion rate along the unprotected portion of the bluff resulting from the recent (2015) collapse of an adjacent bedrock promontory. The setback along the unprotected portion of the bluff was calculated as follows: Historic erosion rate (0.3 ft/yr x 100 years = 30 feet) + a 25% increase in the rate of potential erosion resulting from sea level rise (0.075 ft/yr x 100 years = 7.5 feet) + 10-foot buffer = 47.5 feet, as measured from the top of the bedrock exposed in the bluff-face along cross-section A.

The 100-year blufftop setback is depicted on Plate 1 and is predicated on the seawall system being maintained as required by the 1996 permit.

Along the base of the seawall, wave scour will abrade the bedrock shore platform and over time will undermine the seawall. With a potential increase in the rate of erosion associated with sea level rise, the permitted seawall system may require more frequent maintenance. Regular monitoring and maintenance of the seawall system, as required under the 1996 coastal development permit, will help identify areas of the seawall requiring maintenance and will help ensure the stability of the coastal bluff over the expected design life of the residential project.[1] As such, the proposed improvements will be subject to “ordinary” risk as defined in Appendix C of this report.

Sea Level Rise

The earth experiences climatic cycles in which warming and cooling of the atmosphere and surface of the earth occurs over various lengths of time. These cycles, also known as Milankovitch cycles, determine the amount and angle of incidence of solar insolation on a given portion of the earth. Global cooling (ice ages) occurs when the amount of sunlight reaching the earth is low, and global warming occurs when the earth is receiving greater amounts of insolation. Terrestrial phenomena such as volcanic eruptions, meteor impacts, even large dust storms also affect global earth temperature and climate.

Throughout the late Pleistocene and Holocene, sea level has been rising due to a natural warming of earth’s surface and atmosphere as the earth emerges from its most recent ice-age (about 15,000 years ago). Since the onset of the industrial revolution in the early to mid-1800's, an

1 Current LCP Policy 6.2.12 refers to “the 100-year lifetime of the structure”. Santa Cruz County is considering changes to its LCP and implementation plan, including setting an expected standard design life of 75 years for calculating the blufftop setback for proposed residential coastal development projects. As of the date of this report, the proposed LCP changes have not been ratified.

increasing amount of man-made atmospheric pollution may be causing a significant increase in the rate of earth's warming.

Theories regarding the Greenhouse Effect state that there is an ongoing, accelerated rate of global warming due to entrapment of gases and resultant reflection of radiation in the atmosphere due, in part, to increased production of atmospheric waste by industrial societies throughout the world. With time, the continued warming of the atmosphere could cause increased melting of continental ice, which turn will contribute to the natural rise in sea level.

Since 1880, global sea level has risen nearly 8 inches. Satellite measurements of the world's oceans since 1993 show that sea levels are rising 0.12 inches or more per year (Climate Change International Scientific Congress, 2009). This is approximately double the rate of sea level rise since 1880. In 2007, the Intergovernmental Panel on Climate Change (IPCC) projected sea levels to rise between about 7 and 23 inches by 2100. This range in rates roughly matches the sea level rise rate since 1880 on the low end, and again doubles the measured rate of sea level rise since 1993. The IPCC 2007 did not factor into their estimates uncertainties in the climate-carbon cycle feedback, nor the full effects of ice sheet flow. The Climate Change International Scientific Congress in 2009 concluded that the IPCC 2007 estimates may be a lower-bound for global sea level rise, with sea levels potentially rising 20 to 40 inches by 2100.

Formal projections of future sea-level rise along the west coast of the United States have not been made, however some studies have proposed ranges of possible sea-level outcomes for the California Coast south of Cape Mendocino. The Committee on Sea Level Rise in California, Oregon, and Washington (2012) projects regional sea level to rise between 1.6 and 11.8 inches by 2030, between 4.7 and 24 inches by 2050, and 16.5 to 65.7 inches by 2100, relative to year 2000 levels. The progressively greater ranges in the longer-term sea level rise projections arise from uncertainties in future input variables. We have selected a potential 3.5-foot rise in sea-level over the project lifetime: it is the average of the projected year 2100 levels.

A study by Revell et al. (2011) hypothesizes that with rising sea level the rate of retreat of the California coastline will increase, with the erosion response at a given site determined by the backshore type, the underlying geology, and the historic rate of retreat. Revell et al. calculated that with a 1.4 meter (4.6 feet) rise in sea level by 2100, cliff-backed shorelines may retreat an average of 33 meters (approximately 110 feet) by 2100. For the Santa Cruz County shoreline, Revell et al. (2011) report a calculated average 15-20 meter (49-66 feet) loss of shoreline, based on a 4.6-foot rise in sea level by the end of the century. However, Revell et al. state that a lack of site-specific data for a given site precludes applying any of the above retreat rates to a specific property, and the intent of their work is more suited to regional planning.

Wave scour and a gradual rise in sea level has resulted in the formation of the cliff fronting the subject bluff. The effect of continued or accelerated sea-level rise along both the areal coastline and subject site may hasten erosion and bluff retreat due to a deepening of nearshore waters, allowing larger, more frequent, unattenuated waves to break further onshore. For our 100-year blufftop analysis of the subject site we have postulated a 25% increase in the rate of historic bluff erosion along the unprotected downcoast portion of the subject bluff due to accelerated erosion resulting from sea-level rise (see Cross Section A, Plate 2). Our 100-year setback along the unprotected portion of the subject bluff is approximately 47.5 feet from the bedrock exposed in the bluff-face and is in general agreement with the average retreat distance reported by Revell et al. (2011). The portion of the subject bluff protected by the maintained seawall will not experience the effects of accelerated retreat resulting from sea level rise so long as the seawall is maintained as required by the 1996 permit and maintenance agreement.

It is difficult to say with any certainty what future rates of sea level rise will be, but current estimates of sea level rise in the next 100 years anticipate the most rapid rise will be toward the end of the 21st century and thus the higher rate of bluff retreat will occur toward the end of the century as well. As modeling practices become better refined and the human contribution to global warming and resulting sea-level rise is better understood, future rates of sea-level rise and its impact on coastal erosion may become more predictable.

Sea Level Rise vs. Local Tectonic Uplift

Various researchers have determined long-term uplift rates of the Santa Cruz coastline, either through age-dating of the marine terraces, examining fission tracks in rocks, or by geodesy. The rates of coastal uplift in the Santa Cruz area reported from this research ranges between about 0.1 and 1.0 millimeter per year. Since 1993, satellite measurements have shown that the oceans are rising 3 millimeters (0.12 inches) or more per year, or about three times the highest reported uplift rate (Climate Change International Scientific Congress, 2009).

The 1989 Loma Prieta Earthquake caused uplift of the region west of the fault rupture zone, with greatest uplift occurring closer to the fault. Resurveying of benchmarks in the vicinity of the subject property after the Loma Prieta event revealed that the subject area experienced a little over ½ inch of uplift as a result of the earthquake (County of Santa Cruz Department of Public Works, 1995). This may be a minimum value, as research by others suggests greater amounts of uplift. Because of the long-term episodic nature of tectonic uplift, we have not factored local tectonic uplift into any sea level rise estimate for the subject site during the project lifetime.

Slope Stability

Coseismic Slope Stability

As previously mentioned, the subject property will be subjected to strong ground shaking in the event of a large magnitude earthquake centered on the nearby San Andreas fault. Past ground shaking has triggered numerous failures of varying size along the coastal bluffs in the Santa Cruz region. Review of the local newspaper coverage (Youd and Hoose, 1978), and the Carnegie Commission Report (Lawson et al., 1908) of the 1906 earthquake disclosed no documented accounts of large-scale sea cliff failure in Santa Cruz County due to the earthquake, though there was much sloughing of "earth" from the bluffs near Capitola (Lawson et al., 1908, p. 272). This apparently involved portions of the poorly consolidated terrace deposits that were shaken loose during the earthquake.

The 1989 Loma Prieta earthquake generated numerous coastal bluff failures in the Santa Cruz area. The lithology of the particular site controlled the mode of failure (Plant and Griggs, 1990). Competent, well-jointed Purisima Formation sandstone underlies the coastal bluff from Seabright Beach to New Brighton State Beach and rock falls were the typical mode of failure. Between New Brighton State Beach and Aptos Creek, translational landslides with blufftop fissuring occurred within the terrace deposits. Little failure occurred within the moderately indurated and weakly jointed underlying Purisima Formation sandstone. From Aptos Creek to Manresa State Beach similar translational landsliding occurred within the terrace deposits. Here however, the terrace deposits are underlain by Aromas Sands which also failed in shallow, dry sand flows. South of Manresa State Beach the weakly consolidated dune deposits (which overlie terrace deposits and Aromas Sand) failed as shallow translational slabs.

In the vicinity of the subject property (from Seabright Beach to New Brighton State Beach) failure of the bluff resulting from the Loma Prieta earthquake was primarily by rockfall and blockfall (Plant and Griggs, 1990). The Purisima Formation bedrock in the site vicinity is well indurated but extensively jointed. Failures occurred in areas where the toe of the bluff had been undercut by wave erosion. Failure planes were primarily along joint surfaces and the size of the failure was dependent on joint spacing and orientation. Where the toe of the bluff was protected and not undercut, failures were rare.

Deep-seated landsliding, incorporating the entire height of the coastal bluff, is possible; however, this type of landslide does not appear to be a common mode of failure in the site vicinity. The lack of topographic evidence suggestive of large, deep-seated landsliding (i.e., scarps, bowl-shaped swales, hummocky topography) indicates this failure mechanism has not contributed to recent cliff retreat (Plant and Griggs, 1990). However, the coastal bluff in Santa Cruz County has not been subject to strong seismic shaking under wet winter conditions since the 1906 San Francisco Earthquake. No large-scale, deep-seated landslides of the coastal bluff were reported in Santa Cruz County subsequent to the 1906 event. Although, the lack of reported deep-seated landslides is not a guarantee against their occurrence; reconnaissance mapping was limited in this area and the lack of large failures cannot be confirmed due to a lack of photographic coverage during that time frame.

Pseudostatic slope stability analysis

If pseudostatic slope stability analysis of the coastal bluff is performed by the project geotechnical engineer, it should utilize our geologic cross sections and a site-specific seismic coefficient (k). Ashford and Sitar (2002) developed a method for calculating a site-specific pseudostatic seismic coefficient (k) specifically for a coastal blufftop setting in which ground motion is subject to topographic amplification. Following their guidelines yields a coefficient (k) of 0.52. This is based on a predicted PGA of 0.60g (mean plus one standard deviation), a total bluff height of 62 feet, an estimated slide height of 21.5 feet (occurring within the marine terrace deposits), and “steep” slopes of about 75 degrees. The overall slope of the bluff at the subject site is approximately 70 degrees.

For site-specific pseudostatic slope stability analyses, the Santa Cruz County Planning Department recommends a factor of safety exceeding 1.1 when using a site-specific k-value. A former practice of utilizing a minimum k-value of 0.15 for magnitude 8.25 earthquakes exhibiting site accelerations of less than 0.75g with an acceptable factor of safety of 1.15 had considerable limitations: it was generally over-conservative at large distances from the causative fault and under-conservative at very short distances, and it was predicated on displacements considered unacceptable for residential homes (roughly 3 feet). Additionally, this method did not take into account the effects of topographic amplification.

Aseismic Slope Stability

The sea cliff is also subject to slope failure under aseismic conditions. Although generally smaller than seismically generated failures, storm generated failures are an order of magnitude more common (e.g. a ten-year cycle versus a hundred-year cycle). Small-scale translational slumping is the chief process affecting the marine terrace deposits in the upper portion of the bluff. These materials generally fail due to saturation.

The 100-year blufftop setback depicted on Plate 1 is at least 10 feet landward of the surveyed limit of a deep undercut into the bedrock bluff (Plate 1). The undercut plugged with concrete in July 2017 and in our opinion the potential for ground surface settlement beneath the proposed development is low.

CONCLUSIONS

The coastal blufftop property is located along Opal Cliff Drive in Santa Cruz County, California. Current development plans consist of razing the existing 80-year-old residence and constructing a new single-family dwelling on the property. Santa Cruz County LCP Policy 6.2.12 and Santa Cruz County Code Section 16.10.070(H)(1) requires that new development be set back landward of the projected 100-year blufftop or a minimum of 25 feet from the edge of the coastal bluff, whichever is greater, based on existing site conditions, and that the setback does not take into consideration the effect of any proposed shoreline protection measures. We did not consider any proposed shoreline protection measures in determining the 100-year setback, nor are any new shoreline protection measures included in the proposed development plans.

The coastal bluff at the subject site is about 60 feet high, slopes gently seaward, and was created by the combined processes of sea level fluctuation, tectonic uplift, and coastal erosion over the past tens of thousands of years. The primary geologic hazards at the subject site are seismic shaking and coastal erosion.

The site is located in an area of high seismic activity and will be subject to strong seismic shaking in the future. Modified Mercalli Intensities of up to VIII are possible. The controlling seismogenic source for the subject property is the San Andreas fault, about 9.5 miles to the northeast. The design earthquake anticipated on this fault is M_w 7.9, with an expected duration of strong shaking of about 31 seconds. Deterministic seismic shaking analysis for the site yields a mean peak ground acceleration plus one dispersion of 0.60g.

A permitted seawall system constructed in 1998 protects the majority of the subject bluff from wave erosion. As a condition of the coastal development permit (95-0621) approved in 1996, the seawall must be maintained to ensure its structural integrity. Maintenance work on the seawall was performed in 2016 and 2017. Although the base of the bluff is protected by the seawall system, the upper portion of the bluff will erode in response to weathering, saturation, and seismic shaking. A short segment of the downcoast portion of the subject bluff remains unprotected and has a low measured rate of historical retreat (0.3 feet per year). This segment of the bluff will continue to retreat due to subaerial erosion, seismic shaking, and wave attack. In calculating the blufftop setback for this segment of the bluff, we included a 25% increase in the rate of potential erosion of the unprotected portion of bluff resulting from sea level rise. We also added a ten-foot buffer in calculating the setback to account for any uncertainty in the erosion rate along the unprotected portion of the bluff resulting from the recent (2015) collapse of an adjacent bedrock promontory.

Development at or landward of the 100-year blufftop setback line, as depicted on Plate 1, is geologically feasible provided the seawall is maintained as required by the 1996 permit and the recorded maintenance agreement.

RECOMMENDATIONS

1. The blufftop, bluff-face, and seawall system at the subject site should be regularly monitored, especially after severe storm events. The seawall system should be rigorously maintained as necessary. We should be notified immediately if any adverse conditions are observed along the subject bluff or seawall system so that we may assess the site conditions and make corrective recommendations.

2. New development should be founded at or landward of the 100-year blufftop setback line depicted on Plate 1. This setback line is based in part on the position of the unprotected bedrock bluff-face and incorporates erosion of the bedrock and overlying terrace deposits during the project lifetime.

   A representative from our firm must inspect the staked location of the proposed new residence for conformance with the 100-year blufftop setback prior to excavating or constructing any foundation elements.

3. The project engineers and architect should review our seismic shaking parameters and choose a value appropriate for their particular analyses.

4. Drainage from improved or impervious surfaces, such as walkways, patios, roofs and driveways on the property should be collected in impermeable gutters or pipes and either carried to the base of the bluff via closed conduit or released into an established drainage channel or stormdrain.

   At no time should any concentrated discharge be allowed to spill directly onto the ground adjacent to the existing residence or flow over the blufftop. The control of runoff is essential for control of erosion and prevention of ponding.

5. We request the privilege of reviewing all geotechnical engineering, civil engineering, drainage, and architectural reports and plans pertaining to the proposed development and mitigation measures.

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INVESTIGATION LIMITATIONS

1. The conclusions and recommendations contained herein are based on probability and in no way imply that the proposed development will not possibly be subjected to ground failure, seismic shaking, coastal erosion or landsliding of such a magnitude that it overwhelms the site. The report does suggest that using the site for residential purposes in compliance with the recommendations contained herein is an acceptable risk.

2. This report is issued with the understanding that it is the duty and responsibility of the owner or his representative or agent to ensure that the recommendations contained in this report are brought to the attention of the architect and engineers for the project, incorporated into the plans and specifications, and that the necessary steps are taken to see that the contractor and subcontractors carry out such recommendations in the field.

3. If any unexpected variations in soil conditions or if any undesirable conditions are encountered during construction, Easton Geology, Inc. should be notified so that supplemental recommendations may be given.

