EXHIBIT NO. **14A**

APPLICATION NO.

HUM-MAJ-1-08 – HUMBOLDT COUNTY LCP AMENDMENT (SAMOA TOWN PLAN)

SAMOA LOCATION MAPS (1 of 2)

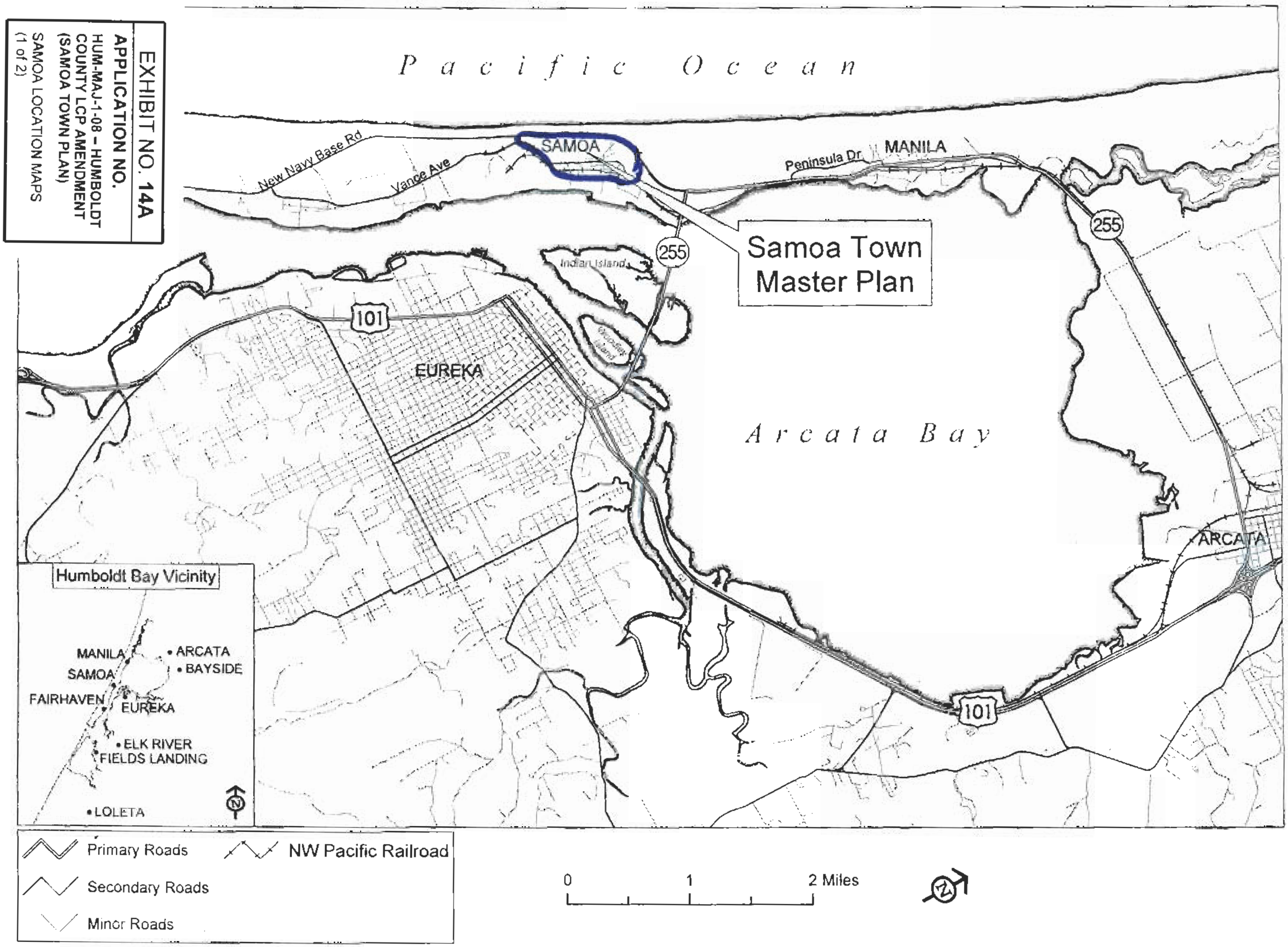

Figure 2F Samoa Fairhaven Redevelopment Sub-Area Map

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EXHIBIT NO. **15A**

APPLICATION NO. HUM-MAJ-1-08

HUMBOLDT COUNTY LCP AMENDMENT (SAMOA TOWN PLAN)

"REVISED TSUNAMI VULNERABILITY EVALUATION, SAMOA TOWN MASTER PLAN, HUMBOLDT COUNTY, CALIFORNIA" PREPARED BY GEOENGINEERS FOR SAMOA-PACIFIC PARTNERSHIP, LLC, DATED 10/17/06 (1 of 24)

REVISED TSUNAMI VULNERABILITY EVALUATION
SAMOA TOWN MASTER PLAN
HUMBOLDT COUNTY, CALIFORNIA

OCTOBER 17, 2006

FOR
SAMOA-PACIFIC PARTNERSHIP, LLC

GEOENGINEERS

File No. 10586-001-00

Revised Tsunami Vulnerability Evaluation
Samoa Town Master Plan
Humboldt County, California
File No. 10586-001-00

October 17, 2006

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SAMOA TOWN MASTER PLAN
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FOR
SAMOA PACIFIC PARTNERSHIP

INTRODUCTION

At the request of the Samoa Pacific Partnership, we have completed a two phase analysis to reduce damage and increase safety against tsunami for residents, business, and visitors to the Samoa Town. For Phase I of the evaluation, GeoEngineers Inc. summarized issues pertaining to the tsunami hazard for Planwest Partners as part of the Environmental Impact Report [EIR] ("Samoa Town Master Plan Final Master Environmental Impact Report" dated April 14, 2006 and the "Samoa Town Master Plan Recirculation Environmental Impact Report" dated May 12, 2006). We included in our evaluation a description of earthquake sources likely to generate a tsunami[1]. This report was revised to clarify that Peninsula School is an existing structure and not part of the present Samoa Town Master Plan project, to clarify the recommended other elevation, for occupied areas of residential structures and to clarify the recommended elevation of the emergency services facilities and designated assembly areas.

The current (Phase II) effort prepared by GeoEngineers Inc. with Planwest Partners presents the geological data and rationale used to establish criteria for the project with respect to "worst case" tsunami run-up elevations.[2] It also describes mitigation and safety measures applied to the Samoa Town Master Plan based on the site plan and mitigation strategies documented in the 2006 EIR documents.

This document is divided into two parts to evaluate the tsunami vulnerability. In Part I of this evaluation, we present data that we used to establish the design event. During preparation of this report, we were provided a copy of Pacific Gas & Electric Company report in support of a proposed facility in Humboldt Bay. We present the basis for the criteria in the EIR In Part II, we discuss the mitigation elements for the Site Plan and the discuss safety and evacuation. Our evaluation is based on a review of available literature, plans provided to us by the project proponent, our knowledge of the area, and professional experience.

PART I: DEFINE EXPOSURE

SEISMIC SETTING: THE DESIGN EVENT

The seismic setting of the Samoa Town Master Plan area is described in Chapter 2.07 of the "Samoa Town Master Plan Final Master Environmental Impact Report" dated April 14, 2006 and the "Samoa Town Master Plan Recirculation Environmental Impact Report" dated May 12 2006. The following is a summary of the seismic setting extracted from that chapter for those unfamiliar with the project or area.

The north coast of California is an area of high seismic activity with at least five distinct sources of earthquakes. Earthquakes capable of causing slight to moderate damage originating within the Gorda Plate and along the Mendocino Fault have a combined recurrence interval of approximately 5.5 years, based on historical records (Dengler, et al., 1992). Earthquake sources that could affect the plan area are:

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[1] Prepared by GeoEngineers Inc. (team consisted of Jane Preuss AICP, with Craig Erdman, PG, CEG, a Professional Geologist and Certified Engineering Geologist and Elson "Chip" T. Barnett PG, a Professional Geologist.

[2] GeoEngineers with Planwest Partners [same team--Jane Preuss joined Planwest Partners in 2005])

1. Faults within the Gorda Plate
   - The stresses produced by the differential motions of the plates causes internal deformation in the Gorda Plate that has resulted in the majority of damaging earthquakes in the Humboldt Bay region (Dengler et al., 1992).
2. The Mendocino Transform Fault Zone
   - The Mendocino Fault Zone extends west from near Cape Mendocino. At its closest point it is located approximately 39 miles southwest of the plan area. It is the second most frequent source of damaging earthquakes in the region.
3. The San Andreas Transform Fault Zone
   - The northern end of the San Andreas Fault Zone is located approximately 43 miles south of the plan area. The San Andreas Fault Zone is capable of producing large earthquakes similar to the 1906 San Francisco Earthquake, which caused significant damage in the Humboldt Bay region.
4. Faults within the North American Plate
   - Fault activity investigations of these indicate that several episodes of movement have occurred within the last 2,000 years; however, there is no historic record (i.e. the last 200 years) of activity on these faults.
5. The Cascadia Subduction Zone (CSZ) where the Gorda and Juan de Fuca Plates are subducted beneath the North American Plate
   - The CSZ is the potential source of the largest magnitude earthquakes in the Humboldt Bay region. It extends from Cape Mendocino northward to Vancouver Island and from approximately 32 miles west of the plan area to over 100 miles east of the plan area. It forms the boundary between the North American plate and the oceanic crust formed by the Juan De Fuca and Gorda plates. The North American plate and the oceanic plates are moving towards each other, forming what geologists refer to as a convergent plate margin. The North American plate is moving over oceanic plates, and the oceanic plates are sliding (subducting) underneath the North American plate.

A great earthquake (magnitude 8 to 9) along the CSZ, similar to the events about 1100 and 300 years ago, is selected as the design event capable of producing a tsunami that could affect the plan area. Recurrence intervals (RI) for such a seismic event range from 150 to 540 years (Toppozada et al., 1995; Darienzo and Peterson, 1995; Petersen et al., 1996; Atwater and Hemphill-Haley, 1997), which equates to a probability of recurrence of about 0.2 to 0.7 percent annually. In comparison, engineers have typically used peak ground accelerations with a 10 percent probability of exceedence in a 50-year period for developing seismic design criteria for structures. This equates to a seismic event with a recurrence interval of about 1 in 500 years, or about 0.2 percent annually. According to Peterson et al. (1996), a rupture along the entire CSZ is expected to have a Magnitude 8.8 (expected to recur every 500 years), while a rupture of only the southern segment would have a magnitude of 8.3 (expected to recur every 150 years).