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Aerial Photographs

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11 April 1973 (1973-74), frames 7-1 and 2, black and white, nominal scale 1:15,840, Big Creek Lumber Company.

18 October 1989 (1989-B), frames 3-9 and 10, black and white, nominal scale 1:12,000, Flown for unknown agency.

22 June 1994 (1994), frames BIG CREEK LUMBER 12-1 and 2, black and white, nominal scale 1:15,840, Big Creek Lumber.

Photos are available for viewing in the Map Room at the University Library at the University of California, Santa Cruz, or on their website, with their collections referenced above in parentheses (e.g., 1963-E, etc.).

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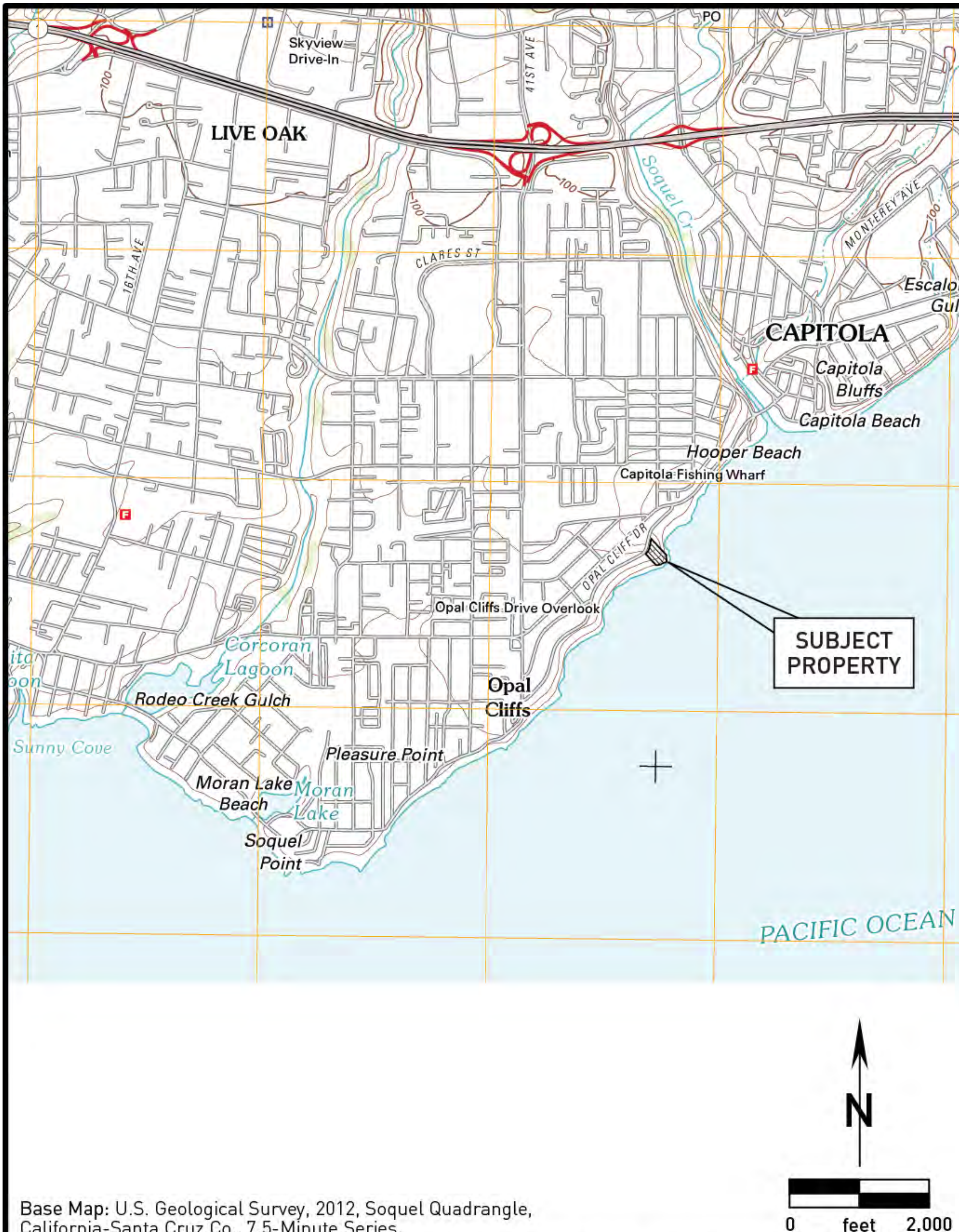
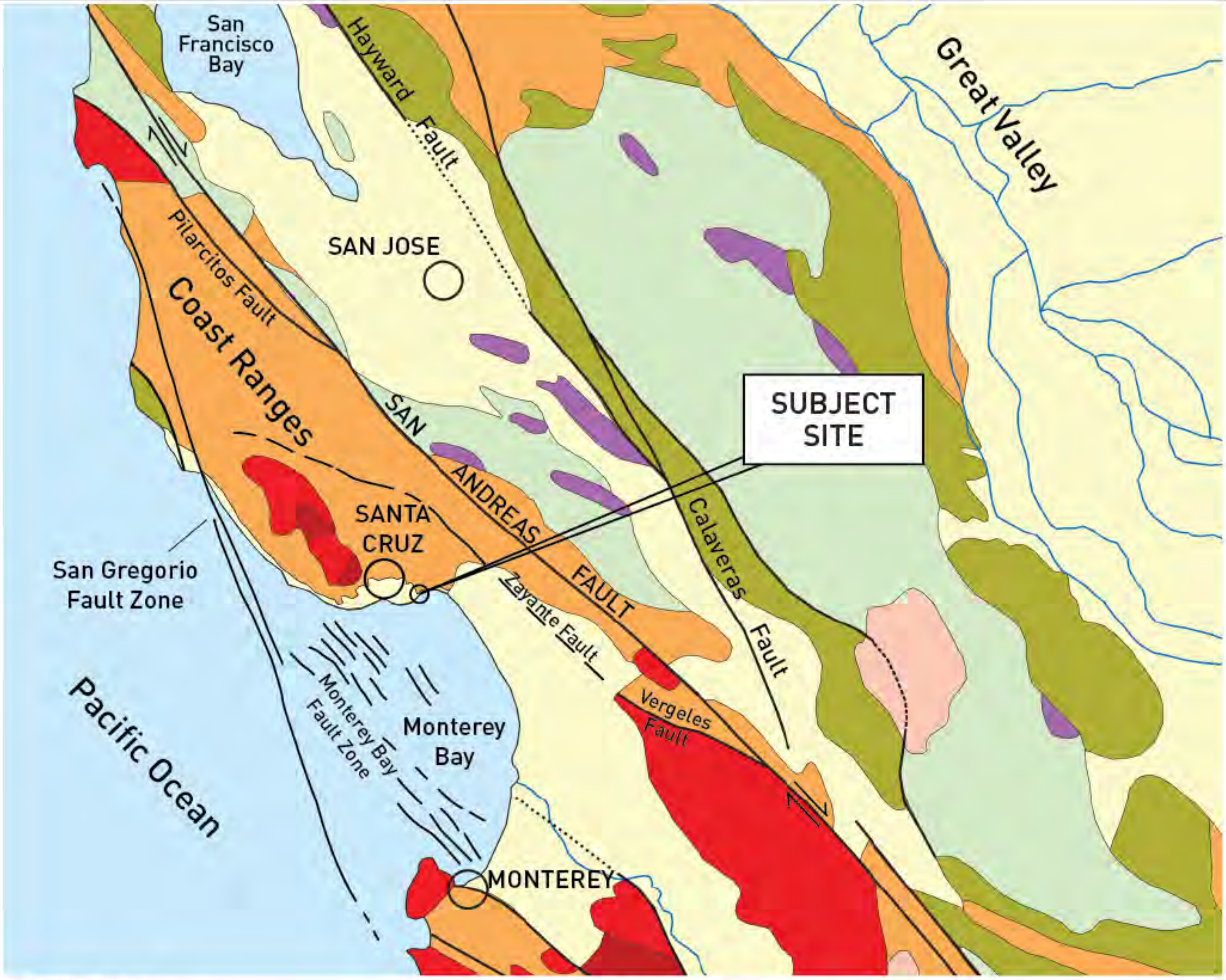
APPENDIX A

FIGURES 1 through 6



Base Map: U.S. Geological Survey, 2012, Soquel Quadrangle, California-Santa Cruz Co., 7.5-Minute Series.

EASTON GEOLOGY, INC. P.O. Box 3533 Santa Cruz, California 95063 831.247.4317	SITE LOCATION MAP Sisney Property 4660 Opal Cliff Drive Santa Cruz, California Santa Cruz County APNs 033-132-05, 06, 13, 14	FIGURE # 1 JOB # C15023



EXPLANATION

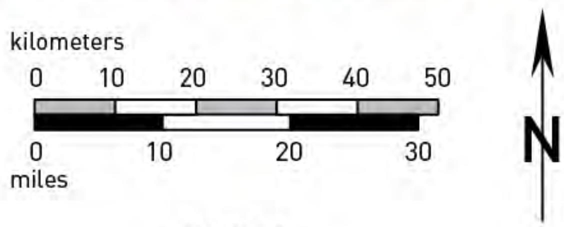
This map is based on the Simplified Geologic Map of California, Map Sheet 57

SEDIMENTARY AND VOLCANIC ROCKS

- Cenozoic nonmarine (continental) sedimentary rocks and alluvial deposits
- Cenozoic marine sedimentary rocks
- Cenozoic volcanic rocks

INTRUSIVE AND IGNEOUS METAMORPHIC ROCKS

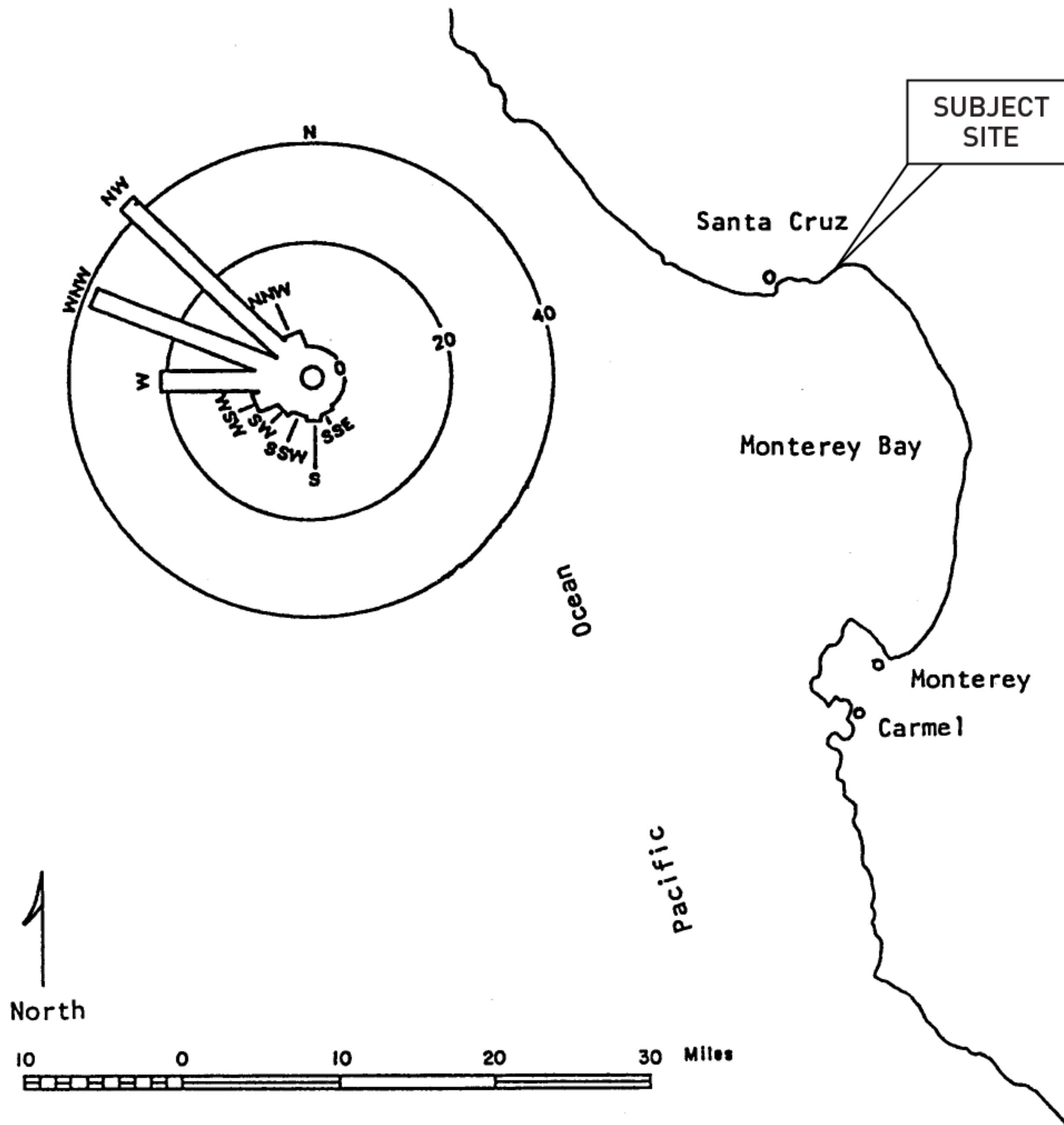
- Granitic rocks - chiefly Mesozoic
- Serpentinized ultramafic rocks - chiefly Mesozoic
- Pre-Cenozoic metamorphic rocks of unknown age
- Late Mesozoic (latest Jurassic and Cretaceous) marine sedimentary rocks; Great Valley Sequence and related rocks
- Late Mesozoic (latest Jurassic and Cretaceous) rocks of the Franciscan Complex



SYMBOLS

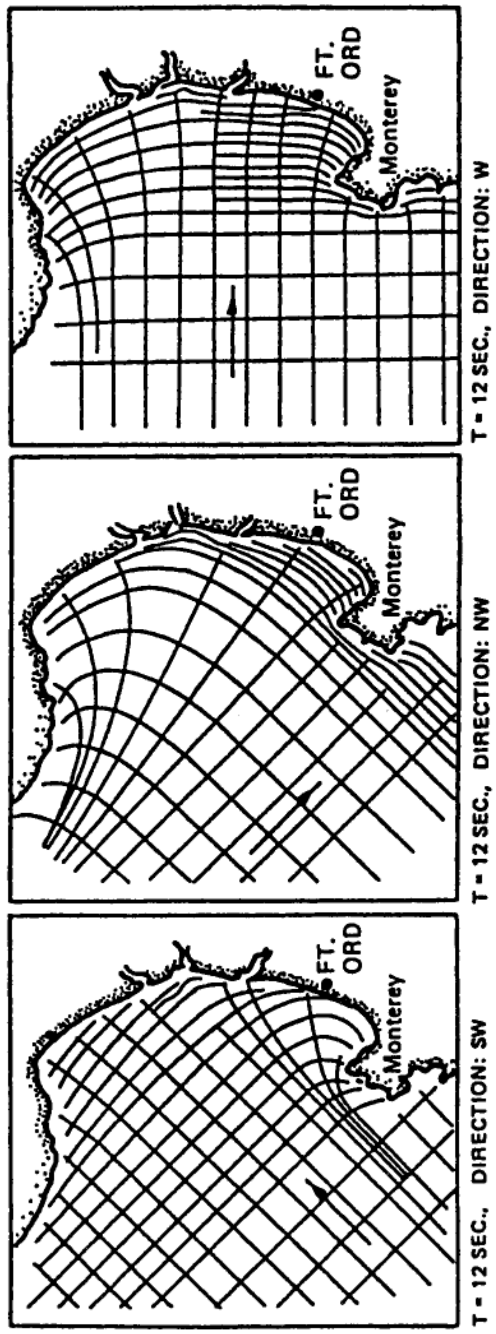
- Contact
- Fault - dotted where concealed; arrows indicate relative movement on strike-slip faults

EASTON GEOLOGY, INC. P.O. Box 3533 Santa Cruz, California 95063 831.247.4317	REGIONAL GEOLOGIC MAP Sisney Property 4660 Opal Cliff Drive Santa Cruz, California Santa Cruz County APNs 033-132-05, 06, 13, 14	FIGURE # 2 JOB # C15023



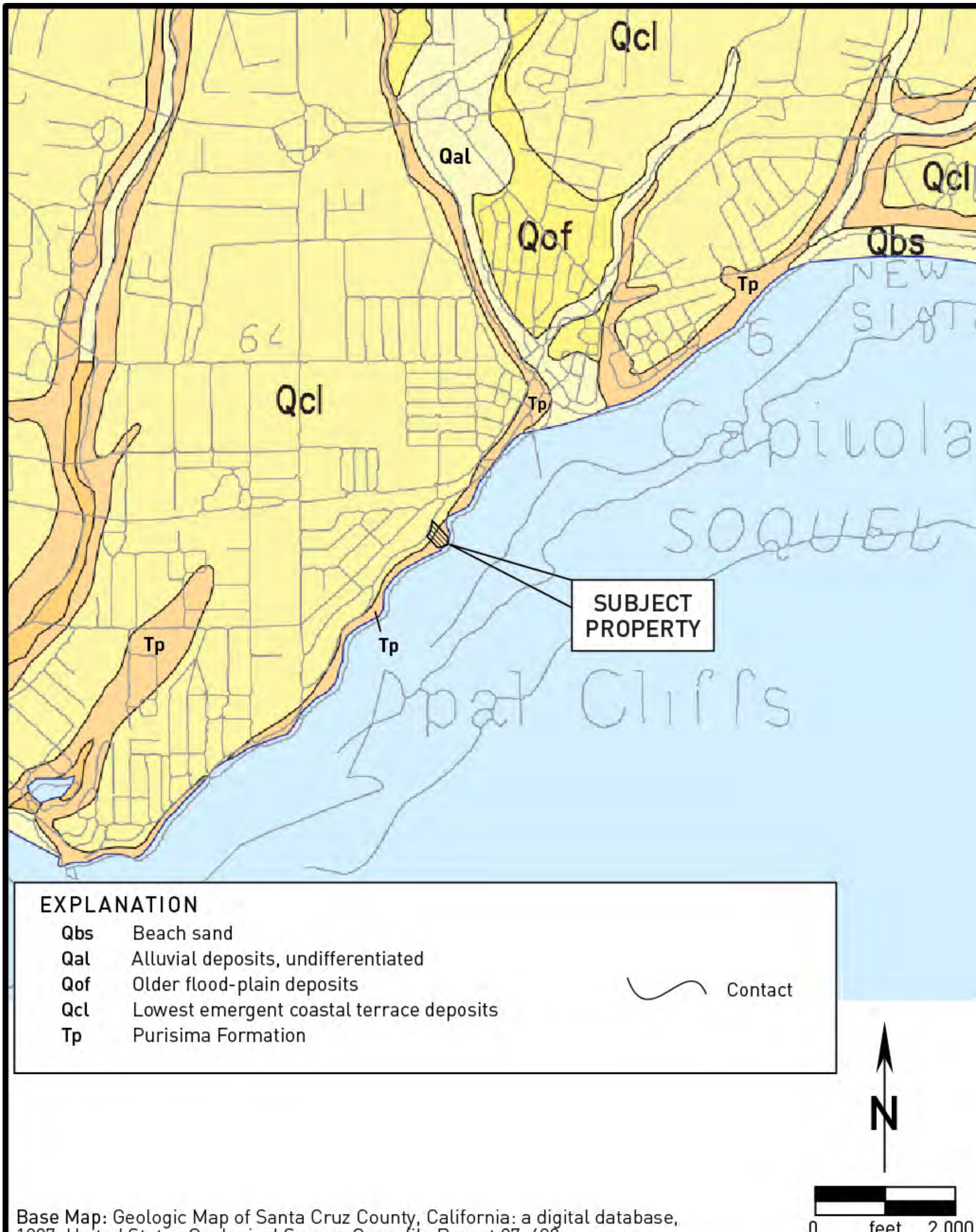
Source : National Marine Consultants, 1960.

EASTON GEOLOGY, INC. P.O. Box 3533 Santa Cruz, California 95063 831.247.4317	WAVE DIRECTION and FREQUENCY Sisney Property 4660 Opal Cliff Drive Santa Cruz, California Santa Cruz County APNs 033-132-05, 06, 13, 14	FIGURE # 3 JOB # C15023



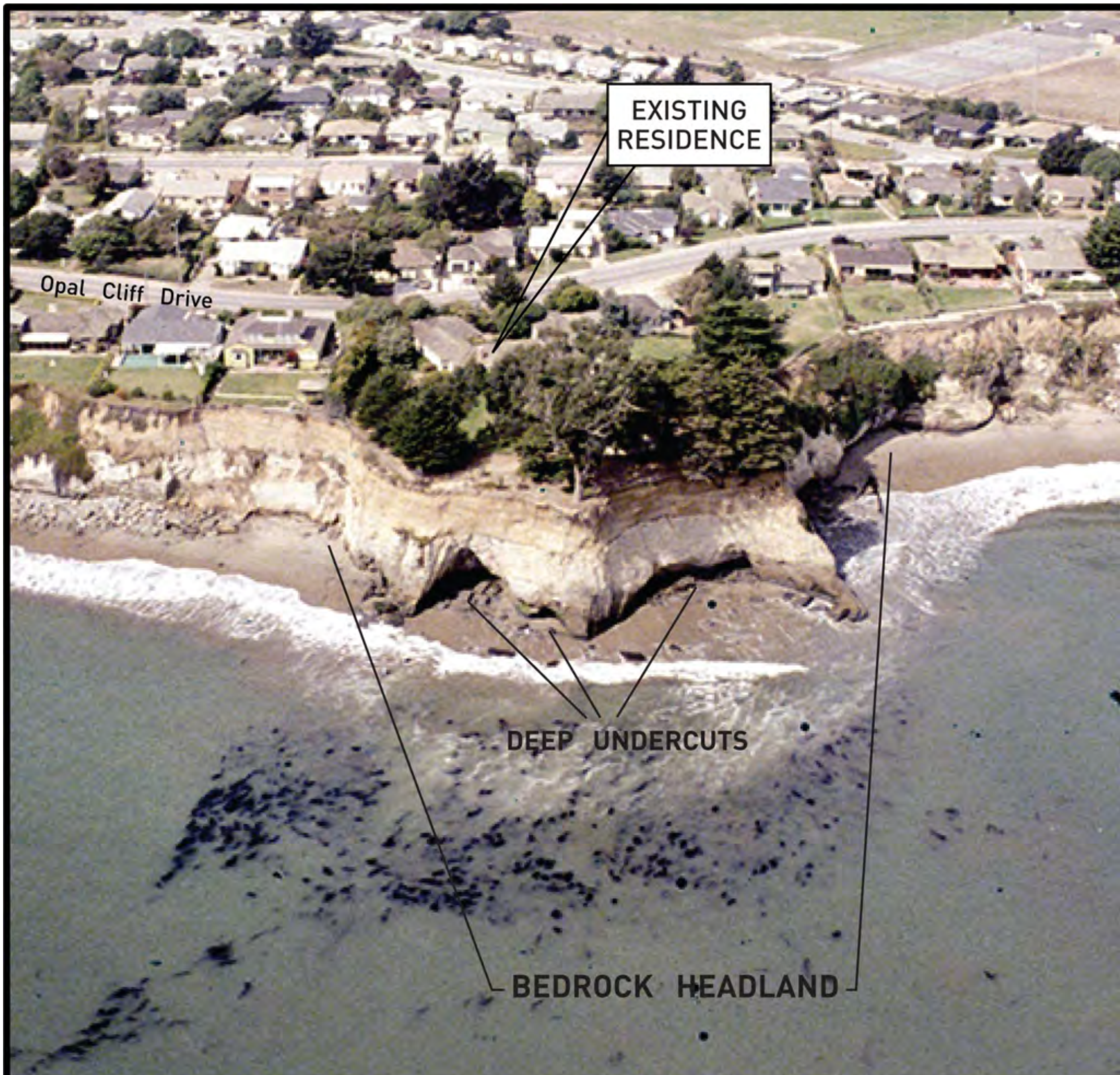
Source : Wiegel 1964.

EASTON GEOLOGY, INC. P.O. Box 3533 Santa Cruz, California 95063 831.247.4317	MONTEREY BAY WAVE REFRACTION Sisney Property 4660 Opal Cliff Drive Santa Cruz, California Santa Cruz County APNs 033-132-05, 06, 13, 14	FIGURE # 4 JOB # C15023



Base Map: Geologic Map of Santa Cruz County, California: a digital database, 1997, United States Geological Survey, Open-file Report 97-489.

EASTON GEOLOGY, INC. P.O. Box 3533 Santa Cruz, California 95063 831.247.4317	**LOCAL GEOLOGIC MAP** Sisney Property 4660 Opal Cliff Drive Santa Cruz, California Santa Cruz County APNs 033-132-05, 06, 13,14	FIGURE # **5** JOB # C15023



EASTON GEOLOGY, INC. P.O. Box 3533 Santa Cruz, California 95063 831.247.4317	**OBLIQUE AERIAL IMAGE OF SUBJECT SITE** Sisney Property 4660 Opal Cliff Drive Santa Cruz, California Santa Cruz County APNs 033-132-05, 06, 13, 14	FIGURE # **6** JOB # C15023

APPENDIX B

STORM HISTORY OF MONTEREY BAY AND THE CENTRAL COAST, 1910 TO PRESENT

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STORM HISTORY OF MONTEREY BAY AND THE CENTRAL COAST 1910 TO PRESENT

(Compiled from U. S. Army Corps of Engineers, 1958, 1998; Bixby, 1962; California Coastal Commission, 1978; Griggs and Johnson, 1983; Santa Cruz Sentinel and Watsonville Register-Pajaronian)

Date	*Description and Damage*	*Direction or Type of Storm*
Mar 21 1910	Heavy storm off coast, mountainous seas. No damage.	.....
Nov 22 1910	Bay was very rough and surf was running high. No ships able to enter or leave Monterey harbor. No damage.	.....
Feb 13 1911	Mountainous waves reported along the beach north of Monterey. No damage.	.....
Oct 4-11 1912	Strong northwest wind and heavy swell. Several wharves at Monterey damaged and boats beached. Heavy surf.	.....
Dec 1912	Watsonville Wharf damaged; waves washed up to Casino building; heaviest seas in history of Monterey Bay.	.....
Apr 29-30 1915	Heavy surf and strong winds. Considerable damage to structures and boats.	.....
Nov 26 1915	Large and powerful waves breaking over wharves at Monterey. No damage.	.....
Jan 27 1916	Southwest gale. Steamship pier at Moss Landing destroyed by tremendous swells.	"southwest gale"
Nov 29-Dec 1 1923	Northeast gale swept 15 boats ashore at Monterey. Heavy seas outside harbor. Freighter beached at Santa Cruz.	"northeast gale"
Feb 11-15 1926	Southerly gale winds and wave damage all along California coast. Pier damaged at Moss Landing. High tide and waves destroyed bathhouse at Santa Cruz; concession building lost practically all of underpinnings. Downtown Capitola flooded. Venetian Court apartments undercut. High waves washed completely over 2,000 feet of new sea wall at Seacliff State Beach, carrying debris back to cliff. Portions of sea wall undercut and caved in. Beach road washed almost entirely away. Sea wall at Swanton Beach partially destroyed. Seaside Company's bandstand collapsed. Breaker broke into and destroyed Ideal Fish Restaurant.	"southerly gale"
Oct 25 1926	Heavy swells running into bay. Giant combers rolled shoreward carrying bay waters almost up to high line of last February's storm. Swept up to Casino.	.....
Dec 8-9 1926	Heavy swells washed one boat ashore at Monterey. No significant damage.	.....
Feb 14-16 1927	At the time, reported to be most violent storm in history of Pacific coast. During high tide, breakers rolled clear to the esplanade. Dashed against Casino. Concrete sea wall at Seacliff State Beach destroyed.	"heavy southwester"

Oct 4 1927	Huge breakers reported along Central California coast. No damage reported.	.....
Dec 30 1928	Powerful surges in Monterey harbor causing damage to freighter attempting to moor.	.....
Jan 3 1931	Piling of Municipal Pier loosened. Boarding in front of Casino damaged.	heavy southwest swell
Feb 4 1931	Damage at Santa Cruz Casino building. High breakers and ground swells. Waves reached bottom of wharf, 14 to 20 feet above mean lower low water.	.....
Feb 20 1931	North winds of gale intensity. Several small boats wrecked.	north winds
Nov 20-21 1931	Strong winds and heavy seas beached numerous small boats at Monterey. No damage to Santa Cruz wharf.	northwest gale
Dec 23-29 1931	Violent storm. Entire coastal area affected. East Cliff Drive between Santa Maria Del Mar and Soquel Point cut by wave action and sections lost. Large quantities of sand eroded from Twin Lakes Beach. At Seacliff State Beach, concession building and bathing pavilion wrecked. Beach littered with debris brought down by storms. Giant breakers washed over pier at Capitola (20 feet above mean lower low water). Considerable damage to Casino.	winds first from southwest, then northwest
Dec 20-21 1932	Very rough on bay and waves breaking over breakwater under construction at Monterey.	winds from northwest
Dec 19 1935	Very heavy surf. Giant breakers demolished steps opposite Nichols Fishing Trip offices on wharf and damaged Stagnaro building.	...
Dec 10-11 1937	Coast Road closed at Waddell. Boats beached at Stillwater Cove.	southwest winds
Dec 9-10 1939	High waves. Breakers and high tide combined to flood lower East Cliff Drive area. Deep water wave height hindcast at 20 feet. At Seacliff State Beach, timber bulkhead destroyed and shoreward end of pier damaged.	southwest wind waves
Jan 8 1940	Casino at Capitola almost a complete wreck. Santa Cruz Casino damaged. East Cliff Drive between Santa Cruz and Capitola weakened. Piling broke loose from wharf. Flooding of a motor camp at Seabright. Debris and mud deposited up to entrance at Casa Del Rey Hotel. Boardwalk drenched.	.....
Feb 26-28 1940	Beach eroded and littered with logs. Hindcasted waves of 25 feet in height.	southwest wind, waves and swell
Dec 26-27 1940	Highway 1 closed after 800 feet of roadway washed away at Waddell from high seas. Timbers along boardwalk collapsed. Huge sections of East Cliff Drive at Schwann's Lagoon collapsed. Crux of local weather trouble was at Seacliff State Beach. Logs up to 10 feet were tossed onto road. An 80-foot section of pier washed out. Houses damaged. 80 feet of Seacliff State Beach lost. Two sections of sea cliff bulkhead ripped out. At Moss Landing houses were under a foot of water.	.....
Jan 8-13 1941	At Seacliff State Beach, about one-half of a timber bulkhead and 60 feet of shore end of pier destroyed. Beach eroded to bedrock.	waves and swell from southwest; crests level with deck of pier (+20 feet above mean lower low water)

Feb 11-13 1941	Large waves in bay. West Cliff Drive caves in. Residents in Seacliff State Beach cut off by slides.	.....
Feb 26-28 1941	Heavy winds, gigantic waves, breakers smashed Casino steps. West Cliff Drive closed due to cliff erosion from wave action. Hindcast wave height at 22 feet.	south-southwest and south- west wind waves and swell
Dec 24-25 1942	North winds and high surf beached four purse seiners at Monterey.	north winds
Jan 22 1943	High surf reported but no wave damage.	southwest winds
Dec 8-9 1943	Very strong northeast winds wrecked 40 fishing boats, piers and pilings in Monterey harbor.	northeast wind
Feb 1-2 1945	Southerly winds and heavy seas. No damage reported.	southerly winds
Mar 4 1946	North winds up to 40 knots. Two large purse seiners washed ashore.	north winds
Jan 28 1947	Northerly gale force winds; 43-foot fishing boat capsized and beached; 80-foot section of dike holding dredge spoil washed out in Monterey.	northerly gale
Apr 4 1947	Strong northerly winds with high surf in bay.	northerly winds
Feb 23 1948	Northwest winds up to 50 mph. Some boats beached in Monterey. Damage light.	northwest winds
Jan 2-3 1949	High winds and seas. Several boats adrift and one lost in Monterey.	.....
Oct 27-29 1950	Northerly gale winds accompanied by gigantic waves pounded Monterey Peninsula. Considerable shoreline erosion. Most damage caused by huge waves which swept up across Aptos Beach Drive at Rio Del Mar Beach. 15 foot combers carried fence posts smashing against residences. Beach club severely battered by waves at Rio Del Mar Beach with sea water and sand flooding many of the 33 homes along the beach. At Seacliff State Beach, 2 large pontoons were torn from their moorings. Homes along beach between Seacliff State Beach and New Brighton State Beach were not damaged as sea wall provided protection. At Santa Cruz waves were 10 to 15 feet high.	northerly gale
Dec 2 1951	Southerly winds up to 40 mph. High surf but no damage.	southerly winds
Feb 231953	Northeast gale winds up to 60 mph drove 7 large fishing boats ashore in Monterey.	northeast winds
Nov 13 1953	Southerly winds. Pleasure Pier at Santa Cruz damaged. Waves overtopped sea wall at Capitola. Beaches eroded. 14-foot waves.	southerly winds
Oct 7 1954	Foreshore of beaches from Santa Cruz to Rio Del Mar lowered. 3 to 5 foot scarp.	heavy ground swells from southwest