GEOLOGIC INDICATIONS OF TSUNAMI

Earthquakes along subduction zones at convergent plate margins are capable of generating significant and destructive tsunami. Geologic strata can help scientists identify events that occurred prior to written records, such as past earthquakes (paleoseismic events) and past tsunami (paleotsunami). Extensive studies have occurred along the Pacific Northwest coast to identify potential indications of past earthquakes and tsunami. Based on these studies, buried wetland deposits (peat and tidal marsh deposits) and drowned forests have been identified at numerous sites along the CSZ in Vancouver (Canada), Washington, Oregon and northernmost California (USA) including the vicinity of the plan area (Atwater, 1987, Clague and Bobrowsky, 1994a, Peterson and Darienzo, 1990, and Jacoby and others, 1995). The buried forest and wetland deposits along coastal areas are interpreted as evidence of paleoseismic activity (Atwater, 1987, Clague and Bobrowsky, 1994a, Peterson and Darienzo, 1990, and Jacoby and others, 1995). Researchers have also observed a clean sand layer at the base of younger marsh deposits and overlying the buried wetland deposits at many of the sites studied. The buried sand layer is interpreted as an indicator of paleotsunami inundation. The age constraints on the various geomorphic features of the North Spit support a scenario in which regional tectonic cycles have played an integral role in development of the sand dunes on the spits. Dune sequences on the North and South Spits along with dune sequences at Clam Beach could reflect at least two complete seismic cycles of the Cascadia subduction zone in the last 2000 years, with tectonic events occurring around 1100 and 300 year BP (Leroy 1999). The presence of anomalous sand layers in coastal marsh deposits provides indications for large waves inundating the coastal area of northern California during the late Holocene, including events in the 300 and 1,100 yr BP range (Carver et al., 1998).

Local evidence of paleoseismic and paleotsunami activity in the vicinity of the plan area - on the Samoa Peninsula and the surrounding Humboldt Bay area - is reported by Vick (1988), Jacoby et al. (1995), and Leroy (1999). Paleoseismic evidence was observed in the buried wetlands in the area of Mad River Slough (Vick, 1988 and Jacoby et al., 1995). Investigations of buried wetlands in the Mad River Slough area identify zones where local coseismic (accompanying an earthquake) subsidence has occurred. There was no clean sand layer at the base of younger wetland deposits and overlying older, buried wetland deposits adjacent to forested dunes in the northern portion of the plan area. It is interpreted that the Samoa Peninsula in the northern portion of the plan area was not overtopped by the tsunami 300 years ago.

TSUNAMI RUN-UP ELEVATION: DISCUSSION OF DUNE OVERTOPPING

The North and South Spits of Humboldt Bay are primarily composed of sand dunes. On the North Spit there are three identifiable phases of dune aggregation represented by four main dune sequences. Leroy (1999) reports paleotsunami evidence in the dune complex of the Samoa Peninsula, including the plan area. He also indicates that localized areas of the Samoa Peninsula were not overtopped by the tsunami that occurred about 300 years ago. Leroy (1999) interprets that the older dune sequences were of sufficient elevation to have prevented overtopping by that tsunami. The older dune sequences are located in the northern and central portion of the Samoa Peninsula and include the northern portion (approximately two-thirds) of the plan area. The older dunes are typically forested, with maximum elevations of about 70 feet (21 m) above sea level (asl). By contrast, Leroy (1999) interprets that low-lying areas in the Humboldt Bay area adjacent to the South Spit and outside the plan area but within the vicinity were overtopped by the tsunami generated about 300 years ago.

According to data and interpretations summarized by Leroy (1999), the Samoa peninsula area experiences co-seismic uplift across much of the area, with co-seismic subsidence occurring within the Freshwater and South Bay synclines. Leroy interprets the evidence to indicate that a seismic event approximately 1100 years ago preserved the wave-cut escarpment and gravel deposits along the western edge of Dune Sequence D. In other words, this feature represents an older beach that was apparently uplifted during a seismic event about 1100 years ago. Leroy (1999) suggests that uplift at this time may have occurred from Clam Beach (north of the Samoa peninsula) south to Table Bluff (at the south end of the South Spit). Interseismic subsidence is inferred by Leroy (1999) and others to occur across the area (i.e. earth subsidence occurs between seismic events).

Dune development is believed to occur primarily after a seismic event that uplifts the shoreline, causing the shoreline to migrate westward and exposing source material for dunes.

The only known area where potential tsunami deposits have been observed is on the southeast side of the South Spit. Leroy (1999) does not show the exact location of the potential tsunami deposit consisting of sand, but states that "Although many cores have been taken in Humboldt Bay, the only *likely* tsunami deposits found to date are on the bay margin, against the southeastern portion of the South Spit. {Italics added.}

Based on the presence of these two sand layers within marsh and estuarine deposits in South Bay, it appears possible that the South Spit was overtopped by tsunami circa 1100 year BP and circa 300 years BP. The dunes on the South Spit are at an average Elevation 4 to 4.5 meters (13 to 15 feet); with one area as high as approximate Elevation 7 meters (23 feet). Most of the maximum elevations are around 5 to 6meters with a low of 3.5 meters reported by Leroy.

As mentioned above, no sand deposits were observed in explorations in the Mad River Slough (Vick, 1989; Jacoby et al., 1995), where at least four buried soil horizons are present and where adjacent dunes are at an average Elevation of 15 meters or greater. The buried soil horizons are interpreted to be the result of co-seismic subsidence.

Based on the above evidence pertaining to overtopping plus lack of sand deposits observed in the Mad River Slough, Leroy (1999) constrained the height of a tsunami from about 4.5 meters to less than 15meters (15 to 50 feet) assuming 1) overtopping of the South Spit and 2) that Dune complex D (on the North Spit) formed a barricade to tsunami (no tsunami deposits in the Mad River Slough). Leroy (1999) assessed that dunes from Samoa to the south end of the North Spit could act as a barricade or could be overtopped, depending on wave height and tidal stage. The dunes in the Samoa area have been modified by previous grading activities (GeoEngineers, 2000a).

The unstated assumption for the maximum inundation height is that the tsunami flowed all the way up to but not over the crest of the dunes. This assumption does not seem reasonable to GeoEngineers because 1) no scour/vegetation loss on the west side of Dune Complex D has been reported and 2) no difference has been reported in soil development/soil loss observed in soil pits on the west side of Dune Complex D versus elsewhere in the complex. Therefore, the maximum is, in the opinion of GeoEngineers, likely lower.

The wave-cut escarpment appears (based on elevation points marked on Leroy's maps) to be at approximate Elevation 2 to 7 meters (6.5 to 23 feet). Leroy (1999) observed a tree stump at the outer edge of the wave-cut escarpment and completed age-dating. The tree died off sometime around 300 years BP, apparently from burial by Dune Sequence A. The age of the tree provides a maximum age for Dune Sequence A. Since this feature (and the tree) appears not to have been obliterated at the time of the last interpreted Cascadia event 300 years ago, we interpret the maximum height of the wave-cut terrace to be near the maximum inundation height of the associated tsunami.

Leroy (1999) argues that the South Spit is "at the minimum elevation at which it can remain stable." Assuming the present heights of the Samoa Peninsula (North Spit) and the South Spit are representative of previous stable configurations of the spits, the tsunami is inferred to have overtopped an area with an average elevation of about 15 feet (approximately 4.5 m) and a maximum elevation of about 20 feet (approximately 6 m).

RUN-UP ELEVATION IN THE PLANNING AREA

Based on the paleotsunami evidence of dune overtopping the tsunami run-up elevation of 20 feet was interpreted to be the maximum dune height overtopped by a tsunami about 300 years along the South Spit (Leroy, 1999). There was no evaluation of wave occurrence relative to tidal stage and storm surge available at the time of our initial evaluation. A 10-foot factor of safety was therefore added to the height of the design event (difference between approximate high and low tides), for a total run-up height of 30 feet above mean sea level (msl). The complexity of vertical response to a great CSZ earthquake in the plan area is a function of numerous tectonic components, as previously discussed. Because of the difficulty in predicting local fault response (potential uplift) and a regional elastic response (potential subsidence), no vertical displacement in response to a great CSZ earthquake was assumed. However, there may be some uplift since the plan area is on the upthrown block of the Little Salmon fault.

REVIEW OF PACIFIC GAS & ELECTRIC REPORT

The Pacific Gas & Electric report (2002) provides a comprehensive summary of tsunami events affecting the Pacific Northwest and specific information pertinent to the ISFSI site, and also pertinent to the Samoa Peninsula. We were also able to discuss some of the findings in the report with William Page of Pacific Gas & Electric and with Dr. Gary Carver during separate telephone calls on September 27, 2006. Some of the key information includes:

- The studies completed for the PG&E report (including the thesis prepared by Thomas Leroy in 1999) used Mean Low Low Water (MLLW) as opposed to Mean Seal Level (MSL) used for most U.S. Geological Survey topographic maps and most engineering projects. The Samoa Master Plan uses a vertical datum of Mean Sea Level. MLLW is about 3.7 feet lower than MSL in the project area (PG&E, 2002).
- Dr. Carver (personal communication, 2006) states that he did not re-interpret the escarpment on the outer face of the dunes on the North Spit to be from a tsunami. He still maintains the escarpment notched into the dunes on the North Spit is from normal coastal processes (e.g. storm surges). Instead, he states that his runup elevation is based on a widely distributed layer of pebbles and cobbles found across the west face of the dunes on the North Spit. According to Dr. Carver, one location was surveyed relative to debris deposits (interpreted to be Mean High High Water [MHHW]) that was believed to be the highest elevation. The pebbles and gravel layer is interpreted to be the lag deposit from a tsunami. The surveyed highest extent of the pebble and gravel layer is approximately Elevation 38 feet MHHW, or about Elevation 34 feet MSL. Dr. Carver states that some drift of the material may have occurred over time. There are other uncertainties, such as whether or not the deposit has experienced uplift since the time of its deposition. It is also not certain if the elevation of the lag deposit is constant or varies across the North Spit. The age of the deposit is uncertain, according to our conversation with Dr. Carver, it sounds like the pebble and gravel layer is buried in a soil horizon. Dr. Carver could not remember the radiocarbon date of trees that provide a minimum age. He referred me back to the PG&E report and to Mr. Page to obtain copies of letters Dr. Carver wrote to Mr. Page.
- It is not clear if the North Spit dune complex has experienced net uplift or perhaps differential uplift. It might be possible to evaluate the potential for differential uplift by evaluating the wave-cut escarpment. Dr. Carver states that no one has evaluated the elevation of the wave-cut escarpment, in part because of the long distance involved and the isolated exposure of the inner edge. We concurred that the most feasible way to survey the escarpment elevation, as well as the elevation of the pebble and gravel layer, is by using a survey-grade global positioning system.
- They summarize six tsunami events recorded on the west coast of North America. These events appear to range about 200 to 850 years apart.

- The event about 300 years ago occurred at low tide. The PG& E report, "there is some evidence that significant earthquakes occur at low tide," citing a written communication by George Plafker (2002).
- In the PG&E report, they used a normal tidal range of 6.9 feet for the Humboldt Bay area, versus the maximum difference of about 10 feet we used.
- The authors of the PG&E report present the estimate of open-coast runup height based on six different analyses that are summarized in Table 9-4 of their report. These include information from geologic data from northern California, oral histories, tsunami modeling of the Humboldt Bay area, back-calculated water depths of tsunami at Lagoon Creek, topographic and geologic constraints on the North and South Spit and empirically-derived runup heights from world-wide data. The resulting runup height is approximately 30 to 40 feet MLLW, or about 26 to 36 feet MSL. The authors state that a Cascadia Subduction Zone rupture with Magnitude 8.8 would result in a runup of 31 feet (MSL). Using Figure 9-19 in the PG&E report, we find that a Magnitude 9.0 Cascadia event (the design event with a recurrence interval of approximately 500 years) should have a runup to approximate Elevation 31 feet (MSL). We are not certain of the discrepancy, and why they plot the Cascadia event off of the trend line rather than on it.

Based on the literature review we have completed, it appears that the expected runup for a Magnitude 9 Cascadia event is approximately Elevation 31 feet msl, which is also the mid-range for the range developed by PGE. Some uncertainties exist based on world-wide trends and for local site conditions. Because of the presence of foredunes, some surface roughness creates friction. This friction will reduce turbulence and slow the tsunami surge. Therefore, a small amount of attenuation, on the order of about 0.95 might be expected within the majority of the Samoa Town Master Plan area. By applying an attenuation factor to the anticipated inundation Elevation 31 foot elevation msl, the resulting runup is approximately Elevation 29.5 feet; which we rounded up to Elevation 30 feet msl. Therefore, we recommend that the lowest habitable floor for residential occupancy should be above Elevation 30 feet msl.

Some of these uncertainties could be evaluated by completing field studies to survey the upslope limit of the pebble and gravel deposits described by Dr. Carver (personal communication, 2006) and to further evaluate effects of uplift in the area. Furthermore, it may be possible that runup heights are greater where features block inundation inland (e.g. dunes). Therefore, inundation may be lower in the slightly lower-lying Samoa Master Plan area than to the north where established dunes are present. The trade-off is that the water velocities may be slightly higher in the Plan area. Computer-based modeling of tsunami using the local information to evaluate wave height could also provide a better indication of the inundation height in the vicinity of the Samoa Town Master Plan, but should utilize more accurately surveyed information before it is accomplished.

PART 2: MITIGATION AND SAFETY

GENERAL

The Samoa Town Master Planning approach presents two types of mitigation strategies: a) measures to minimize damage and b) measures to promote safety.

MITIGATION MEASURES

As discussed by the State of California Seismic Safety Commission (2005), there are no U.S. building codes that provide design guidelines to reduce or prevent damage to structures from tsunami hazard. They contrast differences expressed in FEMA's Coastal Construction Manual (FEMA 55) and the National Tsunami Hazard Mitigation Program "Background Paper #5: Building Design" with respect to the feasibility of designing for tsunami impacts. While the FEMA publication states it is impractical, the

National Tsunami Mitigation Program paper suggests that proper design can significantly reduce the impacts of tsunami on buildings. This paper also reports that only the City and County of Honolulu has implemented building requirements for tsunami. In lieu of appropriate building codes for design of structures, avoidance of the hazard by siting structures above the anticipated runup elevation is suggested.

Use Guidelines for Single-family Use

Planning criteria were developed for uses that could result in potential life loss. Single family occupancy use (lowest habitable floor) will be restricted to above Elevation 30 feet msl.

Use Guidelines for Multi-family Use

Habitation uses will be located above Elevation 30 feet msl. In the case of multi-family and resort use buildings the first floor level can be used for non-residential use such as parking. Residential use could occur on the second story.

Use Guidelines for Public and Critical Facilities

It is recommended that critical facilities be constructed above Elevation 40 feet because they are centers of population concentrations and/or may be necessary for first response and recovery.

MEASURES TO REDUCE TSUNAMI AMPLITUDE AND VELOCITY

Anecdotal evidence from recent tsunami events including the December 26, 2004 Indian Ocean Tsunami strongly indicates that natural features such as off shore reefs, dunes, dense forested areas and wetlands help to reduce both velocity and inundation. In India, there were reports that dense stands of mangrove forests provided protection and helped to reduce velocity and run up elevations. Conversely, there were numerous reports, such as multiple communities in Sri Lanka, that compared the high damage levels experienced by communities where there had been destruction of dunes and off-shore reefs, with low (or even no) damage levels in communities where such features were present.

Preservation and/or enhancement of eco-system features by Samoa Town Master Plan to reduce tsunami wave effects include:

- Dune Preservation
  - No development is proposed west of New Navy Base Road.
  - Designated pathways and trails to Samoa Beach will be constructed in order to avoid creation of non-designated trails. This measure will be stipulated as a condition of subdivision approval.
  - Interpretative signage at the parking areas to inform recreation users of sensitive biological resources in the plan area. This measure will be stipulated as a condition of subdivision approval.
- Vegetation
  - Preservation and enhancement of vegetation in dune areas adjacent to New Navy Base Road and elsewhere will strengthen existing dunes and reduce likelihood of degradation. Plantings will both reduce effects of tsunami while contributing to soil stabilization. Details are provided in the EIR.
  - For proposed Natural Resource and Public Recreation areas, a vegetation planting plan will be developed to reduce the potential for mobilizing large woody debris that could impact structures below the 26 foot elevation. Planting of deep rooted species such as shore pine and shrubs instead of Eucalyptus trees (which are very brittle) in these areas would reduce

potential impacts. Also, some species of Eucalyptus trees are highly flammable. Removal of "danger" species within the plan area is proposed.

- Wetlands
  - Wetlands create added opportunities for friction as well as for water detention.
  - Existing wetlands on the site will be expanded.
  - To improve the functional value of the two small wetlands adjacent developed dunes will be restored to native landscapes, fill material will be removed and native vegetations will be panted within the setback area.

SAFETY MEASURES

Because of the concern about the need for public education to promote evacuation and safety planning for a locally generated tsunami from the CSZ, Bernard et al. (1994) completed inundation modeling of a hypothetical wave to evaluate regional impacts to northern California. For Humboldt Bay an offshore wave height of 30 feet (approximately 10 meters) in water 150 feet deep was assumed. The model used a relatively coarse grid with spacing 100 meters and a topographic elevation model that assumed regular/even topography. As such it was unable to take into consideration the effects of dunes and other irregularities characterizing the Samoa Peninsula. The modeling results where used as the basis for a planning scenario of a great CSZ earthquake along the North Coast of California (Toppozada et al., 1995).

More recent safety planning efforts (Lori Dengler and Jay Patton (estimate: 2005) refined the expected tsunami hazard (See Appendix A of this document). This document (like the previous effort) clearly states that it is to be used only for emergency planning purposes; it is not intended to be used for site design. It is also not clear if the authors adjusted the zonation to reflect mean sea level (msl) versus mean low low water (mllw) used for the studies that their map was based on. Dengler and Patton (2005) report that over 150 paleotsunami sediment core samples have been taken along the margins of the bay and in the Mad River Slough. The only places where identifiable tsunami sands have been found are in the South Bay region immediately adjacent to the spit and in the Hookton Slough area.

Safety aspects of the Samoa Town Master Plan are intended to maximize response effectiveness and evacuation opportunities. Four types of Safety Measures have been proposed:

Central location chosen for the Emergency Services Vehicle Storage Facility

The facility housing the Emergency Services Vehicles is centrally located with respect to harbor facilities and to expected response demands. It should be constructed at or above Elevation 40 feet. In the event of a tsunami the vehicles will be removed from the storage facility to assist with response. The building will then become available for assembly.

Designated Assembly Sites

Assembly sites are safe buildings above the expected tsunami run up elevation where people could take refuge and remain until they are notified that it is safe to leave. Assembly site sites should be buildings that have sanitary facilities and be large enough to accommodate refugees for several hours. The assembly sites should be located so that people can travel by foot within approximately 5 to 8 minutes.

Specific sites meeting these criteria should be completed during preparation of the Safety Plan and following completion of the peer review. We understand the peer review may include tsunami inundation modeling which could help refine locations of potential evacuation sites.

At this time, we understand that the new Emergency Services building has been identified as one structure to be used for shelter. Therefore, we recommend that the floor elevation for assembly at the new Emergency Services building be constructed above Elevation 40 feet msl.

In addition, use of the proposed water tower will be prohibited for vertical evacuation because of its proximity to the commercial gas station and potential for a fire hazard. Signage will be installed.

Evacuation Routes

Strong ground motion from the earthquake essentially constitutes the warning from a CSZ earthquake. Based on this assumption the amount of time available for evacuation will be very short. An evacuation route plan will be prepared for the plan area which will include information on tsunami warning devices. The plan will be kept on file at the Samoa Peninsula Fire department (SPFD) in the Samoa Block Building. Key SPFD emergency services personnel shall be trained in tsunami evacuation procedures. Throughout the plan area, directional signage will be posted on designated paths that show non-vehicular evacuation routes to designated assembly sites.

Safety Plan

A Tsunami Safety Plan will be submitted to the County as a condition of subdivision approval.

- The tsunami evacuation plan, including designated routes will also include information on tsunami warning devices and techniques and a public information and education program targeted at Samoa residents and visitors.
- The applicant will submit a proportional share of the fee towards a fund for the installation and maintenance of a warning siren in the town of Samoa. (If funding for a warning siren becomes available prior to the collection of sufficient funds from each newly proposed residence, the fund can be used for tsunami education, identification of evacuation routes, signage and subsidized weather radios to residents of Samoa).

LIMITATIONS

This report has been prepared for use by Samoa Pacific Partnership, LLC for evaluation of tsunami hazards and mitigation relative to the Samoa Town Master Plan, in Humboldt County, California. This report is not intended for use by others, and the information contained herein is not applicable to other sites. Please refer to Appendix B titled "Report Limitations and Guidelines for Use" for additional information pertaining to use of this report.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to the appendix titled Report Limitations and Guidelines for Use for additional information pertaining to use of this report.

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APPENDIX A
BACKGROUND ON EMERGENCY PREPAREDNESS

APPENDIX A
BACKGROUND ON EMERGENCY PREPAREDNESS

MAPPING HUMBOLDT COUNTY'S TSUNAMI HAZARD

Lori Dengler and Jay Patton, Geology Department, Humboldt State University

WHY IS IT IMPORTANT TO MAP TSUNAMI HAZARD?

Twenty-one tsunamis have been observed or recorded on California's North Coast since 1855. All but four were teletsunamis originating from sources elsewhere in the Pacific. Crescent City in Del Norte County has suffered more tsunami damage in the past 150 years than any other area of the US West coast outside of Alaska. Prior to 1992 only distant source tsunamis were considered by the local emergency planning community a significant risk. The 1992 Cape Mendocino earthquake (Mw 7.1) changed this perception. The earthquake, located on or near the Cascadia subduction zone megathrust fault system, produced a modest local tsunami that was recorded at the tide gauges on the North Spit and at Crescent City and observed by eyewitnesses. Although the tsunami was not damaging, it did raise the concern of scientists and emergency planners about the impact of a larger earthquake/tsunami from the Cascadia subduction zone. The National Oceanographic and Atmospheric Administration (NOAA) conducted numerical modeling of the Humboldt Bay and Crescent City areas (Bernard and others, 1994) to estimate the likely extent of inundation as part of a CDMG (now California Geological Survey) earthquake planning scenario for a magnitude 8.4 earthquake on the Cascadia subduction zone and numerous paleoseismic investigations have looked for evidence of prehistoric earthquakes and tsunamis in the region.

With increased awareness of the tsunami hazard, there has been confusion about areas at risk and areas of safety. Some areas of high hazard have no evacuation planning or tsunami education efforts. Several local schools have developed tsunami evacuation plans even though the location of the school poses no risk. Unnecessary evacuation increases exposure to other earthquake hazards. The hazard maps produced by this project are intended for educational purposes, to improve awareness of tsunami hazards and to encourage responsible emergency planning efforts by illustrating the range of possible tsunami events based on the best currently available information.