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Feb 9-10 1960	Southerly winds up to 45 mph with gigantic waves. Rio Del Mar, Capitola and Seacliff State Beach took brunt of waves. At Capitola waves smashed beach restaurants and amusement concessions. At Rio Del Mar, 25 luxury homes along Beach Road were damaged by gigantic waves. At Seacliff State Beach, camping sites were destroyed, restrooms nearly destroyed. At times during the storm, the concrete ship disappeared completely. One wave took out the end of the concession buildings on wharf. Large areas of hardtop parking areas washed away.	southerly and westerly winds
Winter 1969	Storm waves attacked the Pajaro Dunes area. Erosion of the dunes occurred in certain areas and about 12 lots experienced severe erosion with stairs being undercut. Some automobile bodies were brought in for protection and placed at the toe of the scarp cut by the waves.	.....
Feb 11-15 1976	High waves washed completely over new sea wall at Seacliff State Beach, carrying debris back to cliff. Portions of sea wall undercut and caved in.	southerly gale
Jan 8-9 1978	Sea wall at Seacliff State Beach overtopped and logs and debris scattered across parking and camping area. Extensive damage to sea wall.	storm from southwest
Feb 1980	$1.1 million in damage at Seacliff State Beach. Storm destroyed entire lower beach portion of park, taking roads, parking for 324 cars, and a 2,672 foot sea wall.	southwest
Jan 28-30 1983	$740,000 in damage at Seacliff State Beach. 2,800 feet of new sea wall damaged. 700 feet totally destroyed; 11 RV sites destroyed; restroom heavily damaged; logs and debris washed back to cliff.	waves from southwest
Feb 3-7 1998	Extensive cliff erosion, beach scour, and economic losses.	waves from south and west
Jan 2016	Storm waves damage Capitola and Santa Cruz wharves. Erosion of coastal bluff in Pacifica undermines and threatens numerous structures.	waves from west

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APPENDIX C

SCALE OF ACCEPTABLE RISKS FROM GEOLOGIC HAZARDS

SCALE OF ACCEPTABLE RISKS FROM SEISMIC GEOLOGIC HAZARDS		
Risk Level	Structure Types	Extra Project Cost Probably Required to Reduce Risk to an Acceptable Level
Extremely low[1]	Structures whose continued functioning is critical, or whose failure might be catastrophic: nuclear reactors, large dams, power intake systems, plants manufacturing or storing explosives or toxic materials.	No set percentage (whatever is required for maximum attainable safety).
Slightly higher than under "Extremely low" level.[1]	Structures whose use is critically needed after a disaster: important utility centers; hospitals; fire, police and emergency communication facilities; fire station; and critical transportation elements such as bridges and overpasses; also dams.	5 to 25 percent of project cost.[2]
Lowest possible risk to occupants of the structure.[3]	Structures of high occupancy, or whose use after a disaster would be particularly convenient: schools, churches, theaters, large hotels, and other high rise buildings housing large numbers of people, other places normally attracting large concentrations of people, civic buildings such as fire stations, secondary utility structures, extremely large commercial enterprises, most roads, alternative or non-critical bridges and overpasses.	5 to 15 percent of project cost.[4]
An "ordinary" level of risk to occupants of the structure.[3,5]	The vast majority of structures: most commercial and industrial buildings, small hotels and apartment buildings, and single-family residences.	1 to 2 percent of project cost, in most cases (2 to 10 percent of project cost in a minority of cases).[4]

1 Failure of a single structure may affect substantial populations.

2 These additional percentages are based on the assumptions that the base cost is the total cost of the building or other facility when ready for occupancy. In addition, it is assumed that the structure would have been designed and built in accordance with current California practice. Moreover, the estimated additional cost presumes that structures in this acceptable risk category are to embody sufficient safety to remain functional following an earthquake.

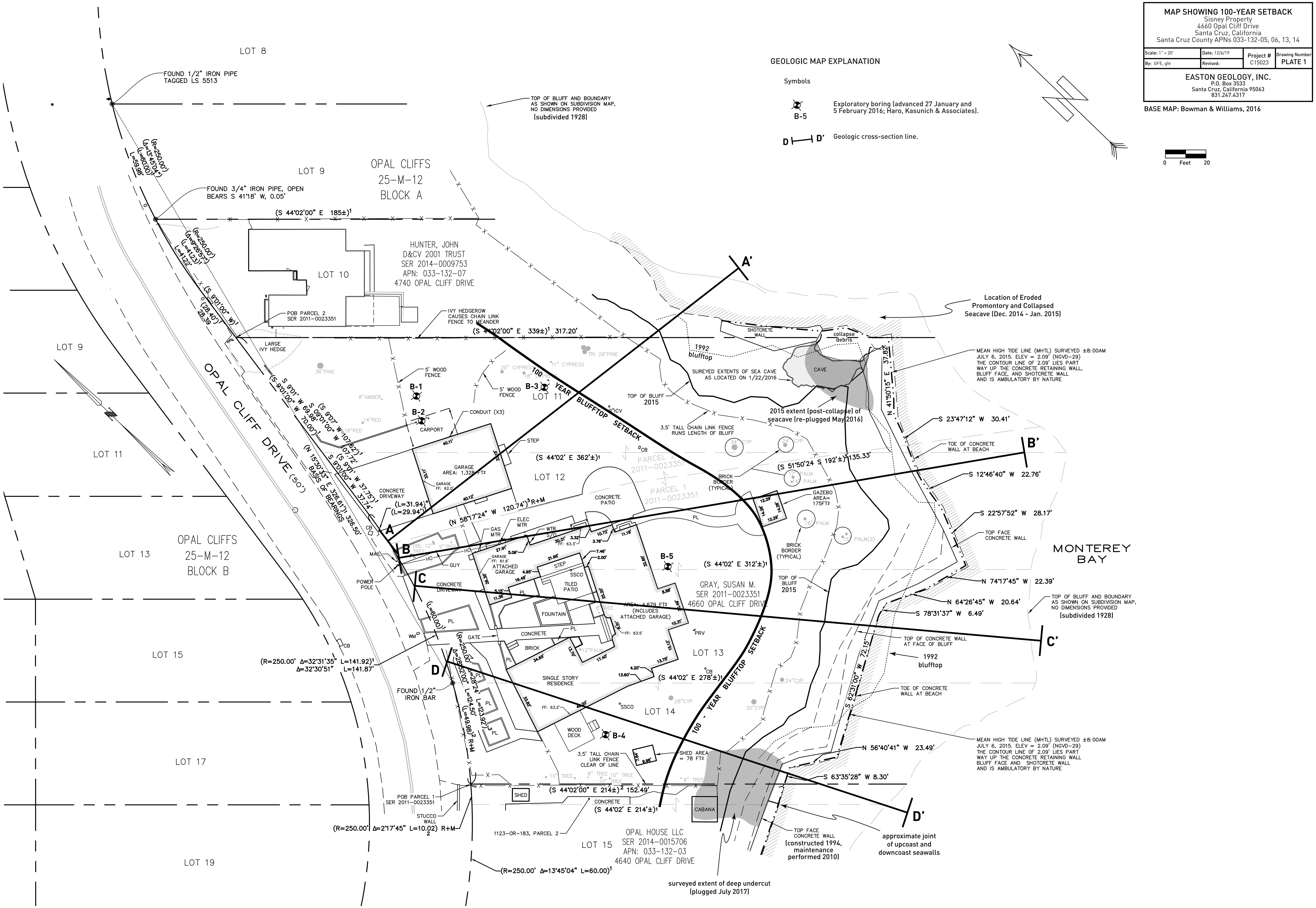
3 Failure of a single structure would affect primarily only the occupants.

4 These additional percentages are based on the assumption that the base cost is the total cost of the building or facility when ready for occupancy. In addition, it is assumed that the structures would have been designed and built in accordance with current California practice. Moreover, the estimated additional cost presumes that structures in this acceptable-risk category are to be sufficiently safe to give reasonable assurance of preventing injury or loss of life during and following an earthquake, but otherwise not necessarily to remain functional.

5 "Ordinary risk": Resist minor earthquakes without damage: resist moderate earthquakes without structural damage, but with some non-structural damage; resist major earthquakes of the intensity or severity of the strongest experienced in California, without collapse, but with some structural damage as well as non-structural damage. In most structures it is expected that structural damage, even in a major earthquake, could be limited to repairable damage. (Structural Engineers Association of California)

Source: *Meeting the Earthquake,* Joint Committee on Seismic Safety of the California Legislature, Jan. 1974, p.9.

SCALE OF ACCEPTABLE RISKS FROM NON-SEISMIC GEOLOGIC HAZARDS[6]		
Risk Level	Structure Type	Risk Characteristics
Extremely low risk	Structures whose continued functioning is critical, or whose failure might be catastrophic: nuclear reactors, large dams, power intake systems, plants manufacturing or storing explosives or toxic materials.	1. Failure affects substantial populations, risk nearly equals nearly zero.
Very low risk	Structures whose use is critically needed after a disaster: important utility centers; hospitals; fire, police and emergency communication facilities; fire station; and critical transportation elements such as bridges and overpasses; also dams.	1. Failure affects substantial populations. Risk slightly higher than 1 above.
Low risk	Structures of high occupancy, or whose use after a disaster would be particularly convenient: schools, churches, theaters, large hotels, and other high rise buildings housing large numbers of people, other places normally attracting large concentrations of people, civic buildings such as fire stations, secondary utility structures, extremely large commercial enterprises, most roads, alternative or non-critical bridges and overpasses.	1. Failure of a single structure would affect primarily only the occupants.
"Ordinary" risk	The vast majority of structures: most commercial and industrial buildings, small hotels and apartment buildings, and single-family residences.	1. Failure only affects owners /occupants of a structure rather than a substantial population. 2. No significant potential for loss of life or serious physical injury. 3. Risk level is similar or comparable to other ordinary risks (including seismic risks) to citizens of coastal California. 4. No collapse of structures; structural damage limited to repairable damage in most cases. This degree of damage is unlikely as a result of storms with a repeat time of 50 years or less.
Moderate risk	Fences, driveways, non-habitable structures, detached retaining walls, sanitary landfills, recreation areas and open space.	1. Structure is not occupied or occupied infrequently. 2. Low probability of physical injury. 3. Moderate probability of collapse.
6 Non-seismic geologic hazards include flooding, landslides, erosion, wave runup and sinkhole collapse		


MAP SHOWING 100-YEAR SETBACK
Sisney Property
4660 Opal Cliff Drive
Santa Cruz, California
Santa Cruz County APNs 033-132-05, 06, 13, 14
Scale: 1" = 20'
Date: 12/6/19
Project # C15023
Drawing Number PLATE 1
By: GFE, gfe
Revised:
EASTON GEOLOGY, INC.
P.O. Box 3533
Santa Cruz, California 95063
831.247.4317
BASE MAP: Bowman & Williams, 2016
0 Feet 20
GEOLOGIC MAP EXPLANATION
Symbols
B-5
Exploratory boring (advanced 27 January and 5 February 2016; Haro, Kasunich & Associates).
D D'
Geologic cross-section line.
LOT 8
LOT 9
LOT 10
LOT 11
LOT 12
LOT 13
LOT 14
LOT 15
LOT 17
LOT 19
OPAL CLIFFS 25-M-12 BLOCK A
OPAL CLIFFS 25-M-12 BLOCK B
OPAL CLIFF DRIVE (50')
FOUND 1/2" IRON PIPE TAGGED LS 5513
FOUND 3/4" IRON PIPE, OPEN BEARS S 41°18' W, 0.05'
TOP OF BLUFF AND BOUNDARY AS SHOWN ON SUBDIVISION MAP, NO DIMENSIONS PROVIDED (subdivided 1928)
HUNTER, JOHN D&CV 2001 TRUST SER 2014-0009753 APN: 033-132-07 4740 OPAL CLIFF DRIVE
POB PARCEL 2 SER 2011-0023351
LARGE IVY HEDGE
IVY HEDGEROW CAUSES CHAIN LINK FENCE TO MEANDER
(S 44°02'00" E 185±)
(S 44°02'00" E 339±) 317.20'
100 - YEAR BLUFFTOP SETBACK
1992 blufftop
SURVEYED EXTENTS OF SEA CAVE AS LOCATED ON 1/22/2016
TOP OF BLUFF 2015
3.5' TALL CHAIN LINK FENCE RUNS LENGTH OF BLUFF
2015 extent (post-collapse) of seacave (re-plugged May 2016)
Location of Eroded Promontory and Collapsed Seacave (Dec. 2014 - Jan. 2015)
SHOTCRETE WALL
collapse debris
CAVE
MEAN HIGH TIDE LINE (MHTL) SURVEYED ±8:00AM JULY 6, 2015. ELEV = 2.09' (NGVD-29) THE CONTOUR LINE OF 2.09' LIES PART WAY UP THE CONCRETE RETAINING WALL, BLUFF FACE, AND SHOTCRETE WALL AND IS AMBULATORY BY NATURE
S 23°47'12" W 30.41'
TOE OF CONCRETE WALL AT BEACH
S 12°46'40" W 22.76'
S 22°57'52" W 28.17'
TOP FACE CONCRETE WALL
MONTEREY BAY
N 74°17'45" W 22.39'
N 64°26'45" W 20.64'
S 78°31'37" W 6.49'
TOP OF CONCRETE WALL AT FACE OF BLUFF
1992 blufftop
TOE OF CONCRETE WALL AT BEACH
N 56°40'41" W 23.49'
S 63°35'28" W 8.30'
TOP FACE CONCRETE WALL (constructed 1994, maintenance performed 2010)
approximate joint of upcoast and downcoast seawalls
surveyed extent of deep undercut (plugged July 2017)
A
A'
B
B'
C
C'
D
D'
B-1
B-2
B-3
B-4
B-5
5' WOOD FENCE
CONDUIT (X3)
CARPORT
STEP
GARAGE AREA: 1,328 FT2
(S 44°02' E 362'±)
PARCEL 2 2011-0023351
PARCEL 1 2011-0023351
CONCRETE PATIO
(S 51°50'24 S 192'±) 135.33'
BRICK BORDER (TYPICAL)
GAZEBO AREA= 175FT2
(N 58°17'24" W 120.74') R+M
CONCRETE DRIVEWAY
ATTACHED GARAGE
TILED PATIO
FOUNTAIN
GAS MTR
ELEC MTR
(S 44°02' E 312')
GRAY, SUSAN M. SER 2011-0023351 4660 OPAL CLIFF DRIVE
AREA: 4,679 FT2 (INCLUDES ATTACHED GARAGE)
(S 15°30'53" E 326.61') 326.50' BASIS OF BEARINGS
MAIL
POWER POLE
GUY
GATE
CONCRETE
BRICK
SINGLE STORY RESIDENCE
(S 44°02' E 278'±)
WOOD DECK
3.5' TALL CHAIN LINK FENCE CLEAR OF LINE
SHED AREA = 78 FT2
(R=250.00' Δ=32°31'35" L=141.92)
Δ=32°30'51" L=141.87'
FOUND 1/2" IRON BAR
(S 44°02'00" E 214±) 152.49'
(S 44°02' E 214'±)
SHED
CABANA
POB PARCEL 1 SER 2011-0023351
STUCCO WALL
(R=250.00' Δ=2°17'45" L=10.02) R+M
1123-OR-183, PARCEL 2
OPAL HOUSE LLC SER 2014-0015706 APN: 033-132-03 4640 OPAL CLIFF DRIVE
(R=250.00' Δ=13°45'04" L=60.00)

GEOLOGIC CROSS SECTION EXPLANATION

Symbols

Geologic contact - dashed where approximate, queried where uncertain.