ABOUT THE MAPS

The Humboldt County Tsunami Hazard Maps combine the results of past studies to depict the relative tsunami hazard of coastal Humboldt County in Northern California. Unlike inundation maps with a single line to show the inland extent of flooding, these maps use a four-color scheme to represent relative risk.

- Highest hazard areas (red) have experienced tsunami or storm wave inundation in historic times and include beaches and low coastal bluffs on the open coast and low areas adjacent to Humboldt Bay and major river deltas. The high hazard zones are also mapped as zone A (100 year flooding) on FEMA Flood Insurance Rate Maps.
- Moderate hazard areas (orange) are areas likely to be flooded by a major tsunami generated by the Cascadia subduction zone based on published paleotsunami studies, numerical modeling (Bernard and others, 1994) and observations of recent tsunamis elsewhere. Current estimates of major Cascadia earthquake recurrence averages about 500 years and range from 200 to 800 years. The most recent great Cascadia earthquake is believed to have occurred in 1700.

- Low hazard areas (yellow) show no evidence of flooding in the paleotsunami record and are likely to provide refuge in all but the most extreme event.
- No hazard areas (grey) are too high in elevation and/or too far inland to be at risk.

A continuous gradational color scale with blurred boundaries help to convey the continuum of possible events and the uncertainty in delineating distinct inundation lines. We emphasize numerous sources of uncertainty in hazard delineation. The ambient tide condition will raise or lower the background sea level by 8 or more feet and will be further affected by El Niño conditions and large storm events and swells. The size and character of faulting in a specific event may also amplify or reduce the size of the resulting tsunami. Only recently has the impact of landsliding been recognize in contributing to tsunami hazards. As large Cascadia event is likely to generate local slumping. The size and location of such slumps can greatly increase tsunami amplitude locally.

The maps are GIS based to facilitate ready adaptation by planners and emergency managers. The maps are intended for educational purposes, to improve awareness of tsunami hazards and to encourage emergency planning efforts of local and regional organizations by illustrating the range of possible tsunami events.

DEFINING HAZARD AREA BOUNDARIES:

This project recognizes the complexity of tsunami hazards. Not only can tsunamis hit the coast at high velocity, the fluctuating surges of water can cause infilling and draw downs of bays and send surges of water miles inland along large coastal rivers. The nature of the hazard and the likely elevations impact will differ in these various areas.

We define four different zones and develop criteria to delineate the hazard area boundaries:

Open Coast Zone: The open coastline directly exposed to the ocean. Includes all areas within 2 km of the coast. This area is vulnerable to inundation and high velocity tsunami waves.

Bay Zone: The margins of Humboldt Bay and lagoons more than 2 km from the coast. This area is vulnerable to rapid changes in water level, fluctuating currents and flooding.

Special Study Zone: Pacific Gas and Electric Company Power Plant and King Salmon opposite the mouth of Humboldt Bay. This area is vulnerable to both Open Coast and Bay effects. Studies of the tsunami hazard have been conducted by PG&E.

Coastal Estuary Zone: Coastal flood plain areas from the end of the Open Coast Zone to elevations inland of 35m. This area is vulnerable to tsunami river bores. Flooding potential strongly dependent on ambient tide and water levels.

Upland Zone: All areas more than 2km inland from the coast not included in the Bay or Coastal Estuary Zones. This zone is not vulnerable to tsunami hazards but will be affected by other earthquake effects if a large Cascadia earthquake occurs.

1. Hazard area boundaries are initially defined for each zone above based on elevation:

Zone	Description	High	Moderate	Low	None
Open Coast	Everywhere within 2km of coast	[redacted]	[redacted]	10 - 35 m elev	above 35 m elev
Coastal Estuary	Low lying flat topography of river valleys and bottomlands	[redacted]	[redacted]	6 - 15 m elev	above 15 m elev
	Low lying flat Bay topography adjacent to Humboldt Bay	[redacted]	[redacted]	3 - 5 m elev	above 5 m elev
Special Study Zone	Area studied by PG&E	[redacted]	[redacted]	7.5 - 20 m elev	above 20 m elev
Uplands	All other areas inland of Open Coast zone	[redacted]	[redacted]		all elevations

2. Hazard boundaries are adjusted using the following:

<u>FEMA Q3 flood maps.</u>

All high hazard zones should also be defined as Zone A (100 year flooding) in the Q3 maps.

<u>NOAA Tsunami Inundation modeling</u>

In 1994, NOAA conducted numerical modeling of the tsunami hazard in the Humboldt Bay region as part of the California division of Mines and Geology Earthquake Planning Scenario for an earthquake on the Cascadia subduction zone. We adjusted the moderate hazard area in some areas to agree with the 1994 study. However, we do not consider the inundation mapping accurate in the Samoa Peninsula region as it used topographic data from USGS 7 1/2 minute quadrangles that do not accurately delineate the dune topography.

<u>Paleotsunami studies</u>

A number of paleoseismic and paleotsunami investigations have been conducted in the Humboldt Bay region since 1980. Many of the studies were supported by Pacific Gas & Electric Company as part of their Humboldt Bay Power Plant hazard assessment. Over 150 paleotsunami sediment core samples have been taken along the margins of the bay and in the Mad River Slough. The only places where identifiable tsunami sands have been found are in the South Bay region immediately adjacent to the spit and in the Hookton Slough area. In addition, a Masters thesis (Leroy, 1999) examined the relative ages of soil and dune deposits on both spits. The paleoseismic studies show no evidence for significant overtopping of the Samoa Peninsula from the town of Samoa north.

See map areas as defined above for the Northern Samoa Peninsula.

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APPENDIX B
REPORT LIMITATIONS AND GUIDELINES FOR USE

APPENDIX B

REPORT LIMITATIONS AND GUIDELINES FOR USE[3]

This appendix provides information to help you manage your risks with respect to the use of this report.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES, PERSONS AND PROJECTS

This report has been prepared for the exclusive use of Samoa Town Partnership and their authorized agents. This report may be made available to contractors and regulatory agencies for review. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

GeoEngineers structures our services to meet the specific needs of our clients. For example, a geotechnical or geologic study conducted for a civil engineer or architect may not fulfill the needs of a construction contractor or even another civil engineer or architect that are involved in the same project. Because each geotechnical or geologic study is unique, each geotechnical engineering or geologic report is unique, prepared solely for the specific client and project site. Our report is prepared for the exclusive use of our Client. No other party may rely on the product of our services unless we agree in advance to such reliance in writing. This is to provide our firm with reasonable protection against open-ended liability claims by third parties with whom there would otherwise be no contractual limits to their actions. Within the limitations of scope, schedule and budget, our services have been executed in accordance with our Agreement with the Client and generally accepted geotechnical practices in this area at the time this report was prepared. This report should not be applied for any purpose or project except the one originally contemplated.

A GEOTECHNICAL ENGINEERING OR GEOLOGIC REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

This report has been prepared for the proposed Samoa Town Master Plan. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If important changes are made after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate.

[3] Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; www.asfe.org .

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. Always contact GeoEngineers before applying a report to determine if it remains applicable.

Most Geotechnical And Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied our professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

Do not over-rely on the preliminary construction recommendations included in this report. These recommendations are not final, because they were developed principally from GeoEngineers' professional judgment and opinion. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for this report's recommendations if we do not perform construction observation.

Sufficient monitoring, testing and consultation by GeoEngineers should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. You could lower that risk by having GeoEngineers confer with appropriate members of the design team after submitting the report. Also retain GeoEngineers to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having GeoEngineers participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, but recognize that separating logs from the report can elevate risk.

GIVE CONTRACTORS A COMPLETE REPORT AND GUIDANCE

Some owners and design professionals believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering or geologic report, but preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might an owner be in a position to give contractors the best information available, while requiring them to at least share the financial responsibilities stemming from unanticipated conditions. Further, a contingency for unanticipated conditions should be included in your project budget and schedule.

CONTRACTORS ARE RESPONSIBLE FOR SITE SAFETY ON THEIR OWN CONSTRUCTION PROJECTS

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties.

READ THESE PROVISIONS CLOSELY

Some clients, design professionals and contractors may not recognize that the geoscience practices (geotechnical engineering or geology) are far less exact than other engineering and natural science disciplines. This lack of understanding can create unrealistic expectations that could lead to disappointments, claims and disputes. GeoEngineers includes these explanatory "limitations" provisions in our reports to help reduce such risks. Please confer with GeoEngineers if you are unclear how these "Report Limitations and Guidelines for Use" apply to your project or site.

GEOTECHNICAL, GEOLOGIC AND ENVIRONMENTAL REPORTS SHOULD NOT BE INTERCHANGED

The equipment, techniques and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study and vice versa. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Similarly, environmental reports are not used to address geotechnical or geologic concerns regarding a specific project.

BIOLOGICAL POLLUTANTS

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings, or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants and no conclusions or inferences should be drawn regarding Biological Pollutants, as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria, and viruses, and/or any of their byproducts.

If Client desires these specialized services, they should be obtained from a consultant who offers services in this specialized field.

EXHIBIT NO. **16A**

APPLICATION NO. HUM-MAJ-1-08

HUMBOLDT COUNTY LCP AMENDMENT (SAMOA TOWN PLAN)

"THIRD PARTY REVIEW OF SAMOA TOWN MASTER PLAN TSUNAMI VULNERABILITY REPORT" PREPARED BY JOSE BORRERO, FREDRIC RAICHLEN, HARRY YEH (UNDATED). COPY SUBMITTED TO THE COASTAL COMMISSION BY HUMBOLDT COUNTY, 3/8/07.

THIRD PARTY REVIEW OF SAMOA TOWN MASTER PLAN TSUNAMI VULNERABILITY REPORT

by

Jose Borrero, Fredric Raichlen, Harry Yeh

EXECUTIVE SUMMARY

The third party review of the tsunami vulnerability of the Samoa Town Plan was undertaken to investigate the framework of assumptions that led to an elevation of +30 ft MSL for the lowest habitable floor for residential occupancy in Samoa Town suggested by GeoEngioneers (GE). This review will be presented along with certain suggestions. Generally we found that the tsunami vulnerability report by GeoEngineers depended strongly on geological evidence of tsunami attack from past events and a view of the dune system to the west of the Town as providing a "tsunami barrier". This has prompted us to use a sophisticated numerical model of the area that incorporates two Cascadia Subduction Zone earthquakes (magnitudes 8.5 and 9.0) into the model to define inundation zones on the North Spit.

The review that was undertaken has three major sections as presented herein:

- Review of the section in the GeoEngineers' report dealing with the geological aspects of tsunami mitigation.
- The development of a numerical model and a discussion of the results of applying this model using the current topography of the north peninsula to investigate inundation patterns for two CSZ earthquakes (magnitudes 8.5 and 9.0).
- Review of the section of GeoEngineers' report devoted to mitigation and safety.

(In these sections appropriate selections from the GeoEngineers' report and the PG&E (2002) report are presented for the convenience of the reader with our comments presented in bold-face font.)

CONCLUSIONS

The following major conclusions were drawn from the combined review of the GeoEngineers' report and the application of the numerical model used in this review.