B-5 Exploratory boring (advanced 27 January and 5 February 2016; Haro, Kasunich & Associates).

Earth Materials

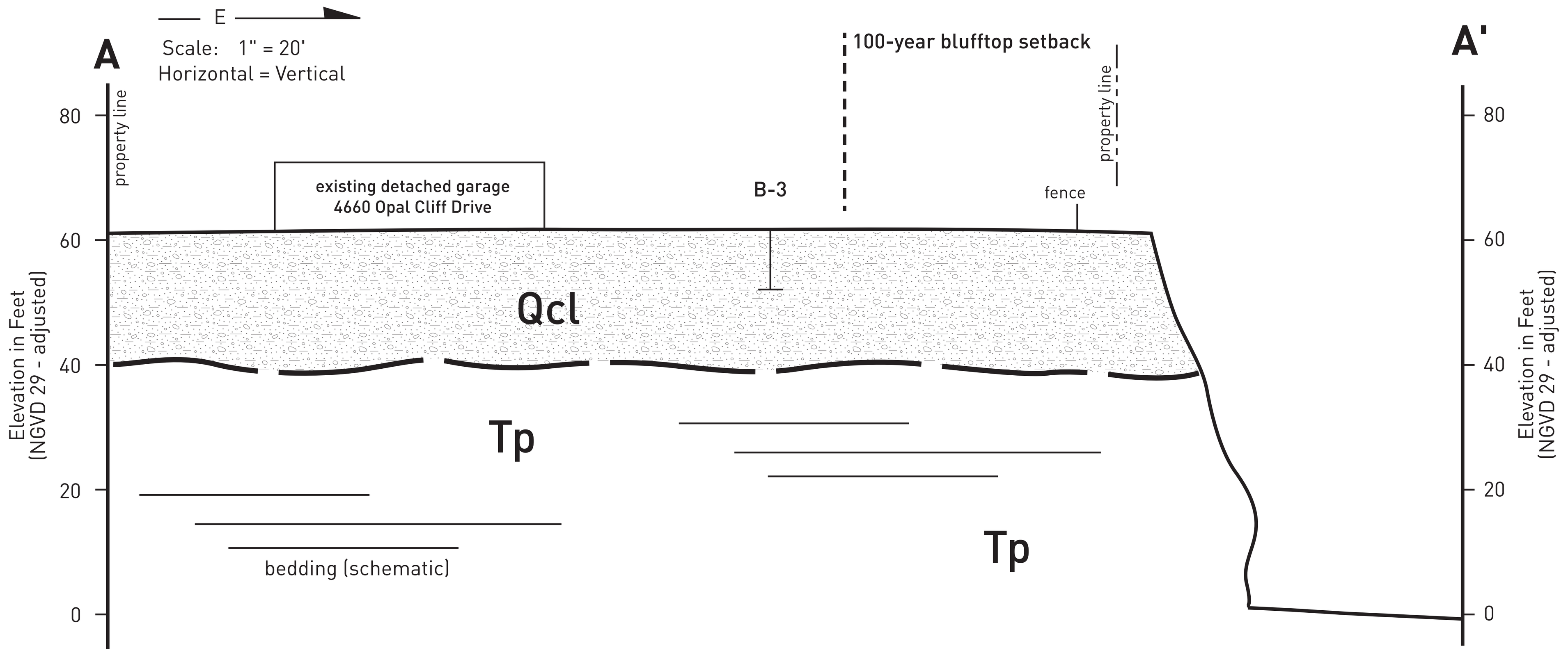
Qbs	Beach sand
Qcl	Marine terrace deposits
Tp	Purisima Formation bedrock

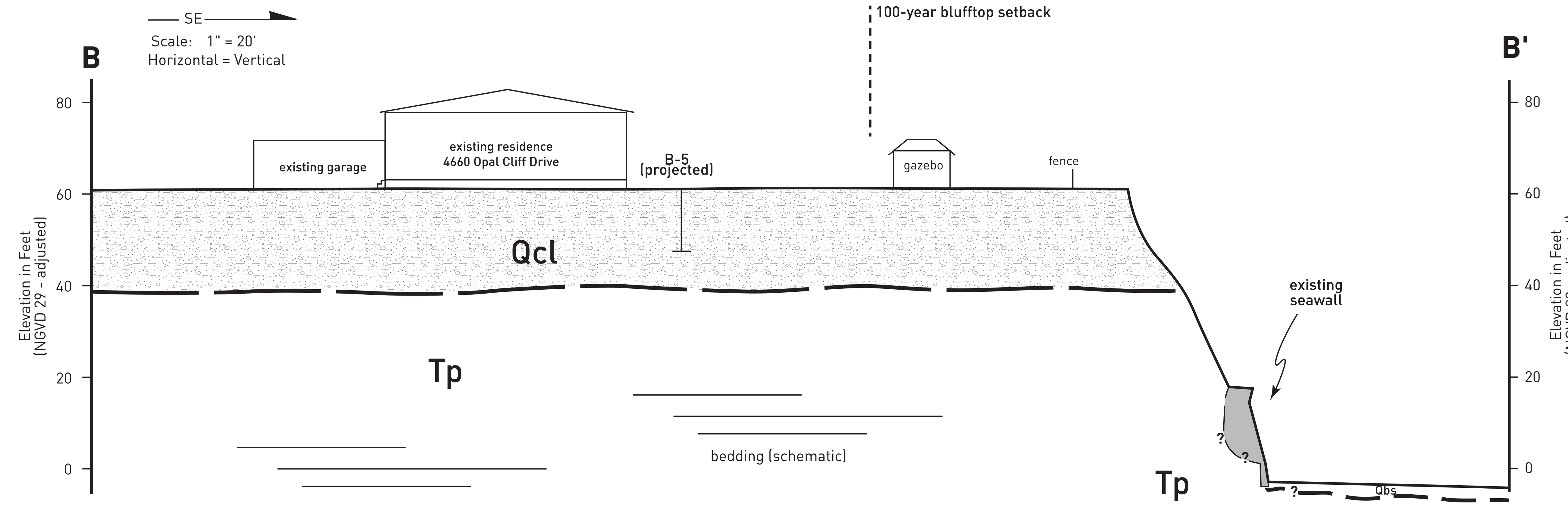
GEOLOGIC CROSS SECTIONS
Sisney Property
4460 Opal Cliff Drive
Santa Cruz, California
Santa Cruz County APNs 033-132-05, 06, 13, 14

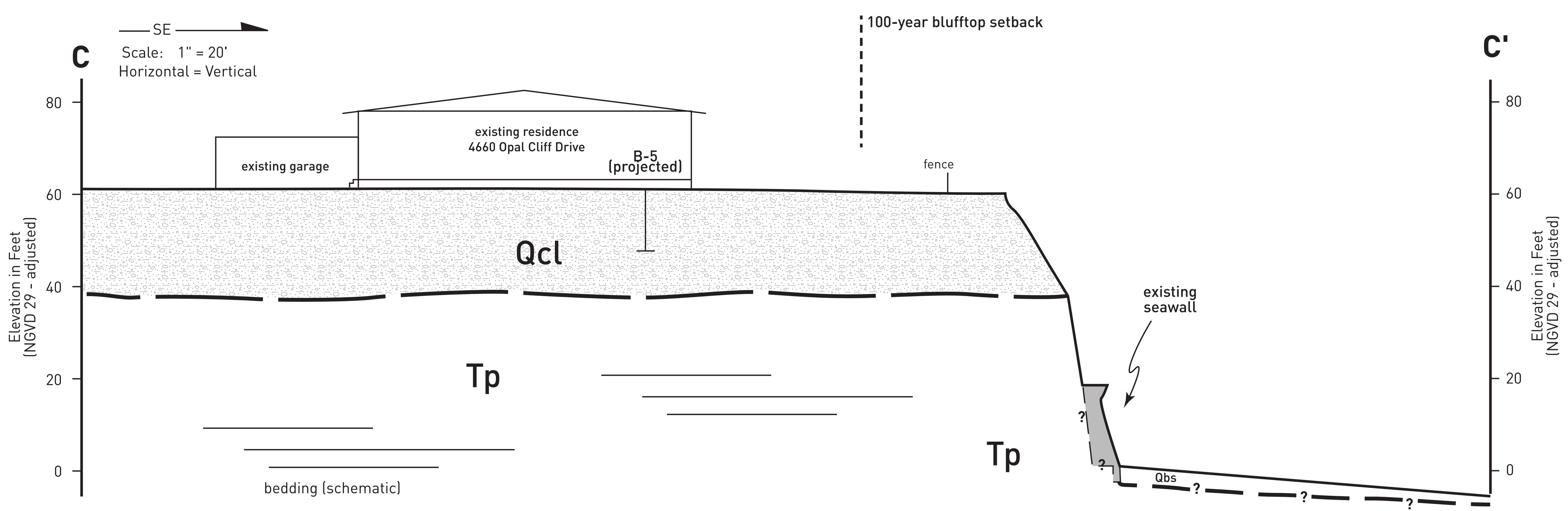
Scale: 1" = 20' H=V	Date: 12/6/19	Project # C15023	Drawing Number PLATE 2
By: GFE, gfe	Revised:		

EASTON GEOLOGY, INC.
P.O. Box 3533
Santa Cruz, California 95063
831.247.4317

0 Feet 20







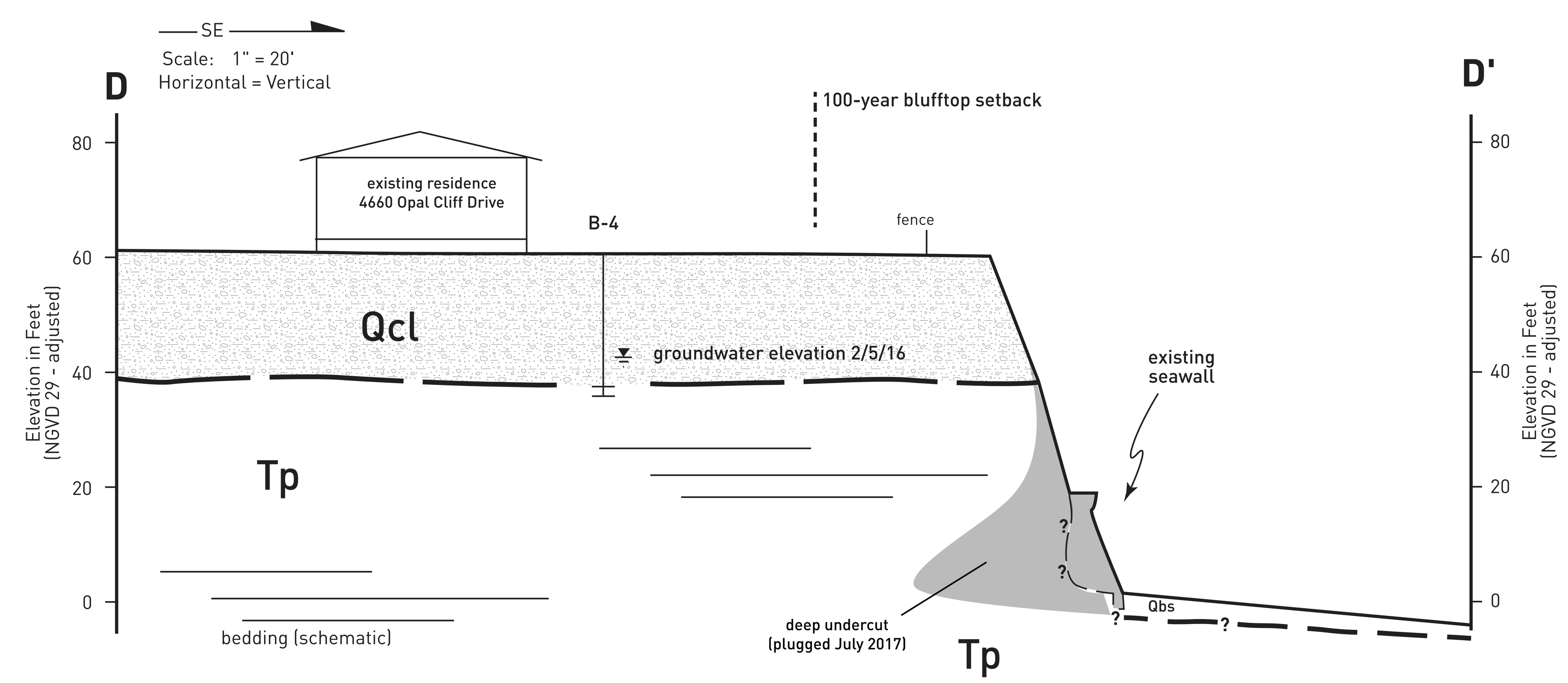


Exhibit 5
A-3-SCO-20-0027

CALIFORNIA COASTAL COMMISSION
455 MARKET STREET, SUITE 228
SAN FRANCISCO, CA 94105-2219
VOICE (415) 904-5200
FAX (415) 904-5400

April 27, 2023

BLUFF SETBACK REVIEW MEMORANDUM

To: Nolan Clark, Coastal Program Analyst

From: Joseph Street, Ph.D. P.G., Commission Staff Geologist Joseph Street

Re: Bluff Setback Analysis for CDP A-3-SCO-20-0027 (Sisney SFD), 4660 Opal Cliff Dr., Santa Cruz County

Introduction

The proposed project involves the demolition of an existing house and construction of a new, 6,700 square foot residence and related development at 4660 Opal Cliff Dr., in the Live Oak beach area of unincorporated Santa Cruz County. Project plans indicate that the new residence would be set back a minimum of 45 feet from the edge of the approximately 60-foot-high coastal bluff, while a proposed lap pool would be set back about 34 feet from the bluff edge. A plan view of the site is shown in **Figure 1**.

The purpose of this memo is to evaluate the total bluff top setback that would be needed to minimize geologic and coastal hazards to the proposed development, and to assure stability and structural integrity over a 100-year project life, without reliance on existing or future shoreline or bluff armoring devices, consistent with the County of Santa Cruz's certified Local Coastal Program (LCP). As discussed in greater detail in the staff report, the LCP requires that new bluff top development include a setback "sufficient to provide a stable building site over the 100-year lifetime of the structure" (Land Use Plan (LUP) Policy 6.2.12), and, at sites where geologic or coastal hazards are present, that "[m]itigation of the potential hazard is not dependent on shoreline or coastal bluff protection structures …" (LUP Policy 6.2.15). To this end, I have reviewed the following reports, submitted by the Applicant, addressing geologic and coastal hazards conditions on the subject property:

1) Easton Geology, 2015, "Assessment of 100-year Coastal Blufftop, 4660 Opal Cliff Drive, Santa Cruz, California, Santa Cruz County APN 033-132-04, 05, 06", signed by G. Easton (CEG), July 30, 2015.

2) Easton Geology, 2019, "Geologic Investigation, Sisney Property, 4660 Opal Cliff Drive, Santa Cruz, California, Santa Cruz County APN 033-132-0, 05, 13, 14", signed by G. Easton (CEG), December 6, 2019.

I have also reviewed project plans (Franks & Brenkwitz, L.I.P., "Proposed Site Plan", June 27, 2018) and consulted several other sources (listed below) which provide additional geological and coastal hazards information. I have also visited the project area and observed the coastal bluffs along Opal Cliffs Drive on many previous occasions.

Geologic Site Conditions

As described in Ref. (2), the coastal bluff at the site forms a steep seacliff composed primarily of sedimentary rock – siltstone and sandstone -- of the Pliocene-aged Purisima Formation. The Purisima bedrock is weathered and friable, and only moderately resistant to marine erosion. Above an elevation of approximately 40 feet (NGVD29), the bedrock is overlain by much younger, Quaternary-aged marine terrace deposits consisting of poorly consolidated clay, silt, sand, gravel and cobbles. The subject property occupies a broad, fault-controlled headland of comparatively resistant bedrock, with less resistant rock units exposed at the base of the bluff both up- and downcoast. Nonetheless, the Purisima bedrock at the site has been subject to substantial marine erosion, as evidenced by previous observations of bluff retreat (see below) and the presence of several large sea caves ("undercuts") that have formed along several small faults within the headland (**Fig. 2**). As a direct consequence of concerns related to bluff erosion, most of the bluff at the site has been armored with a 290-foot-long bluff toe seawall, three sea cave plugs and an upper bluff shotcrete retaining wall (**Fig. 1**). A smaller segment of the bluff toe along the northeastern (downcoast) face of the headland remains unarmored.