- Our numerical simulations predict the maximum tsunami elevation on the seaward face of the seaward dunes of about 20 feet to 24 feet. This is consistent with the geologic evidence that was used as the basis in the GeoEngineers' report. This agreement provides us with some degree of confidence in our estimate. Consequently, we recommend eliminating the factor of safety used by GeoEngineers, i.e., a somewhat arbitrary factor of safety of 1.5. Instead of this factor of safety, we added the effect of maximum tides (3 feet to 4 feet re MSL) to the prediction. This results in the maximum predicted tsunami inundation elevation of 24 ft to 28 ft MSL for the general area of the Samoa Town Master Plan.

- We must caution that there are still many uncertainties involved in our predicted tsunami elevation for a number of reasons. First, the tsunami source we used in our simulation is based on the estimated co-seismic seafloor displacement resulted from the rupture of main fault, which is not an exact science. Furthermore, the rupture in a splay fault could create enhanced seafloor displacement; thereby much greater tsunami may result. There also is a possibility that strong seismic motions may trigger a large submarine landslide, which could generate excessively large tsunamis locally. In addition, in some aspects of the numerical study we assumed a coseismic uplift of the North Spit which may or may not be accurate. Therefore, the estimate by GeoEngineers of the 30 ft elevation for habitable floors for the Samoa Town Master Plan site is reasonable considering all of the uncertainties involved in such a tsunami inundation prediction.

- Unlike the phenomenon of river floods, tsunamis are rare events and a minimal amount of data, if any at all, are available for a given locality. Hence a probabilistic (or risk) analysis for a given site is usually impractical. The best practice to establish a design tsunami condition must be based on the combination of a theoretical understanding of the problem, rational numerical modeling, past field experience, and engineering judgment. We believe that the geological evidence of the study by GeoEngineers and PG&E combined with the results of our numerical model study provide a certain degree of confidence in estimating the tsunami vulnerability of the Samoa Town Master Plan site.

- Even if the tsunami source were identified, local tsunami effects could not be predicted accurately because the flows interact strongly with the complex three-dimensional bathymetry and topography of the area. This is especially true for the prediction of the effects of a tsunami on the east side of Samoa. If the tsunami entered Humboldt Bay through the entrance from the south end of North Spit and propagated northward along the 30-ft deep dredged channel it is possible that the east side of Samoa could be more vulnerable than the west side. This is because of the low elevation of some of the developed area. An accurate prediction of inundation for such a complex tsunami propagation process is difficult. In Section II where the numerical model results are presented and discussed it can be seen that the numerical model can handle this aspect of tsunami effects in only an approximate manner.

- We emphasize that a sufficient number of the assembly sites (shelters) be constructed at strategically planned locations for vertical evacuation. These structures must be designed by qualified professional engineers and can be multi-use or stand alone structures. They should be located based on expected arrival times of a tsunami.

- It is not clear if the ground elevation of the new Emergency Services building should be above 40 feet MSL or that of the upper floor that will be used for evacuation. It is emphasized that there must be multiple assembly sites

- Evacuation routes to the shelters must be carefully planned not only for the residents but also for beach visitors in the event of an earthquake.

- Inside of the shelters, warning signs stating that "tsunami effects last for several hours" must be posted.

- The Samoa Town Plan should not allow any fences in the township, except for those required, and those must be low enough not to hinder evacuation.

- The Safety Plan should include annual evacuation drills and the Plan should be reviewed and updated annually.

I. REVIEW OF THE GEOLOGICAL INDICATIONS OF TSUNAMI VULNERABILITY

In the review of this section of the report we considered the important elements of the geological investigations and the run-up considerations that led to the estimate of the inundation elevation of +30 ft MSL suggested by GeoEngineers. Some important points brought out by GeoEngineers in this section of their report will be presented and discussed.

- **To a large extent the determination of the maximum inundation elevation at the site of the Samoa Town Master Plan is based on the Master of Science thesis of Leroy (1999) and the report of PG&E relating to the Humboldt Bay ISFSI site (Independent Spent Fuel Storage Installation) (December 27, 2002).**

- **It is not clear in either the GeoEngineers' report, PG&E report, or Leroy (1999) whether the authors have made a distinction between run-up and inundation. These can be two distinct phenomena that must be clearly stated in referring to potential flooding scenarios for the Samoa Town Master Plan area. Run-up refers to the elevation to which a wave, e.g., a tsunami, will propagate up a slope (or in this case a dune-face). Inundation is the elevation of flooding due to the wave that may or may not be the same as the run-up.**

The presence of inconsistent sand layers in coastal marsh deposits provides indications of large waves inundating the coastal area of northern California during the late Holocene, including events in the 300 and 1100 yr BP (before present) range.

- **Although this does not refer directly to the Samoa Town Master Plan area it does suggest that major waves occurred at the time of tectonic events occurring around 300 and 1100 yr BP. This observation basically layed the groundwork for the *possibility* of the inundation of the North Spit by tsunamis.**

It is stated that in the Samoa peninsula (the North Spit) paleoseismic evidence was observed in the area of the Mad River Slough approximately four miles north of the Samoa Town Master Plan site. Paleoseismic evidence refers to ground subsidence or uplift associated with past tectonic events and does not, *per se*, refer to historic tsunami events.

- **Leroy (1999) postulates that the Samoa peninsula area experiences co-seismic *uplift* across much of the area due to CSZ earthquake, thereby providing additional protection from dune overtopping in the Samoa Town Master Plan site and from inundation from Humboldt Bay.**

It is stated that there is a general lack of clean sand layers at the base of younger wetland deposits overlying older buried wetland deposits adjacent to the forested dunes in the northern portion of the plan area.

- **This suggests that the dunes seaward of the Samoa Town Master Plan area were not *overtopped* by the tsunami run-up associated with the event of 300 years ago, i.e., 1700. In the event of a major earthquake along the Cascadia Subduction Zone with a magnitude of 9.0 and the generation of a massive tsunami it is probable that, at least, the region of the coast north of Samoa would be inundated. Even though there are high dunes and a forested region north of the Samoa Town Master Plan site providing some protection from local tsunamis, massive waves generated by a magnitude 9.0 CSZ earthquake may travel overland from the north toward the south affecting the North Spit.**

- **In an indirect way, attention has been given to the potential for tsunami flooding of the Samoa Town from the east, i.e., from Humboldt Bay. This is from evidence of the overtopping of the South Spit by past extreme events. There is another caveat, and that is that the dune field is not two dimensional so even though certain dune heights are discussed in the GeoEngineers' report, the dunes in fact are three dimensional, i.e., there are regions in the seaward dune field with peaks that range in height. Therefore, there is a possibility of flow through the lower elevation sections of the dunes. In addition, dune erosion caused by the initial waves in a tsunami wave train may occur that can result in overtopping by subsequent waves. Therefore, the expected run-up on the seaward face of the dunes is important to establish.**

Leroy (1999) states, in the section entitled: "Evaluation of the Spits as Tsunami Barricade", that " the only likely tsunami deposits found to date are on the bay margin against the southeastern portion of the South Spit".

- **Our interpretation of this is that tsunami deposits have not been found elsewhere on the North Spit, but overtopping of the South Spit is possible with related flooding of the North Spit.**

The statement is made that dune development is believed to occur primarily after a seismic event that uplifts the shoreline.

- **This does not address the possibility that major storm wave events in combination with winds can play an important role in the formation and accretion or the erosion of the seaward dune field. In addition, as mentioned earlier, the impingement of tsunamis on the dunes, even in non-overtopping events, can modify the dune shape and enhance (or deter) run-up from subsequent earthquakes and tsunamis.**

- **The estimate of run-up in the GeoEngineers' report is somewhat confusing. It is stated that this is based on considerations of the overtopping of the South Spit with an average elevation of about 15 ft (4.5 m) MSL and a maximum elevation of about 20 ft (6 m) MSL. (This implies bay-side flooding.) This is used as the basis for the inundation level in the Samoa Town Master Plan area. To the maximum of about 20 ft MSL a factor of safety of 1.5 is applied to arrive at a height of 30 ft above MSL being the height for mitigation considerations. (We**

are not in favor of assigning an arbitrary factor of safety to such results.) Indeed it is stated that the 10 ft added to the 20 ft elevation is approximately the difference between high and low tides. We consider this to be excessive. Actually the mean tidal range at Samoa (40° 50' N ;124° 11' W) is 5.4 ft and the spring tidal range is 7.3 ft. Referring to MSL, this would result in a spring tidal range of about 3 ft to 4 ft above MSL. Thus, a reasonable level would be about 24 ft re MSL rather than 30 ft re MSL as stated in the report. The estimate of PG&E of a 31 ft run-up on the seaward dune face due to a CSZ earthquake and resultant tsunami is used by GeoEngineers to support their recommended base elevation for buildings of 30 ft. This approach is considered somewhat questionable, since the GeoEngineers recommendation is based on the factor of safety of 1.5. We believe that an estimate based on the run-up on the seaward dune face is a more reliable approach. It is seen in Section II (the section treating the numerical model) that this is the approach taken by us.

The PG&E report (December 27, 2002) that dealt with the ISFSI (Independent Spent Fuel Storage Installation) site at Humboldt Bay was reviewed in regard to the facts that could be applied to the North Spit relative to the question of inundation at the Samoa Town Master Plan site. Several of their conclusions are summarized in the following with the page reference to their report shown in italics at the end of the comment.

- **The conjecture is presented regarding the escarpment on the west of the dunes and whether it could have been caused by a tsunami. From their description we tend to agree with PG&E that major storm wave events could have caused this, although a causative tsunami cannot be completely ruled out.** ***(personal communication of GeoEngineers with Dr. Carver)***

- **In the review of paleotsunami evidence found by PG&E geologists PG&E stated that no tsunami evidence was found at Mad River Slough, Eureka Slough, or at the Humboldt Bay Power Plant. There was evidence of three tsunamis in the South Bay region. They further state:** "Evidence of paleotsunamis are also evident in the sand dunes of the North Spit. No evidence of past tsunami inundation was found at High Praire Creek or at six sites investigated around the north and east sides of Humboldt Bay." ***(PG&E Report Pg. 9-58 and Table 9-2)***

- **It is stated that the dunes on the northern part of the North Spit range from 53 ft to 72 ft re MLLW (or about 49 ft to 68 ft re MSL). Observations show that these dunes had never been overtopped by past tsunamis. PG&E states that this places an upper limit on run-up on the seaward face of these dunes. As discussed earlier, this does not eliminate the possibility of inundation at the Samoa Town Master Plan site from the bay-side by tsunami propagation through the entrance to Humboldt Bay or through lower elevations in the three-dimensional dune field.** ***(PG&E Report Pg. 9-19)***

- **PG&E bases its estimate of the inundation in Humboldt Bay on the work of Leroy (1999) reviewed earlier. They state the run-up height "had to be**

higher that 18 to 23 ft re MLLW (about 14 to 19 ft re MSL) for about the past millennium. *(PG&E Report Pg. 9-32)*

- **The tidal range of 10 ft used in the GeoEngineers' report appears excessive as discussed earlier. *(PG&E Report Pg. 9-39)***

- **The PG&E report estimates the open-coast run-up height based on various analyses. They state that a CSZ magnitude 8.8 earthquake would result in a run-up of 31 ft re MSL. This elevation is used by GeoEngineers to support their estimate of 20 ft re MSL plus a factor of safety of 50% resulting in a safe elevation for structures of 30 ft re MSL. *(PG&E Report Pg. 9-39).* (As mentioned earlier this question will be discussed by us in Section II of this report.)**

The statement is made on Page 6 of the GeoEngineers' report (October 17, 2006) that based on a literature review the expected run-up (not inundation) for a Magnitude 9 earthquake on the CSZ is approximately 31 ft re MSL which they state is at the middle of the range developed by PG&E.

- **It is not clear what literature was reviewed by GeoEngineers to arrive at this estimate other than the thesis of Leroy (1999) and the PG&E report of 2002.**

The GeoEngineers' report speaks of an attenuation factor of a tsunami of 95% in the Samoa Town Master Plan area.

- **In our opinion this is speculation. Based on these estimates the elevation of the lowest habitable floor was given as 30 ft MSL. It is our opinion that with little knowledge of the dissipation mechanism for tsunami flow overland it is reasonable not to consider attenuation due to surface effects.**

It is stated by GeoEngineers that the estimate of inundation would be placed on a firmer base by conducting numerical model studies.

- **The results of the limited numerical investigation by us using currently available topography of the study area are presented in Section II. (Any more comprehensive numerical study would have to be conducted under a separate contractual understanding.)**

II. NUMERICAL MODELING OF SCENARIO EVENTS

In order to assess the validity of the tsunami inundation and runup levels used in the vulnerability report we conducted a numerical modeling study of tsunami inundation in the Humboldt Bay region for two seismic sources.

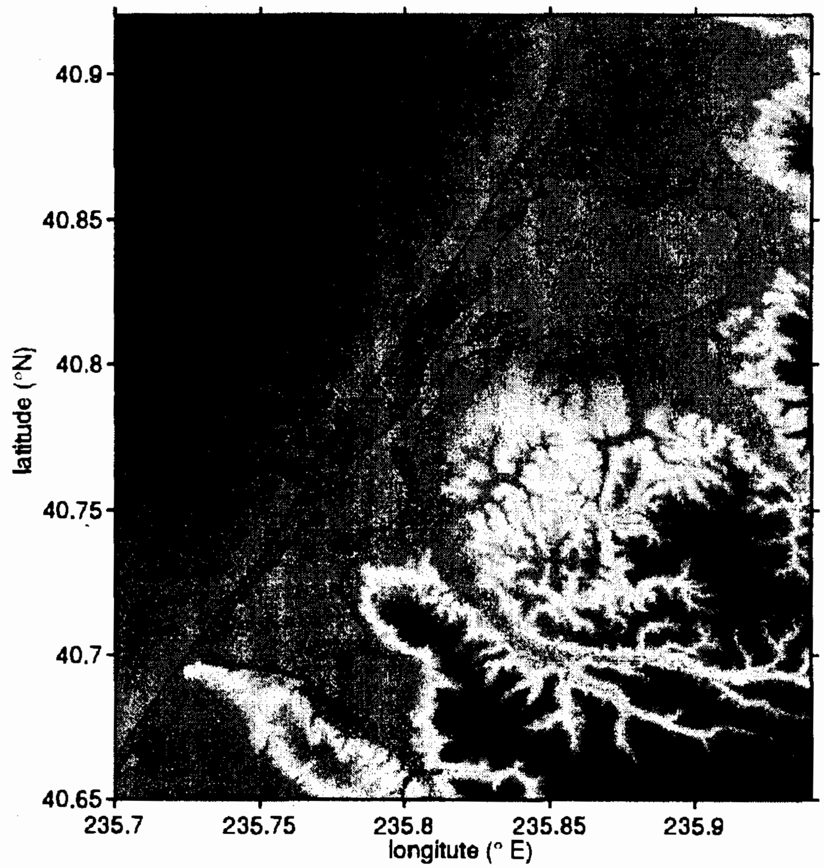

Figure 1: Map showing the region considered in the numerical model. The star indicates the study site.

The Numerical Model

Numerical modeling of tsunamis consists of three parts; generation, propagation and coastal effects that include runup and inland inundation. We assume an instantaneous, static initial condition of the water surface calculated from the earthquake displacement field using Okada [1985]'s model for a fault rupture at depth. For tsunami propagation and runup, we use the model MOST, which solves the 2+1 non-linear shallow water wave equations in rectangular or spherical coordinates (Titov and Gonzales, 1997 and Titov and Synolakis, 1997). Runup calculations are performed using a moving shoreline algorithm to evolve the wave front over dry land (Titov and Synolakis, 1998). Runup and inundation are computed over the post earthquake deformed topography.

We used a system of three nested grids. The bathymetry and topography data were merged in a GIS from the highest resolution and re-gridded to a uniform 1-arc second (~25 m) resolution. The nested grid configuration allows for more efficient computation of propagation in areas where local runup is not of interest. The outermost grid was re-sampled to a resolution of 30-arcsec, the intermediate grid to 15-arcsec, while innermost grid down to 1-arcsec (23 by 31 m at 41.7° N). Details of the multi grid computations are discussed in Borrero et al. [2001, 2005].

Seismic Sources

We modeled two faulting scenarios to assess the local tsunami hazard from a CSZ rupture. The first scenarios was a $M_W = 8.5$ event based on the SP1 source described in Bernard et al., 1994 for a rupture of the southern segments of the CSZ and including slip partitioning on the Little Salmon Fault. We also consider a second scenario with $M_W = 9.0$ which is similar to the hypothesized 1700 AD event described in Satake et al. [2003] combined with the model of Bernard et al. [1994]. For the northern part, the fault area is 800 km by 100 km with a uniform slip of 8 m. The southern part is made up of multiple faults per Bernard et al. [1994] and it is identical to SP1. The associated deformation fields for these scenarios are shown in Figure 2 with the detailed faulting parameters for each listed in Table 1. The two scenarios are essentially the same for the southern segments of the CSZ. The difference in magnitude is made up in the 9.0 event by extending the rupture northward some 800 km.

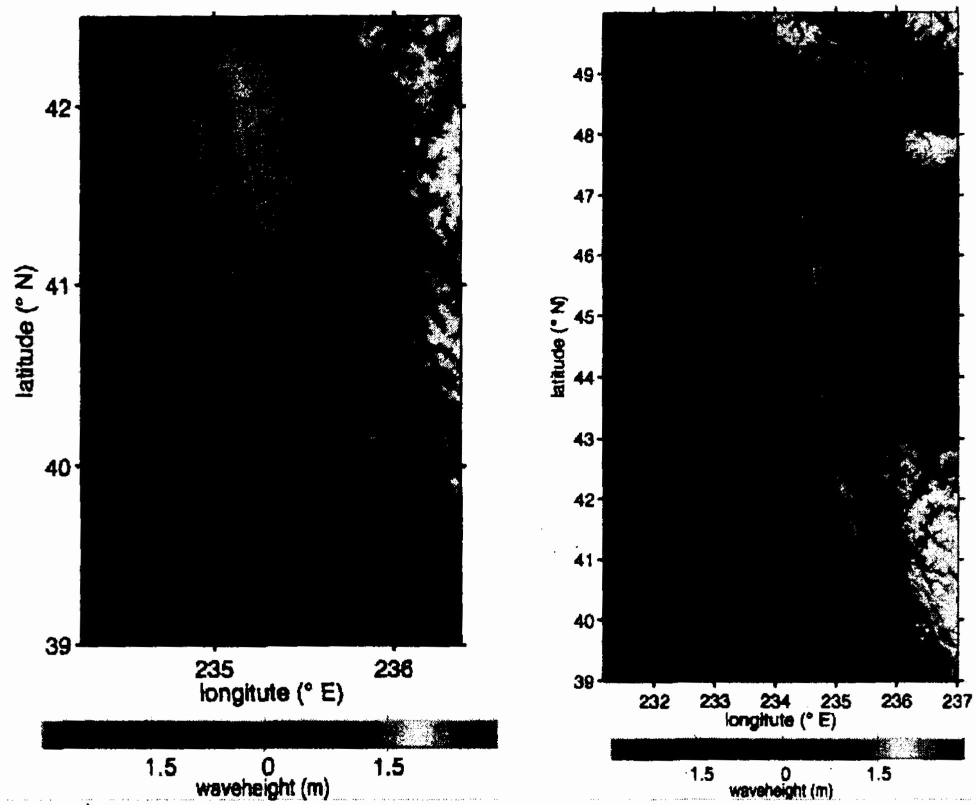

Figure 2: Initial surface deformation for the two scenarios modeled. $M_W = 8.5$ on the left and $M_W = 9.0$ on the right.

Tsunami Source	L (km)	W (km)	disp (m)	M_W
SP1	----	----	----	8.5
segment 1	150	30	4	
segment 2	150	10	4	
segment 3	150	70	8	
segment 4	90	30	4	
segment 5	90	70	8	
segment 6	90	10	4	
Extended event	----	----	----	9
SP1	240	100	6.6	
extension	800	100	8	

Table 1: The detailed faulting parameters of the two scenarios used in modeling. M_W = 8.5 scenario is consist of six segments and M_W = 9.0 uses eight more additional segments to extend the rupture towards north.

The Numerical Model Results

Inundation

Figure 3 – 10 compare the model results obtained from the two scenarios. Figures 3 – 6 are for the M_W = 8.5 event, while Figures 7 – 10 are for the M_W = 9.0 event. Figures 3 and 7 shows the inundated areas, the depth of the inundation over land and the overall runup for each of the two scenarios. For each of the cases modeled the proposed Samoa Town Master Plan area was not inundated. Our model suggests that for these events the dunes on the northern sand spit are high enough to prevent inundation directly from the sea. This is shown in Figures 5 and 9. These figure show cross sections of maximum tsunami wave height plotted along with the local topography. The profile number is shown at the top of each figure, and the location of each profile is presented in Figures 4 and 8 for the two different tectonic events.

It is also interesting to note that the region is not inundated from the lagoon side either. In addition, animations of the time histories of water levels from the numerical simulations do not show this area being flooded. We attribute this to the degree of local co-seismic uplift which is incorporated into the model. Because the ground level was raised during the seismic event, the end result is that waves which would have otherwise inundated the area are unable to flood over the new land level. This effect was observed in recent tsunami events such as the March 28, 2005 Nias-Simeulue tsunami where local ground uplift was on the order of 2 – 4 m. Thus, the amount of uplift associated with the CSZ earthquakes is important to the inundation process, and this will be discussed later.

Figures 6 and 10 show time series histories of water levels on either side of the North Spit. The time histories are shown relative to ground levels before the earthquake event, i.e., no assumed coseismic uplift of the North Spit is considered. The time series are taken from locations in water that is deep enough so the full cycle of the wave can be observed, i.e., Gage 1 was located at 7.6 m depth and Gage 2 was located at 4.55 m depth. Both sites are uplifted about 1.2 m during the earthquake.

Model Caveats

While these two specific scenarios do not produce destructive levels of inundation at the study site, this should not be interpreted as an indication that this site is safe from all possible tsunami events. This simulation depicts the results from a very specific set of conditions and assumptions. Real tsunami events are by nature extremely variable and unpredictable.