Bluff Erosion & Retreat

Recent history demonstrates that the coastal bluffs along Opal Cliff Drive are susceptible to significant erosion and retreat when subject to direct wave attack, particularly during strong winter storms. Beaches seaward of the bluff are generally narrow or absent, providing little buffer against storm waves. The frequency with which the bluff is impacted by storm waves in the future will, along with the force of the waves, determine how quickly the bluff retreats over the project life. In basic terms, bluff erosion at the site proceeds episodically, with marine erosion at the bluff toe resulting first in undercutting, then failure of the bedrock portion of the lower bluff face, occurring as block failures along near-vertical joints or fractures in the bedrock. Failures within the lower bluff bedrock will eventually undermine and cause secondary failures within the upper bluff terrace deposits, which, due to their lower strength, cannot maintain steep slopes and will "lay back" via erosion and sloughing until they reach a more stable angle. Though marine erosion (wave attack) is the primary cause of bluff erosion at the site, other factors, such as high groundwater and soil saturation (e.g., during rain events), uncontrolled runoff and earthquakes can also contribute to bluff retreat.

Historical annualized bluff retreat rates along the Opal Cliffs shoreline have been estimated in several previous studies based on analysis of historical aerial photographs, topographic maps, and site surveys. Ref. (1) examined four bluff profiles on different portions of the site and estimated long-term bluff retreat rates ranging from 0.2 – 1.2 feet per year. Ref. (2), based on a comparison of the mapped bluff edge position in 1928 and 1992 site surveys, reported long-term retreat rates of 1.1 ft./yr. along the southeast facing (upcoast) portion of the bluff, and 0.3 ft./yr. along the more sheltered, unarmored northeast facing (downcoast) portion of the bluff. These retreat rate estimates avoided the period after 1999, when the bluff toe seawall was installed, and thus represent bluff erosion under unarmored conditions. The historical bluff retreat rates in Refs. (1) and (2) are comparable to those reported by Moore & Griggs (2002) (average of 0.92 ft/yr., 1953-1994) and by the

U.S. Geological Survey (Hapke and Reid, 2007; Barnard et al. 2018) (0.37 – 0.94 ft/yr., ~1930 – 2010) for the northeastern part of the Opal Cliffs bluffs, spanning the project site.[1]

Applicant's Bluff Retreat Analysis

Ref. (2) provided an analysis of the potential for bluff retreat over the next 100 years assuming that the existing shoreline armoring (seawall, cave fills, etc.) was in place and would remain functional into the future, precluding any further erosion of the bluff toe on the protected portion of the bluff. The analysis made a reasonable allowance for erosion of the bedrock face above the seawall due to bluff weathering and/or earthquake-induced failures; it was assumed that the bluff above the seawall would erode 5 feet horizontally, and that the upper bluff terrace deposits would further lay back to a 1.5:1 (~34°) slope. All told, the Applicant's analysis yielded 100-year setback distances of about 30 – 75 feet along the currently-armored portion of the bluff. Along the smaller, unarmored upcoast segment of the bluff, Ref. (2) began with the observed historical average bluff retreat rate of 0.3 ft./yr., assumed a 25% increase in this rate to account for future sea level rise (i.e., to 0.375 ft./yr.), and added an additional 10-foot buffer (presumably to account for uncertainties) to arrive at a 100-year bluff retreat distance of 47.5 feet. However, the setback line shown on the project plans is as little as 30 feet from the bluff edge along this segment, and the northeastern edge of the proposed house would be about 45 feet from the bluff edge, less than the 47.5 ft setback recommended by Ref. (2). The Applicant's 100-year setback line is shown in **Fig. 1**.

However, as explained in the staff report, the LCP does not allow new development to rely on the protection afforded by the armoring devices in establishing appropriate setbacks, as has been assumed in Ref. (2). Rather, the LCP requires that the setback be sufficient to provide a stable building site for 100-years without relying on shoreline armoring. In other words, the setback for new development must be determined based on the erosion that would occur under natural, unarmored conditions. Moreover, any assessment of bluff retreat over the next 100 years (i.e., through the year 2123) must take into account the likelihood of sea level rise (SLR) during this time, which is expected to result in accelerated erosion and retreat of coastal bluffs when compared with the past.

Sea Level Rise

Both the rate and magnitude of future SLR are highly uncertain, depending on both future emissions and earth system processes (e.g., ice sheet dynamics) that are incompletely understood. In an effort to frame these uncertainties and provide guidance on addressing SLR for policy-makers in California, the *State of California Sea-Level Rise Guidance* (OPC 2018)[2] and its associated SLR science update (Griggs et al. 2017) provided a range of California-specific projections of future SLR, under several greenhouse gas emissions scenarios, within a quasi-probabilistic framework.[3] For example, under a high emissions

[1] Long-term, annualized average bluff retreat rate estimates such as these are useful for projecting future bluff retreat over long periods of time, but it is important to recall that coastal bluff erosion at the site is dominated by discrete episodes of erosion – i.e., large bluff erosion events – typically occurring during severe winter storms. As discussed in Ref. (2), episodic erosion along the Opal Cliff bluffs has often occurred during large storms with waves approaching the coast from the west-southwest (e.g., during El Nino events).

[2] Available at https://www.opc.ca.gov/updating-californias-sea-level-rise-guidance/.

[3] Following the method of Kopp et al. (2014), the probabilistic projections provided in the *Rising Seas* and State Guidance reports reflect the probability that a given amount of SLR was predicted by the ensemble of climate models used to estimate future SLR (from processes such as thermal expansion, glacier and ice sheet mass balance, oceanographic conditions, etc.).

pathway, the report estimates that, by 2100, SLR on the Central Coast (represented by the Monterey tide gauge) could exceed 2.3 feet under a 50% probability scenario (median model result), 3.3 feet under a ~20% probability scenario, 4.3 feet under a 5% probability scenario (95th percentile model result), and 6.9 feet under a 0.5% probability result (>99th percentile result) (further SLR is expected through 2120 and beyond).[4] Both the State Guidance and the Commission's *Sea-Level Rise Policy Guidance* (2018 update) recommend specific sea level rise projections for use in different types of planning and policy decisions, depending on factors such as adaptive capacity and risk tolerance. For "medium-high risk aversion" decisions like the siting of residential development, for which the consequences of being wrong (i.e., loss of life and property) are greater and the range of adaptation options is limited, both documents recommend that hazards associated with the 1-in-200 chance (0.5% probability) projections be addressed through some combination of siting, design, and future adaptive measures.

Rising sea level is expected to cause significant changes to the California coast, including the narrowing or loss of beaches where they are backed by less-erosive bluffs or artificial barriers to inland migration, such as shoreline armoring (Vitousek et al. 2017). Along Opal Cliffs, where the fronting beaches are already narrow or absent, sea level rise (SLR) will lead to increased wave attack at the base of the bluff and, very likely, increased rates of bluff erosion. SLR shrinks the distance between the wave breaking point and bluff positions ("coastal squeeze"), results in deeper water and reduced wave attenuation, and can be expected to increase the frequency, force and effectiveness of wave attack on coastal bluffs (e.g., Limber et al. 2018). Other effects of climate change, such as possible changes in storm tracks, wave climate and the frequency of large El Niño events (e.g., NRC 2012; Wang et al. 2017), will also influence rates of bluff retreat. Nonetheless, the degree to which bluff retreat will respond to sea level rise remains highly uncertain and will necessarily be mediated by site-specific factors.

Future Bluff Retreat with Sea Level Rise

As discussed above, the Applicant's 100-year bluff retreat analysis (Ref. 2) considered only a scenario with existing shoreline armoring in place, and, for unprotected portions of the bluff, assumed a modest (25%) increase in the rate of bluff retreat as a result of sea level rise. Here, I independently evaluate the potential for bluff retreat over the next 100-years in the absence of armoring, and using two different methods, supported by current science, for projecting bluff retreat under several SLR scenarios. Specifically, my analysis focuses on the higher end scenarios from OPC (2018), including SLR of approximately 4 feet (~20% probability), 5 feet (~5% probability), and 8.5 feet (~0.5% probability, i.e., the "medium-high risk aversion scenario recommended for residential development in the OPC and Commission SLR guidances) in 2120. Unsurprisingly, the resulting bluff retreat projections – and thus the recommended 100-year setbacks – greatly exceed those in the Applicant's analysis.

Method 1: USGS CoSMoS Cliff Retreat Model

The first analysis approach I used was to consult data from the USGS Coastal Storm Modeling System (CoSMoS) 3.1 (Barnard et al. 2018; Limber et al. 2018), which includes

---

[4] The State is currently preparing an updated SLR Guidance for 2023, which will likely rely on new regional SLR projections from NOAA (Sweet et al. 2022). Although the NOAA analysis framework differs from that of OPC (2018), the overall range in SLR projections is similar.

projections of coastal bluff retreat along individual cross-shore transects for multiple sea level rise scenarios.[5] CoSMoS median projections[6] for the transect (No. 7309) nearest the subject site, crossing the upcoast lot (Lot 14), are given in **Table 1.1** (below). The historical bluff retreat rate used in this projection (from USGS studies), 0.94 ft./yr., was similar to those reported in Refs. (1) and (2) for this portion of the bluff.

Table 1.1: CoSMoS Bluff Retreat Projections, Subject Site (Transect 7309)

Historical Bluff Retreat Rate = 0.94 ft./yr.

Sea Level Rise Amount	**Corresponding SLR Scenario** (OPC 2018)	**Projected bluff retreat distance** (ft)
3.3 feet	~20% probability in 2100 ("low risk aversion")	139
4.1 feet	5% probability in 2100 **~20% prob. in 2120 ("low risk aversion")**	156
4.9 feet	~3% probability in 2100 **~5% probability in 2120**	181
6.6 feet	~1% probability in 2100 ("med-high risk aversion") ~3% probability in 2120	243
8.2 feet	**~0.5% probability in 2120**	323

Under all the SLR scenarios evaluated, CoSMoS projects 100-year bluff retreat amounts (156 – 323 feet) much greater than those provided in the Applicant's analysis for the upcoast segment of the bluff (30 – 75 feet of retreat), which, as noted previously, included the effects of the existing armoring. The bluff retreat projection for 4.1 ft of SLR in 2120 (156 feet) is shown as a light blue dashed line in **Fig. 1**.

An alternate approach, also relying on the CoSMoS model but substituting in the site-specific historical erosion rates provided by Refs. (1) and (2), is to calculate the factor of increase (or "multiplier") in the projected bluff retreat rate for a given amount of SLR, above the historical baseline, and then apply this factor of increase to the observed, site-specific historical bluff erosion rates in order to project future bluff retreat over the next 100 years. For this analysis, I first determined the factors of increase in the projected bluff retreat rate, for several future SLR scenarios, for each of the eight CoSMoS transects (nos. 7307 – 7314) along the Opal Cliff Dr. bluffs between 41st and 49th Avenues. I then averaged the factors of increase for each transect under each SLR scenario, applied the average "multiplier" to the historical erosion rate for the upcoast

[5] The CoSMoS cliff retreat projections integrate the output of eight numerical and statistical models which relate wave climate (wave height, period, frequency, impact intensity) to the erosion of bluff materials. Cliff retreat is modeled along hundreds of transects (~100 m spacing), based on the historical erosion rate, shore platform and cliff profile, and wave power derived from the broader CoSMoS model (Barnard et al. 2014). Model behavior also includes wave run-up, wave set-up that raises the water level during large wave events, and tidal levels. Historical retreat rate estimates for each cross-shore transect are based on the previous analysis of Hapke and Reid (2007), with cliff edge positions and retreat rate estimates updated to 2010. The CoSMoS cliff retreat projections, viewable in Google Earth, are publicly available at https://www.sciencebase.gov/catalog/item/57f4234de4b0bc0bec033f90.

[6] CoSMoS also estimates the uncertainty associated with each projection, typically ± 25 – 30%.

(1.15 ft./yr., average of 1.1 ft/yr and 1.2 ft/yr values provided by Refs. 1-2) and downcoast (0.3 ft./yr.) segments of the bluff at the subject site, and calculated bluff retreat distances over the next 100 years. The results of this analysis are given in **Tables 1.2** and **1.3**:

Table 1.2: CoSMoS Bluff Retreat Projections, "Multiplier" Method – Upcoast Segment

**Average of 8 local CoSMoS Transects (#7307 – 7314); Historical Bluff Retreat Rate = 1.15 ft./yr.*

Sea Level Rise Scenario (OPC 2018)	**Projected Factor of Increase in Bluff Retreat Rate** (above historical)	**Projected Average Bluff Retreat Rate**, 2016 – 2120 (ft/yr)	**Projected 100-year bluff retreat distance** (ft)
4.1 feet in 2120 "low risk aversion" ~20% probability	1.5	1.70	170
4.9 feet in 2120 ~5% probability	1.75	2.03	203
8.2 feet in 2120 "med-high risk aversion" ~0.5% probability	2.9	3.38	338

Table 1.3: CoSMoS Bluff Retreat Projections, "Multiplier" Method – Downcoast Segment

**Average of 8 local CoSMoS Transects (#7307 – 7314); Historical Bluff Retreat Rate = 0.3 ft./yr.*

Sea Level Rise Scenario (OPC 2018)	**Projected Factor of Increase in Bluff Retreat Rate** (above historical)	**Projected Average Bluff Retreat Rate**, 2016 – 2120 (ft/yr)	**Projected 100-year bluff retreat distance** (ft)
4.1 feet in 2120 "low risk aversion" ~20% probability	1.5	0.44	44
4.9 feet in 2120 ~5% probability	1.75	0.53	53
8.2 feet in 2120 "med-high risk aversion" ~0.5% probability	2.9	0.88	88

Again, the analysis results in much greater 100-year bluff retreat projections (170 – 338 feet) for the upcoast portion of the site than in the Applicant's analysis. On the unarmored, downcoast segment of the bluff, the range in projected bluff retreat (44 – 88 feet) is more similar to the analyzed setback of 47.5 feet in Ref. (2), but only for the lower SLR scenario (4.1 ft. in 2120). The bluff retreat projection using this approach for 4.1 ft of SLR in 2120 (156 feet) is shown as a dotted blue line in **Fig. 1**.

Method 2: Simplified SCAPE Model

The second approach I employed was a simple equation ("SCAPE Equation"), derived from previous modeling studies[7], which projects a future bluff retreat rate (R_2) as a function of the historical bluff retreat rate (R_1), historical sea level rise rate (S_1), and projected future sea level rise rate (S_2):

$$R_2 = R_1\ (S_2 / S_1)^{0.5} \qquad \text{(SCAPE Equation)}^{8}$$

This equation is necessarily a simplified representation of the complex processes governing the erosion response of a coastal bluff to changing sea level, but has been shown to reproduce the projections of the full process-based model from which it is derived in simulations of "soft rock" bluffs, where beaches are narrow or absent, under equilibrium conditions (Ashton et al. 2011). **Table 2.1** and **2.2**, below, provide estimates of future bluff retreat at the site calculated using the SCAPE equation, using sea level rise scenarios and future sea level rise rates provided by OPC (2018). Because OPC (2018) does not provide SLR rate projections beyond 2100, I have extended the analysis to 2120 by assuming that the rate of SLR in 2100 remains constant (no further acceleration) for the next 20 years. This simplifying assumption results in <u>lower</u> bluff retreat projections than if SLR rates were allowed to continue to increase beyond 2100. As with the CoSMoS analysis, I have provided separate projections for the upcoast and downcoast bluff segments.

Table 2.1: Bluff Retreat Projections from SCAPE Equation – Upcoast Segment

**Historical Sea Level Rise Rate (S1) = 1.96 mm/yr. (San Francisco tide gauge)[9]*

**Historical Bluff Retreat Rate = 1.15 ft./yr. (Refs. 1, 2)*

Sea Level Rise Scenario (OPC 2018)	***S2*** **Future SLR rate** 2080-2100 (mm/yr) (OPC 2018)	***R2*** **Future bluff retreat rate** 2080-2100 (ft/yr)	**Average bluff retreat rate** 2023 – 2100 (ft /yr)	**Projected 77-year bluff retreat** (2100) (ft)	**Extrapolated 100-year bluff retreat** (2123) (ft)
4.1 feet in 2120 "low risk aversion" ~20% probability	16	3.29	2.22	171	222
5.2 feet in 2120 ~5% probability	22	3.85	2.50	193	250
8.5 feet in 2120 "med-high risk aversion" ~0.5% probability	37	5.0	3.07	237	307

Table 2.2: Bluff Retreat Projections from SCAPE Equation – Downcoast Segment

[7] This equation is a "best fit" equation derived from the Soft Cliff and Platform Erosion (SCAPE) model of Walkden and Hall (2005) and Walkden and Dickson (2008), a process-based numerical model developed to simulate cliff retreat in response to sea level changes.