This is stated very clearly in the 1994 Bernard et. al. report when they note that due to averaging in the determination of fault plane solutions, "tsunami wave amplitudes will be much higher than a fault plane generating mechanism might indicate". Furthermore, the PG&E study states: "Potential tsunamis from the Cascadia subduction zone could generate wave runup along the open coast at Humboldt Bay. The height would probably be greater if the earthquake also triggered one or more large submarine landslides off the adjacent coast; however, no evidence of such larger, landslide-generated tsunamis in the past 2,000 and probably the past 3,600 years has been found in Humboldt Bay". It is impossible in this study to properly account for all of the potential variables inherent in tsunami inundation; submarine landslides are one potential variable.

The PG&E study summarizes that tsunami wave heights from a large rupture on the CSZ would be on the order of '30 – 40 feet'. A tsunami of this height would overtop the southern spit but not overtop the northern spit. The possibility of a large coseismically induced landslide cannot be ignored. There is evidence of extremely high runup values (66 – 69 feet) at Orick, located to the north of Humboldt Bay. The reason for the extremely high runup here is not known. An enhanced tsunami caused by a coseismic landslide or bathymetric focusing are two possibilities.

The PG&E report notes that "recent detailed bathymetric mapping of the Cascadia continental margin has revealed several enormous landslide masses off shore of Oregon that have features interpreted as indicative of large and sudden movements of thousands of square miles of the lower continental slope" "The presence of these large offshore submarine landslides suggests a mechanism for generating anomalously large tsunamis at infrequent intervals" They go on to state that "no geologic evidence for such tsunamis has been found in the late Holocene coastal stratigraphy in northwestern California or other places along the Cascadia coast".

Chapter 9 of the PG&E report gives an overview of tsunami modeling efforts performed for this region and compares these results to runup data from observed tsunamis throughout the world. One must be careful in interpreting these worldwide results as runup is controlled to a first order by the local bathymetry. Based on empirical data alone, a tsunamigenic earthquake of magnitude 8.8 on the Cascadia subduction zone "would generate average maximum runup heights along the northern California coast of 31 feet MSL (35 feet MLLW). The runup range for magnitude 8.5 to 9.2 is 28 to 37 feet [32 to 41 feet MLLW])".

PG&E studied several different tsunami modeling studies performed for the Humboldt Bay area. The results are summarized briefly below.

1) **Wiegel, 1965** – ***postulated a tsunami runup of 25 ft form a locally generated magnitude 8 earthquake with a return period of 800 years***. PG&E state "He concluded, "Based upon present evidence, there appears to be little likelihood of the generation of a large tsunami in a region near Humboldt Bay." It should be noted that at the time of his analysis, in late 1964, the existence of the Cascadia subduction zone as a potential local tsunami source was yet to be recognized."

2) **PG&E, 1966** – "Using a Corps of Engineers procedure (Camfield, 1980) and Brandsma and others' ***maximum tsunami wave of +5.2 feet*** at a point offshore in water of moderate depth (600 feet), PG&E (1985b) computed the wave runup at the mouth of Humboldt Bay to be 16.1 feet above mean lower low water. This runup height would decrease as the wave propagated through the bay to the PG&E power plant site, although no quantitative analysis of the attenuation was done."

3) **Houston and Garcia, 1980 -** Predicted tsunamis for the west coast of the U.S. for flood insurance purposes. PG&E state "Houston and Garcia's (1980) ***100-year tsunami runup at the entrance to Humboldt Bay was estimated to be 10.6 feet above mean lower low water, and the 500-year tsunami runup was estimated to be 20.7 feet above mean lower low water.*** Similar to the above procedure, no specific analysis was performed to predict water levels at the power plant site itself."

4) **Whitmore, 1993** – PG&E states: "In the numerical analysis by Whitmore (1993), Cascadia subduction zone source parameters were used to compute inundation wave amplitudes along the coast of Washington, Oregon, northern California, and adjacent areas to the north and south. The largest event analyzed was magnitude 8.8 that ruptured from central Washington to between Eureka and Crescent City. The fault rupture was 400 miles long, dipped 13 degrees, and the maximum seafloor uplift was 12 feet. At points along the coast opposite the modeled earthquake, the ***maximum computed tsunami amplitude was 19 feet***, with an ***average maximum amplitude of about 15 feet***. Maximum amplitudes were computed at three locations within Humboldt Bay (Eureka: 1.7 feet, Fields Landing: 0.66 feet, and Bucksport, between Eureka and Fields Landing: 2.8 feet). ***The maximum amplitude of 8.7 feet was calculated on the ocean side of the North Spit***, just to the south of the end of the modeled fault rupture."

5) **NOAA, Bernard et al., 1994** – PG&E State "The planned approach for the study (Bernard and others, 1994), included application of seismic source models for the Cascadia subduction zone to predict the generation of significant tsunami waves impinging on Humboldt Bay and Crescent City, followed by numerical modeling of inundation in these two areas of interest. ***The initial results of the seismic source modeling indicated the Cascadia subduction zone produced tsunami wave amplitudes that were judged to be unreasonably small.*** Therefore, Bernard and others (1994) evaluated the complexities of recent tsunamis generated by earthquakes in Nicaragua (1992), Indonesia (1992), and Japan (1993), and used an empirical approach to estimate the incident wave amplitudes at Humboldt Bay. ***Using tsunami observations associated with the 1964 Alaska and 1993 Hokkaido earthquakes, they judgmentally derived a 10-meter (33-foot) incident wave at a 50-meter (164- foot) water depth to be used in inundation models***.

6) ***Lamberson and others (1998)*** – As Described in PG&E, "Roland Lamberson, Professor at Humboldt State University, has developed, along with his students, a numerical tidal model calibrated for Humboldt Bay. During 1997, they performed a pilot study (Lamberson and others, 1998) to assess the feasibility of using their current finite-difference tidal model to simulate tsunami wave amplitudes and water velocities inside Humboldt Bay. ***They tested their model at low tide (0 set at mean lower low water), using an arbitrary input set of three large (4 to 6 meter amplitude) waves at the mouth of Humboldt Bay, having a period of 15 minutes.*** At the entrance to Humboldt Bay the third wave had the maximum wave height of 8 meters (26 feet MLLW). ***A wave overtopping the spits was not included in their model***, although the input wave clearly would have washed over the South Spit and the southern portion of the North Spit. In their model, the maximum flooding at the ISFSI site occurred during the second wave,

and had an elevation of 5 meters (16.4 feet) above mean lower low water. Current velocities at the ISFSI site were a maximum of 2 meters (6.6 feet) per second. Lamberson and others (1998) concluded their model performed well."

7) ***Myers and others (1999)*** – From the PG&E Report: "Edward Myers, a Ph.D. student, and a team of researchers from the Oregon Graduate Institute developed a finite element model for propagation of Cascadia subduction zone tsunami waves from their source near the plate interface off the coast of the Pacific northwest, to the coast. To generate the tsunamis, they used various rupture models for the Cascadia subduction zone as presented in Priest and others (2000). These models assume a geometry of the plate interface and vary the rupture dimensions by adjusting the locations and amounts of slip on the seaward and landward transition zones around a central locked zone. They estimated regions and amounts of seafloor uplift corresponding with each of these rupture scenarios, assumed the sea floor uplift was directly transferred to the sea surface as the initial conditions for their model. They then propagated the tsunami wave trains through their finite element grid toward the coast, and reported the estimated wave heights and run-up velocities associated with each of the scenarios. In their study, the authors reported their results for a number of locations along the coast from Cape Mendocino to the northern Olympic Peninsula. These results depend on a relatively coarse finite element grid, and are most useful to estimate tsunami-focusing mechanisms offshore, but are considered approximate for estimation of runup at the coast (A. Baptista, personal communication, 2002). The authors chose two sites for detailed estimation of runup characteristics: Seaside and Newport, Oregon. The finite element grid was much denser than the regional grid at these two sites to permit detailed estimation of runup routes, flow velocities, and runup heights. The authors report that predicted wave heights and runup velocities are very sensitive to grid density, reinforcing the notion that estimates of run-up outside of Seaside and Newport should be considered approximate. Furthermore, Dr. Baptista (Personal communication, 2002) reports that runup velocities predicted by these models are much less accurate than wave heights. ***This model predicts wave heights at the coast at Humboldt Bay between 17 and 30 feet (MLLW) and flow velocities between 3 and 13 ft/s, but they did not model runups within Humboldt Bay***. At Klamath, near Lagoon Creek, they predict wave heights between 17 and 46.5 feet (MLLW) and flow velocities between 6.5 and 15 ft/s, but preferably around 10 ft/s.

Finally the PG&E Report summarizes the tsunami hazard with the following statement: "The runup height from a local Cascadia-generated tsunami on the open coast at the mouth of Humboldt Bay is estimated to be as much as 30 to 40 feet above mean lower low water at the bay entrance. This estimate considers evidence of paleotsunamis at the North Spit, and assumes overtopping and erosion of the sand barriers and marsh at the South Spit. It compares well with the predicted runup height estimates from historical tsunamis in continental margin settings in Alaska, Chile, Peru, and Colombia, as well as runup estimates for paleotsunamis at Lagoon Creek and Crescent City."

Conclusion

We believe that the PG&E report is accurate and comprehensive. Our modeling supports the evidence that the north spit has not been overtopped by direct tsunami attack, however this does not mean that it can never happen, especially in the light of the extreme (~69 ft) rununp heights believed to have occured at nearby Orick and the horrendous effects of the 2004 Boxing Day tsunami in Sumatra. Furthermore, the particular source models we used for this preliminary study were based on the source models of Bernard et al., 1994, which the authors themselves remark may be too small to accurately represent the hazard. Larger events can be arbitrarily constructed that will result in larger runup and possibly overtopping of the north spit dunes, especially towards the southern end of the north spit where maximum dune elevations are lower.

Our judgement is that the 30 ft elevation for habitable floors for the Samoa Town Master Plan is conservative. This area is undeniably in a high risk area for tsunamis and earthquakes. Any future developments in this area, such as the Samoa Town Master Plan, should carefully weigh the tsunami hazard before allowing an increase in population density there.

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Titov, V. V., and F. Gonzales (1997), Implementation and testing of the method of splitting tsunami (MOST) model, Technical Memorandum ERL PMEL 112, NOAA.