[8] The exponent term (m) governs the sensitivity with which bluff retreat responds to sea level rise; $m = 0.5$ is the value of the best-fit equation, but it can be adjusted to fit local conditions if warranted (Ashton et al. (2011).

[9] The historical SLR rate from the San Francisco tide gauge is used here because the period of record is much longer than at the Monterey tide gauge. If the SLR rate from Monterey (1.62 mm/yr.) were used, the projected future bluff retreat rates (R2) would be greater.

**Historical Sea Level Rise Rate (S1) = 1.96 mm/yr. (San Francisco tide gauge)*
**Historical Bluff Retreat Rate = 0.3 ft./yr. (Refs. 1, 2)*

Sea Level Rise Scenario (OPC 2018)	***S2*** **Future SLR rate** 2080-2100 (mm/yr) (OPC 2018)	***R2*** **Future bluff retreat rate** 2080-2100 (ft/yr)	**Average bluff retreat rate** 2018 – 2100 (ft/yr)	**Projected 77-year bluff retreat** (2100) (ft)	**Extrapolated 100-year bluff retreat** (2123) (ft)
4.1 feet in 2120 "low risk aversion" ~20% probability	16	0.86	0.58	45	58
5.2 feet in 2120 ~5% probability	22	1.0	0.65	50	65
8.5 feet in 2120 "med-high risk aversion" ~0.5% probability	37	1.30	0.80	62	80

As with the CoSMoS-based analyses, the SCAPE equation projects much greater 100-year bluff retreat distances (222 – 307 ft) for the upcoast portion of the site than in the Applicant's analysis. On the unarmored, downcoast segment of the bluff, the range in projected bluff retreat (58 – 80 feet) also exceeds the analyzed setback of 47.5 feet in Ref. (2). The bluff retreat projection using SCAPE, for a SLR scenario of for 4.1 ft in 2120, is shown as a dark blue dashed line in **Fig. 1**.

The above projections follow from a set of reasonable but precautionary assumptions, including the higher-end SLR scenarios provided by OPC (2018) and a relatively sensitive bluff erosion response to rising sea level. Although both CoSMoS and the SCAPE equation have limitations, and all projections of responses to sea level rise have a very high level of uncertainty, the projections provide useful information on the amounts and rates of bluff retreat could occur in the future with rising sea level, in the absence of shoreline armoring. Both approaches yield similar results, including a lower end of 222 feet and higher end of 307 feet in the SCAPE model, compared to 170 and 338 feet in the CoSMoS model (and 88 feet and 80 feet for SCAPE and CoSMoS, respectively, for downcoast medium-high risk aversion scenario). All of these retreat projections are well above the Applicant's proposed setbacks that take into consideration the protection afforded by the existing armoring device.

Conclusion

In summary, the Applicant's bluff retreat analysis (Refs. 1, 2) relied on the continued presence of shoreline armoring structures at the site to arrive at a 100-year geologic setback line that varies from about 30 – 75 feet from the current bluff edge.[10] In contrast, my analysis evaluated the potential 100-year bluff retreat under unarmored conditions and assumed future sea level rise ranging from approximately 4 – 8.5 feet by 2120. Under a SLR scenario of 4.1 feet in 2120 (OPC "low risk aversion"), the upcoast segment of the site

[10] As noted above, on the northeastern, downcoast portion of the site, the Applicant's setback line (see **Fig. 1**) is significantly closer to the bluff edge (~30 ft setback) than the setback distance of 47.5 ft recommended by in the Easton (2019) analysis (Ref. 2).

could experience 156 – 222 feet of bluff retreat, while the more sheltered downcoast segment could experience 44 - 58 feet of bluff retreat. This range of 100-year bluff retreat projections is shown in **Fig. 1**, and far exceeds the geologic setback line from the Applicant's analysis (Ref. 2), except near the northern property line. Under the higher SLR scenarios more typically used by the Commission for evaluating bluff top development, the setback needed to assure stability for 100-years, absent armoring, would be larger. For example, under the "medium-high risk aversion" scenario recommended by the OPC and Commission SLR guidances, amounting to about 8.5 feet of SLR in 2120, the 100-year bluff retreat projections in my analysis ranged from 307 – 338 feet, exceeding the depth of the subject property.

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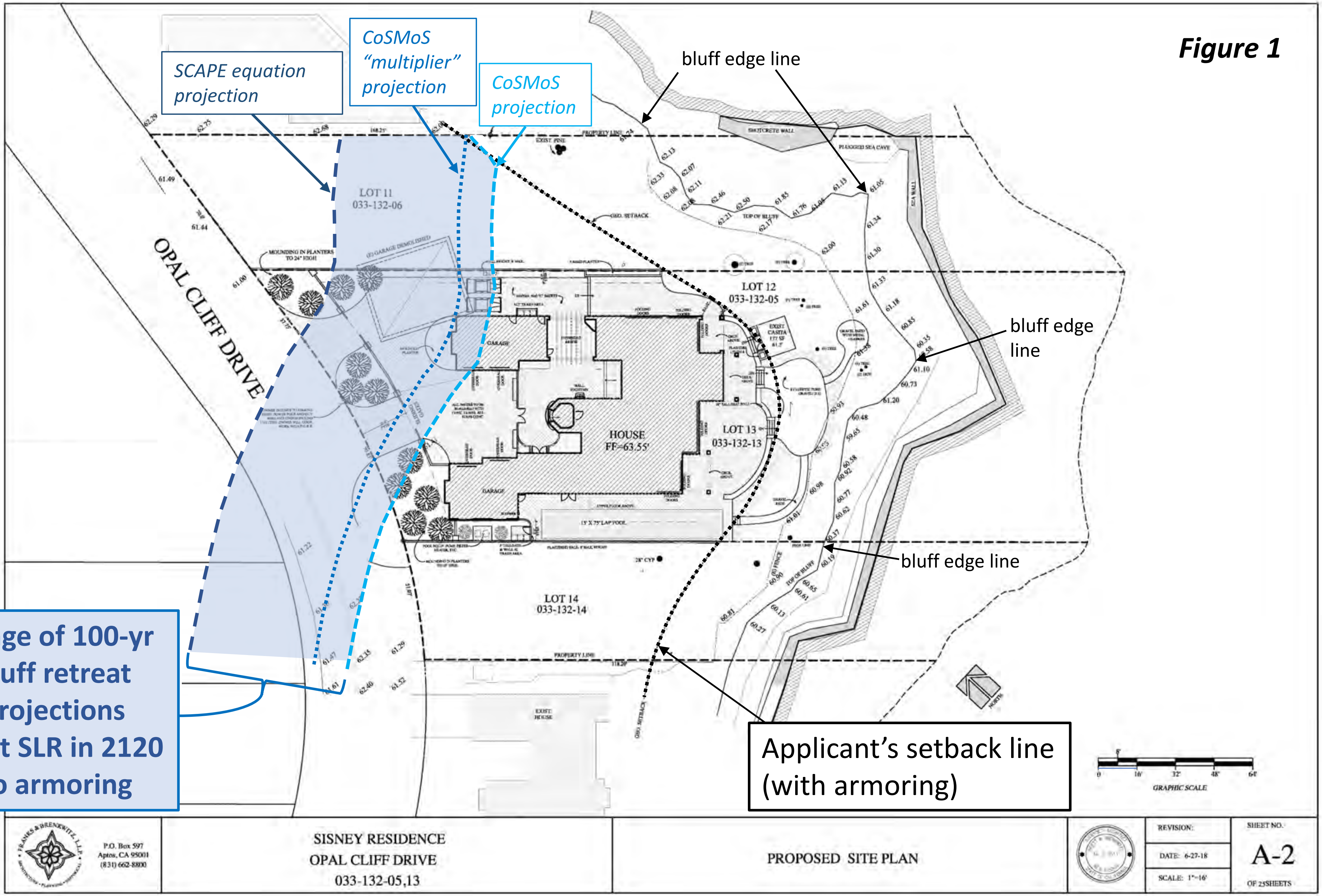
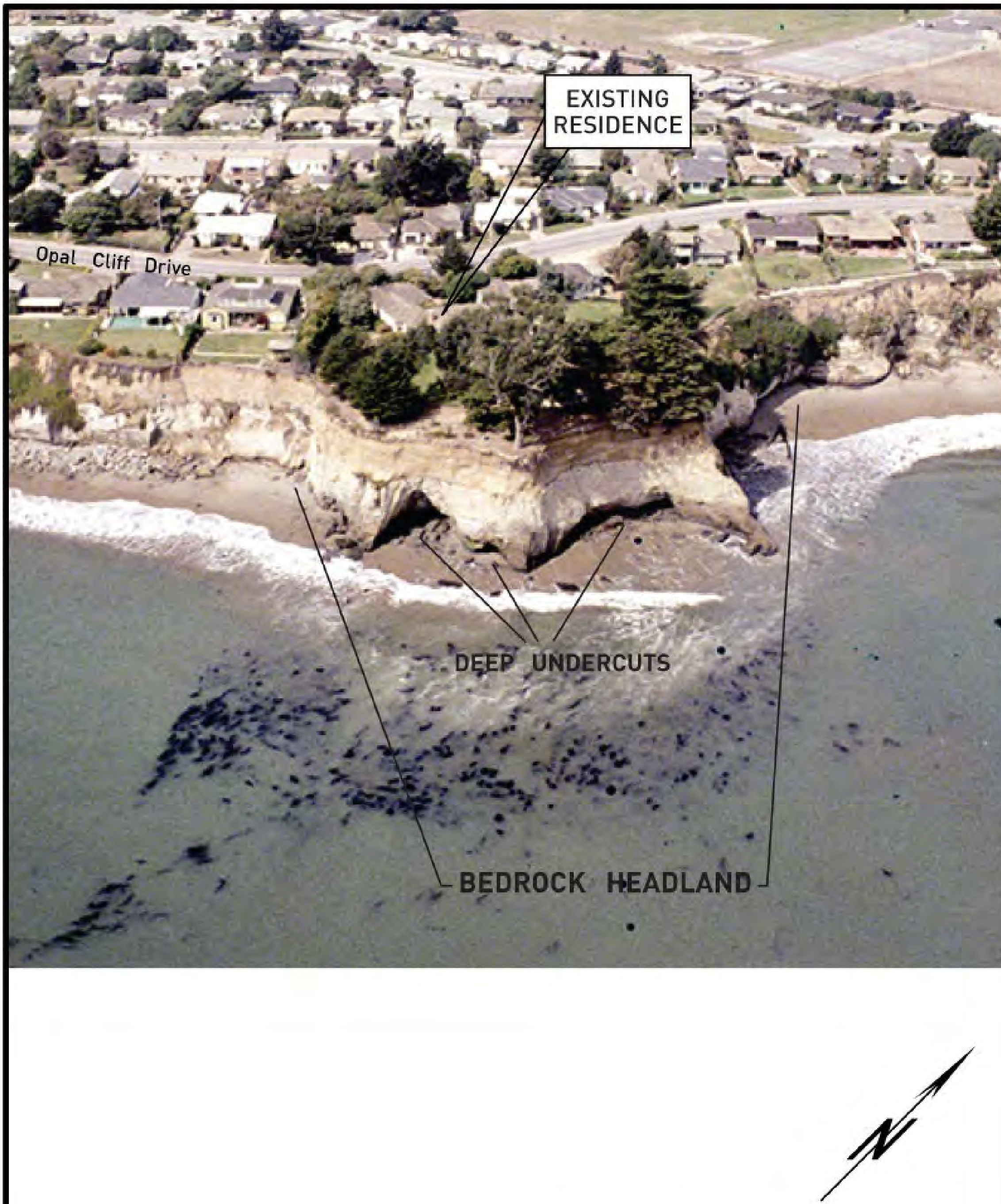


Figure 1
SCAPE equation projection
CoSMoS "multiplier" projection
CoSMoS projection
bluff edge line
bluff edge line
bluff edge line
Range of 100-yr bluff retreat projections 4.1 ft SLR in 2120 no armoring
Applicant's setback line (with armoring)
OPAL CLIFF DRIVE
LOT 11 033-132-06
LOT 12 033-132-05
LOT 13 033-132-13
LOT 14 033-132-14
HOUSE FF=63.55'
PROPERTY LINE
GRAPHIC SCALE
SISNEY RESIDENCE
OPAL CLIFF DRIVE
033-132-05,13
PROPOSED SITE PLAN
P.O. Box 597
Aptos, CA 95001
(831) 662-8800
REVISION:
DATE: 6-27-18
SCALE: 1"=16'
SHEET NO.
A-2
OF 25SHEETS

Figure 2: Oblique Aerial View of Site in 1979



Background Image: California Coastal Records Project, 1979, Copyright (C) 2002-2019, Kenneth & Gabrielle Adelman, California Coastal Records Project, www.Californiacoastline.org

EASTON GEOLOGY, INC. P.O. Box 3533 Santa Cruz, California 95063 831.247.4317	OBLIQUE AERIAL IMAGE OF SUBJECT SITE Sisney Property 4660 Opal Cliff Drive Santa Cruz, California Santa Cruz County APNs 033-132-05, 06, 13, 14	

Applicable Local Coastal Program Provisions and Coastal Act Sections

Chapter 1 – Interpretation

In any case in which the interpretation or application of an LCP policy is unclear, as that policy may relate to a particular development application or project, the application or interpretation of the policy which most clearly conforms to the relevant Coastal Act policy shall be utilized.

Coastal Hazards

LUP Policy 6.2.4: Mitigation of Geologic Hazards and Density Considerations. Deny the location of a proposed development or permit for a grading project if it is found that geologic hazards cannot be mitigated to within acceptable risk levels; and approve development proposals only if the project's density reflects consideration of the degree of hazard on the site, as determined by technical information.

LUP Policy 6.2.10: Site Development to Minimize Hazards. Require all developments to be sited and designed to avoid or minimize hazards as determined by the geologic hazards assessment or geologic and engineering investigations.

LUP Policy 6.2.12: Setbacks from Coastal Bluffs. All development activities, including those which are cantilevered, and non-habitable structures for which a building permit is required, shall be set back a minimum of 25 feet from the top edge of the bluff. A setback greater than 25 feet may be required based on conditions on and adjoining the site. The setback shall be sufficient to provide a stable building site over the 100-year lifetime of the structure, as determined through geologic and/or soil engineering reports. The determination of the minimum 100-year setback shall be based on the existing site conditions and shall not take into consideration the effect of any proposed shoreline or coastal bluff protection measures.

LUP Policy 6.2.15: New Development on Existing Lots of Record. Allow development activities in areas subject to storm wave inundation or beach or bluff erosion on existing lots of record, within existing developed neighborhoods, under the following circumstances: (a) A technical report (including a geologic hazards assessment, engineering geology report and/or soil engineering report) demonstrates that the potential hazard can be mitigated over the 100-year lifetime of the structure. Mitigations can include, but are not limited to, building setbacks, elevation of the structure, and foundation design; (b) Mitigation of the potential hazard is not dependent on shoreline or coastal bluff protection structures, except on lots where both adjacent parcels are already similarly protected; and (c) The owner records a Declaration of Geologic Hazards on the property deed that describes the potential hazard and the level of geologic and/or geotechnical investigation conducted.

LUP Policy 6.2.17: Prohibit New Building Sites in Coastal Hazard Areas. Do not allow the creation of new building sites, lots, or parcels in areas subject to coastal hazards, or in the area necessary to ensure a stable building site for the minimum 100-year lifetime, or where development would require the construction of public facilities or utility transmission lines within coastal hazard areas or in the area necessary to ensure a stable building site for the minimum 100-year lifetime.

IP Section 16.10.070(H): Permit Conditions for Development on Coastal Bluffs.

(1) Criteria in Areas Subject to Coastal Bluff Erosion. Projects in areas subject to coastal bluff erosion shall meet the following criteria:

> (a) For all development and for nonhabitable structures, demonstration of the stability of the site, in its current, pre-development application condition, for a minimum of 100 years as determined by either a geologic hazards assessment or a full geologic report.
>
> (b) For all development, including that which is cantilevered, and for nonhabitable structures, a minimum setback shall be established at least 25 feet from the top edge of the coastal bluff, or alternatively, the distance necessary to provide a stable building site over a 100-year lifetime of the structure, whichever is greater.
>
> (c) The determination of the minimum setback shall be based on the existing site conditions and shall not take into consideration the effect of any proposed protection measures, such as shoreline protection structures, retaining walls, or deep piers.

IP Section 16.10.070(H)(7): Permit Conditions for Development on Coastal Bluffs. Creation of New Parcels and Location of New Building Sites. New parcels or building sites created by minor land divisions, subdivisions or development approvals or permits, and multi-residential structures in coastal hazard areas shall conform to the following criteria: . . . (b) Determination by the Planning Director based on the geologic report that the long-term stability and safety of the development does not depend on or require shoreline protection structures.

Public Access and Recreation

Coastal Act Section 30210. In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse.

Coastal Act Section 30211. Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization, including, but not limited to, the use of dry sand and rocky coastal beaches to the first line of terrestrial vegetation.

Coastal Act Section 30212.

(a) Public access from the nearest public roadway to the shoreline and along the coast shall be provided in new development projects except where (1) it is inconsistent with public safety, military security needs, or the protection of fragile coastal resources, (2) adequate access exists nearby, or (3) agriculture would be adversely affected. Dedicated accessway shall not be required to be opened to public use until a public agency or private association agrees to accept responsibility for maintenance and liability of the accessway.

(b) For purposes of this section, “new development” does not include:

> (1) Replacement of any structure pursuant to the provisions of subdivision (g) of Section 30610.
>
> (2) The demolition and reconstruction of a single-family residence; provided, that the reconstructed residence shall not exceed either the floor area, height or bulk of the former structure by more than 10 percent, and that the reconstructed residence shall be sited in the same location on the affected property as the former structure.
>
> (3) Improvements to any structure which do not change the intensity of its use, which do not increase either the floor area, height, or bulk of the structure by more than 10 percent, which do not block or impede public access, and which do not result in a seaward encroachment by the structure.
>
> (4) The reconstruction or repair of any seawall; provided, however, that the reconstructed or repaired seawall is not seaward of the location of the former structure.
>
> (5) Any repair or maintenance activity for which the commission has determined, pursuant to Section 30610, that a coastal development permit will be required unless the commission determines that the activity will have an adverse impact on lateral public access along the beach.
>
> As used in this subdivision, “bulk” means total interior cubic volume as measured from the exterior surface of the structure.

(c) Nothing in this division shall restrict public access nor shall it excuse the performance of duties and responsibilities of public agencies which are required by Sections 66478.1 to 66478.14, inclusive, of the Government Code and by Section 4 of Article X of the California Constitution.

Coastal Act Section 30221. 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.

Coastal Act Section 30235. Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fishkills should be phased out or upgraded where feasible.

Coastal Act Section 30253. New development shall do all of the following:

(a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.

(b) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.

(c) Be consistent with requirements imposed by an air pollution control district or the State Air Resources Board as to each particular development.

(d) Minimize energy consumption and vehicle miles traveled.

(e) Where appropriate, protect special communities and neighborhoods that, because of their unique characteristics, are popular visitor destination points for recreational uses.

LUP Policy 6.2.16: Structural Shoreline Protection Measures. Limit structural shoreline protection measures to structures which protect existing structures from a significant threat, vacant lots which through lack of protection threaten adjacent developed lots, public works, public beaches, or coastal dependent uses. Require any application for shoreline protection measures to include a thorough analysis of all reasonable alternatives, including but not limited to, relocation or partial removal of the threatened structure, protection of the upper bluff or area immediately adjacent to the threatened structure, engineered shoreline protection such as beach nourishment, revetments, or vertical walls. Permit structural protection measures only if non-structural measures (e.g. building relocation or change in design) are infeasible from an engineering standpoint or not economically viable. The protection structure must not reduce or restrict public beach access, adversely affect shoreline processes and sand supply, increase erosion on adjacent properties, or cause harmful impacts on wildlife and fish habitats or archaeological or paleontological resources. The protection structure must be placed as close as possible to the development requiring protection and must be designed to minimize adverse impacts to recreation and to minimize visual intrusion. Shoreline protection structures shall be designed to meet approved engineering standards for the site as determined through the environmental review process. Detailed technical studies shall be required to accurately define oceanographic conditions affecting the site. All shoreline protective structures shall incorporate permanent survey monuments for future use in establishing a survey monument network along the coast for use in monitoring seaward encroachment or slumping of revetments or erosion trends. No approval shall be given for shoreline protective structures that do not include permanent monitoring and maintenance programs. Such programs shall include a report to the County every five years or less, as determined by a qualified professional, after construction of the structure, detailing the condition of the structure and listing any recommended maintenance work. Maintenance programs shall be recorded and shall allow for County removal or repair of a shoreline protective structure, at the owner's expense, if its condition creates a public nuisance or if necessary to protect the public health and safety.

LUP Policy 7.7.4: Maintaining Recreation Oriented Uses. Protect the coastal blufftop areas and beaches from intrusion by nonrecreational structures and incompatible uses to the extent legally possible without impairing the constitutional rights of the property owner, subject to policy 7.6.2.

LUP Policy 7.7.10: Protecting Existing Beach Access. Protect existing pedestrian, and, where appropriate, equestrian and bicycle access to all beaches to which the public has a right of access, whether acquired by grant or through use, as established through judicial determination of prescriptive rights, and acquisition through appropriate legal proceedings. Protect such beach access through permit conditions such as easement dedication or continued maintenance as an accessway by a private group, subject to policy 7.6.2.

LUP Policy 7.7.12: Lateral Access. Determine whether new development would interfere with or otherwise adversely affect public lateral access along beaches. If such impact will occur, the County will obtain dedication of lateral access along the beach to the first line of terrestrial vegetation to the base of the bluffs, where present, or to the base of any seawall; and the dedication of lateral access along bluff tops where pedestrian and/or bicycle trails can be provided and where environmental and use conflict issues can be mitigated. Unrestricted lateral access to North Coast beaches shall be provided where environmental and public safety concerns can be mitigated. All dedications required shall comply with policy 7.6.2 and the other policies of this chapter.

IP Section 13.20.110(F): Coastal Development Permit Findings. If the project is located between the nearest through public road and the sea or the shoreline of any body of water located within the Coastal Zone, that the project conforms to the public access and public recreation policies of Chapter 3 of the Coastal Act.

IP Section 16.10.070(H): Permit Conditions for Shoreline Protection Structures.

(3) Shoreline protection structures shall be governed by the following:

(a) Shoreline protection structures shall only be allowed on parcels where both adjacent parcels are already similarly protected, or where necessary to protect existing structures from a significant threat, or on vacant parcels which, through lack of protection threaten adjacent developed lots, or to protect public works, public beaches, and coastal dependent uses.

(b) Seawalls, specifically, shall only be considered where there is a significant threat to an existing structure and both adjacent parcels are already similarly protected.

(c) Application for shoreline protective structures shall include thorough analysis of all reasonable alternatives to such structures, including but not limited to relocation or partial removal of the threatened structure, protection of only the upper bluff area or the area immediately adjacent to the threatened structure, beach nourishment, and vertical walls. Structural protection measures on the bluff and beach shall only be permitted where nonstructural measures, such as relocating the structure or changing the design, are infeasible from an engineering standpoint or are not economically viable.

(d) Shoreline protection structures shall be placed as close as possible to the development or structure requiring protection.

(e) Shoreline protection structures shall not reduce or restrict public beach access, adversely affect shoreline processes and sand supply, adversely impact recreational resources, increase erosion on adjacent property, create a significant visual intrusion, or cause harmful impacts to wildlife or fish habitat, archaeologic or paleontologic resources. Shoreline protection structures shall minimize visual impact by employing materials that blend with the color of natural materials in the area.

(f) All protection structures shall meet approved engineering standards as determined through environmental review.

(g) All shoreline protection structures shall include a permanent, County approved, monitoring and maintenance program.

(h) Applications for shoreline protection structures shall include a construction and staging plan that minimizes disturbance to the beach, specifies the access and staging areas, and includes a construction schedule that limits presence on the beach, as much as possible, to periods of low visitor demand. The plan for repair projects shall include recovery of rock and other material that has been dislodged onto the beach.

(i) All other required local, State and Federal permits shall be obtained.

<u>**Visual Resources**</u>

LUP Objective 5.10a: Protection of Visual Resources. To identify, protect and restore the aesthetic values of visual resources.

LUP Objective 5.10b: New Development in Visual Resource Areas. To ensure that new development is appropriately designed and constructed to have minimal to no adverse impact upon identified visual resources.

LUP Policy 5.10.6: Preserving Ocean Vistas. Where public ocean vistas exist, require that these vistas be retained to the maximum extent possible as a condition of approval for any new development.

LUP Policy 5.10.7: Open Beaches and Blufftops. Prohibit the placement of new permanent structures which would be visible from a public beach, except where allowed on existing parcels of record, or for shoreline protection and for public beach access. Use the following criteria for allowed structures: (a) Allow infill structures (typically residences on existing lots of record) where compatible with the pattern of existing development. (b) Require shoreline protection and access structures to use natural materials and finishes to blend with the character of the area and integrate with the landform.

IP Section 13.10.325: Large Dwelling Permit Requirements and Design Guidelines.

(A) Approvals. No residential structure shall be constructed which will result in 5,000 square feet of floor area or larger, exclusive of accessory structures associated with the residential use, unless a Level V approval is obtained pursuant to the provisions of this section.

(B) Findings. All applications subject to this section shall be approved only if one or more of the following findings can be made:

> (1) The proposed structure is compatible with its surroundings given the neighborhood, locational or environmental context and its design is consistent with the large dwelling design guidelines in subsection (D) of this section; or
>
> (2) The proposed structure, due to site conditions, or mitigation measures approved as part of the application, will be adequately screened from public view and will not adversely impact public viewsheds, neighboring property privacy or solar access, and its design is consistent with the large dwelling design guidelines set forth in subsection (D) of this section. (For structures within the Coastal Zone requiring a coastal development permit, additional findings shall be made pursuant to IP Chapter 13.20.)

(C) Conditions. Conditions of project approvals made pursuant to this section may include mitigation measures necessary to preserve the neighborhood character in which the proposed structure(s) will be located, to preserve neighboring property privacy or solar access, and/or to screen the structure(s) from the road. Such measures may include, but are not limited to: house and accessory structure resiting, additional landscape screening and house redesign, including possible reduction in floor area.

(D) Large Dwelling Design Guidelines. New large dwellings and related accessory structures regulated by this section are subject to the following design guidelines. The intent of these guidelines is to assist the applicant in meeting the requirements of the large dwelling regulations, and to assist the Urban Designer, Planning Director and Zoning Administrator in reviewing applications.

Large dwellings and their related accessory structure should be designed so that:

(1) Changes in the natural topography of the building site are minimized.

(2) Grading cuts and fills are minimized, and when allowed, are balanced.

(3) House design and accessory structure horizontal elements follow hillside contours, where applicable.

(4) Colors and material are used to reduce the appearance of building bulk. Use of earthtone colors is encouraged.

(5) Building height appearance is minimized by varying the height of roof elements and setting back higher portions of the structure from prominent viewpoints.

(6) Ridgeline silhouettes remain unbroken by building elements. Building envelopes should be allocated to the lower portions of hillside lots, where feasible.

(7) The structure(s) is compatible in terms of proportion, size, mass and height with homes within the surrounding neighborhood.

(8) Architectural features break up massing. This can be accomplished by varying roof lines, puncturing large wall expanses with bay windows or recessed wall planes, or using a combination of vertical and horizontal architectural elements.

(9) Landscaping helps blend the structure(s) with the natural environmental setting of the site. This can be done by preserving existing vegetation as much as possible, siting the structure(s) to take advantage of existing trees and land forms, and by planting fast-growing, native landscaping to screen elements visible from viewpoints located off the parcel on which the structure is located.

(10) The view to adjacent properties is controlled. This can be done by minimizing second-story windows facing close neighboring properties, orienting upper floor balconies and decks toward large yard areas, locating the structure on the site as far from property lines as possible, and using landscaping to enhance privacy.

(11) The location of the structure(s) on the site minimizes view blockage within public viewsheds.

IP Section 13.20.130(B-D): Coastal Zone Design Criteria.

(B) The following design criteria shall apply to projects located in the Coastal Zone:

(1) Visual Compatibility. All development shall be sited, designed and landscaped to be visually compatible and integrated with the character of surrounding neighborhoods or areas. Structure design should emphasize a compatible community aesthetic as opposed to maximum-sized and bulkier/boxy designs, and should apply tools to help provide an interesting and attractive built environment (including building façade articulation through measures such as breaking up the design with some areas of indent, varied rooflines, offsets, and projections that provide shadow patterns, smaller second story elements set back from the first, and appropriate surface treatments such as wood/wood-like siding or shingles, etc.).

(2) Minimum Site Disturbance. Grading, earth moving, and removal of major vegetation shall be minimized. Developers shall be encouraged to maintain all mature trees over six inches in diameter except where circumstances require their removal, such as obstruction of the building site, dead or diseased trees, or nuisance species. Special landscape features (rock outcroppings, prominent natural landforms, tree groupings) shall be retained.

(3) Ridgeline Development. Hilltop and hillside development shall be integrated into the silhouette of the existing backdrop such as the terrain, landscaping, natural vegetation, and other structures. Ridgeline protection shall be ensured by restricting the height and placement of buildings and landscape species and by providing landscape screening in order to prevent projections above the ridgeline that are visible from public roads or other public areas. If there is no other building location on a property except a ridgeline, this circumstance shall be verified by the Planning Department with appropriate findings and mitigation measures to ensure that the proposed structure is compatible with its environment, is low profile, and is visually screened. Land divisions which would create parcels whose only building site would lead to development that would be exposed on a ridgetop shall not be permitted and land divisions shall be appropriately conditioned to prohibit ridgeline development in all cases.

(4) Landscaping. Development shall include landscaping meant to provide visual interest and articulation, to complement surrounding landscaping (including landscaping in adjacent rights-of-way), to screen and/or soften the visual impact of development, and to help improve and enhance visual resources. When a landscaping plan is required, new or replacement vegetation shall be consistent with water-efficient landscape regulations, compatible with surrounding vegetation and shall be suitable to the climate, soil, and ecological characteristics of the area.

(5) All development that is more than one story, where allowed by the site regulations of the basic zone district, that is located in significant public viewsheds (including adjacent to shoreline fronting roads, public accessways, parks, beaches, trails, natural areas, etc.) shall be sited and designed so that upper stories do not cantilever toward, loom over, or otherwise adversely impact such significant public viewsheds and community character.

(6) Front yard averaging shall only be allowed where the front setback so established does not adversely impact significant public viewsheds (including those associated with shoreline fronting roads, public accessways, parks, beaches, trails, natural areas, etc.) and community character.

(7) Development shall be sited and designed so that it does not block or significantly adversely impact significant public views and scenic character, including by situating lots, access roads, driveways, buildings, and other development (including fences, walls, hedges and other landscaping) to avoid view degradation and to maximize the effectiveness of topography and landscaping as a means to eliminate, if possible, and/or soften, if not possible, public view impacts.

(C) Rural Scenic Resources. In addition to the criteria above that applies throughout the Coastal Zone, the following design criteria shall also apply to all development proposed outside of the Urban Services Line and the Rural Services Line located in mapped scenic resource areas or determined to be in a scenic resource area during project review:

(2) Site Planning. Development shall be sited and designed to fit the physical setting carefully so that its presence is subordinate to the natural character of the site, including through appropriately maintaining natural features (e.g., streams, riparian corridors, major drainages, mature trees, dominant vegetative communities, rock outcroppings, prominent natural landforms, tree groupings, etc.) and requiring appropriate setbacks therefrom. Screening and landscaping suitable to the site shall be used to soften the visual impact of development unavoidably sited in the public viewshed.

(D) Beach Viewsheds. In addition to the criteria above that applies throughout the Coastal Zone, and the criteria above that also applies within rural areas (as applicable), the following design criteria shall also apply to all projects located on blufftops and/or visible from beaches:

(1) Blufftop Development.

(b) Within the Rural Services Line and the Urban Services Line, new blufftop development shall conform to the rural scenic resources criteria in subsection (C)(2) of this section.