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Numerical Model Results

$M_W = 8.5$ case

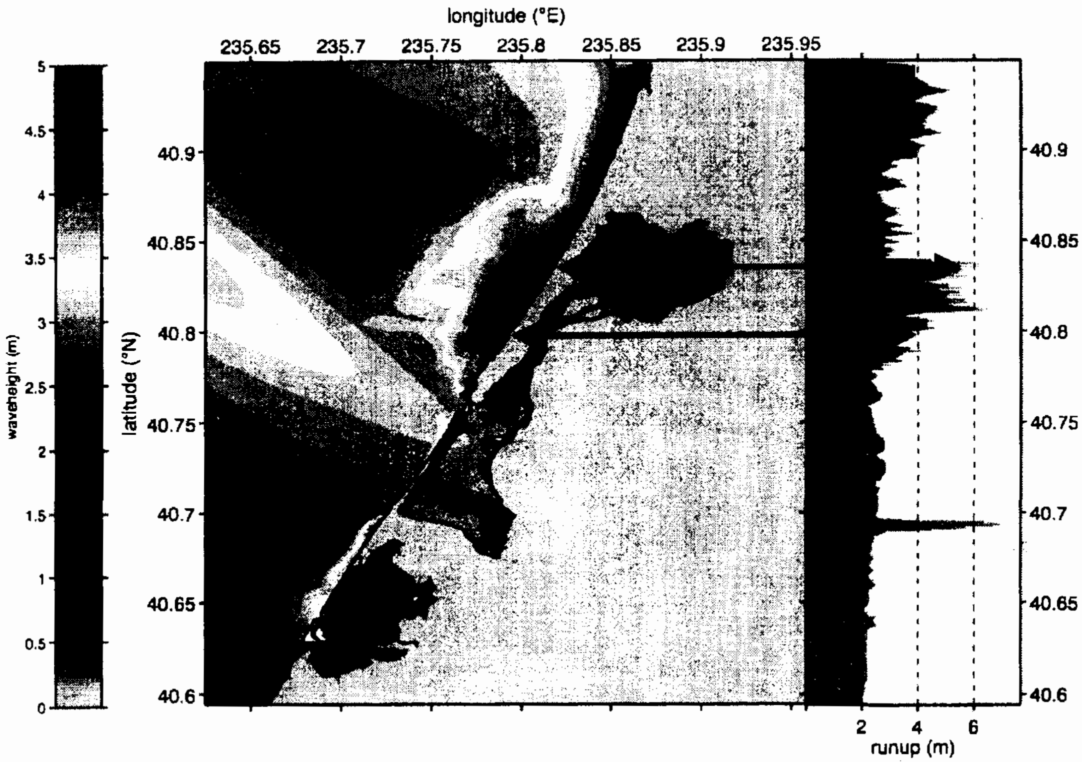


Figure 3: Maximum waveheights offshore, inundated areas and onshore runup for the $M_w = 8.5$ case.

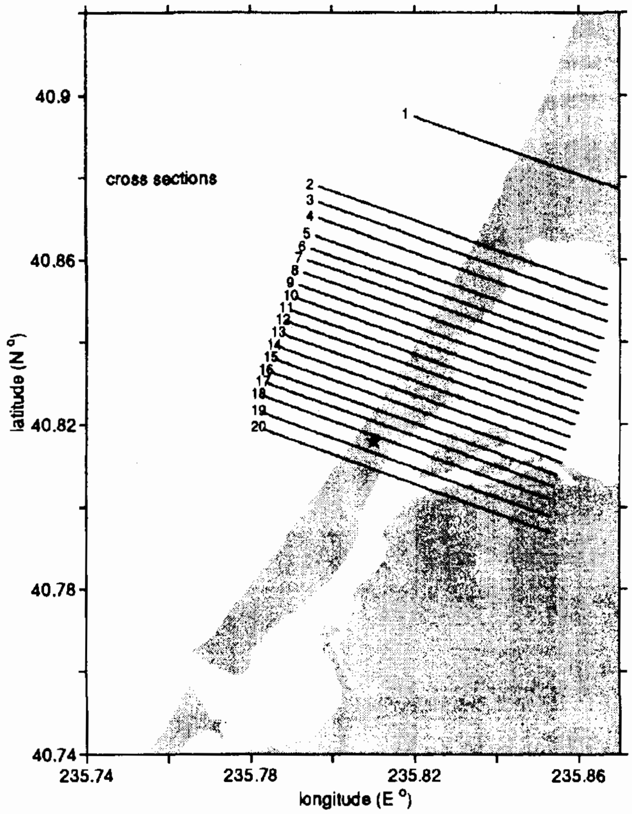
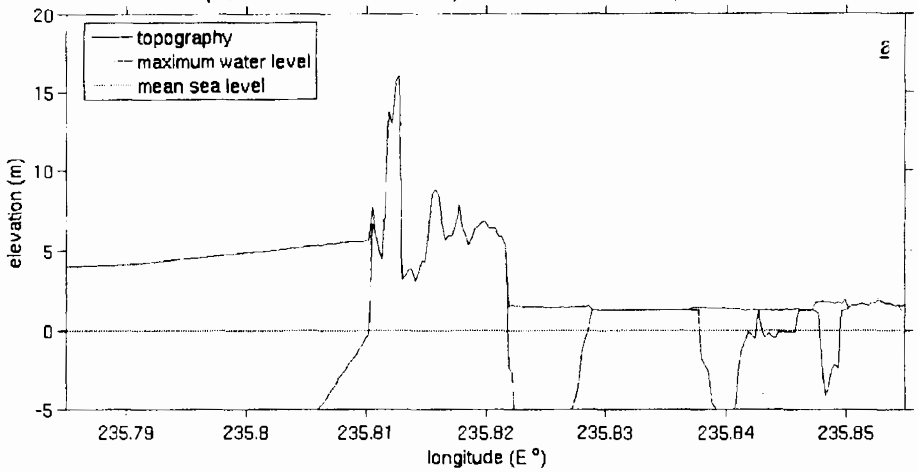
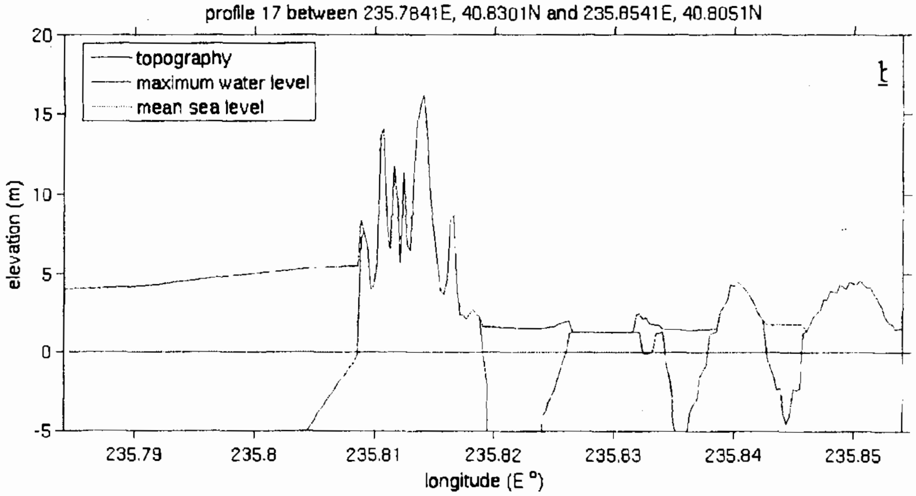


Figure 4: Locations of cross shore profiles. Profiles 16 – 20 cover the study area and are shown below for each case.

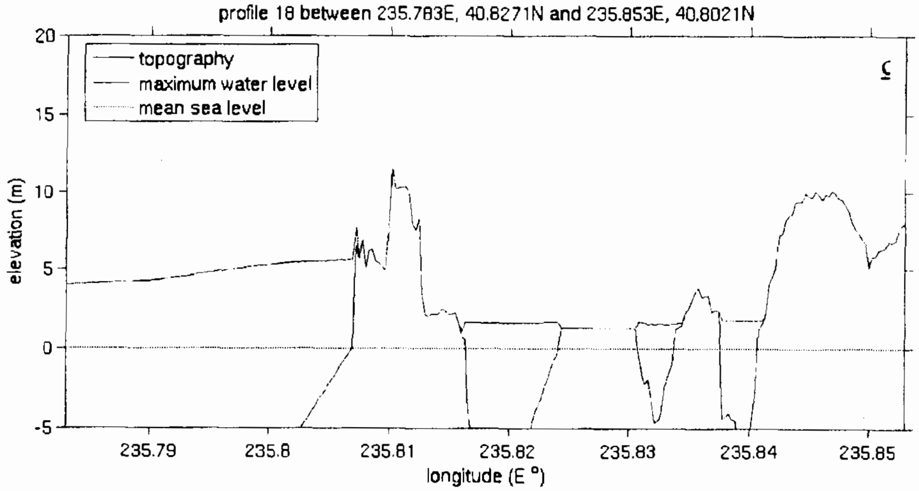
profile 16 between 235.7849E, 40.8329N and 235.8549E, 40.8079N



profile 17 between 235.7841E, 40.8301N and 235.8541E, 40.8051N



profile 18 between 235.783E, 40.8271N and 235.853E, 40.8021N



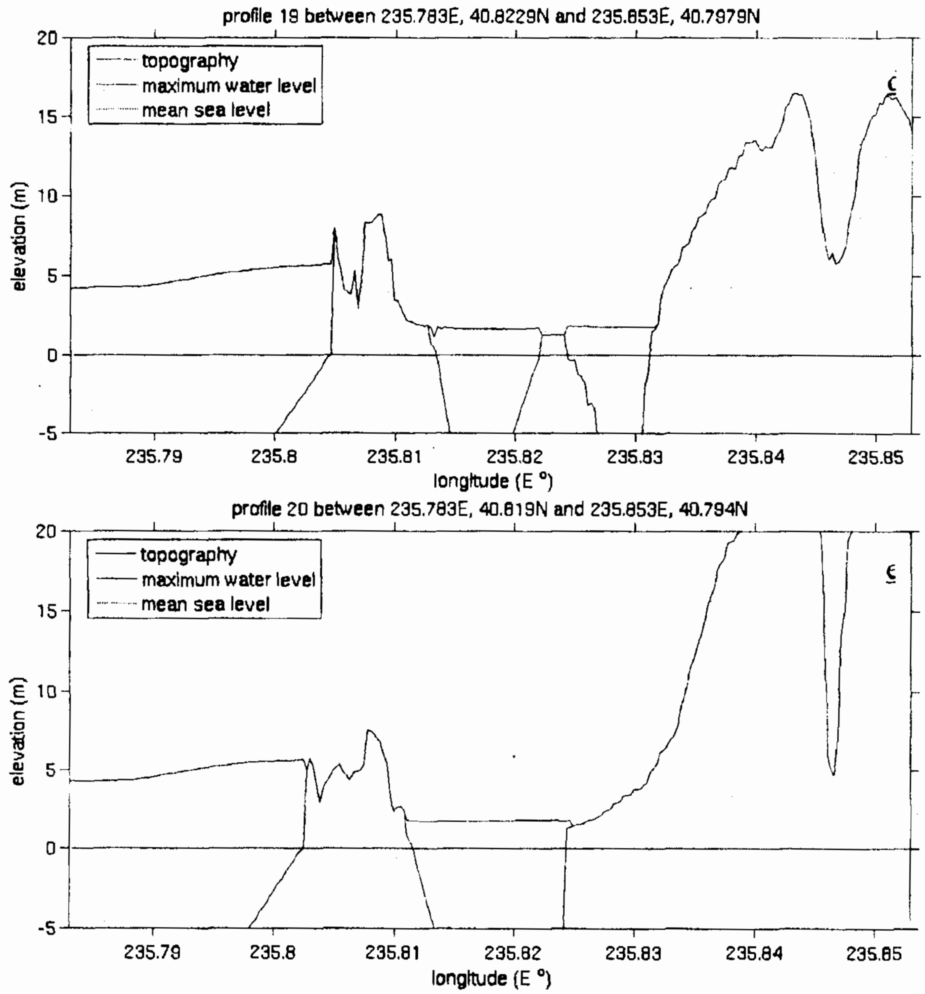


Figure 5 (a-e): Profiles of maximum water levels plotted against mean sea level and local topography for Scenario 1 ($M_W = 8.5$). Note how dune regions are not overtopped by tsunami surges approaching from the seaward side.

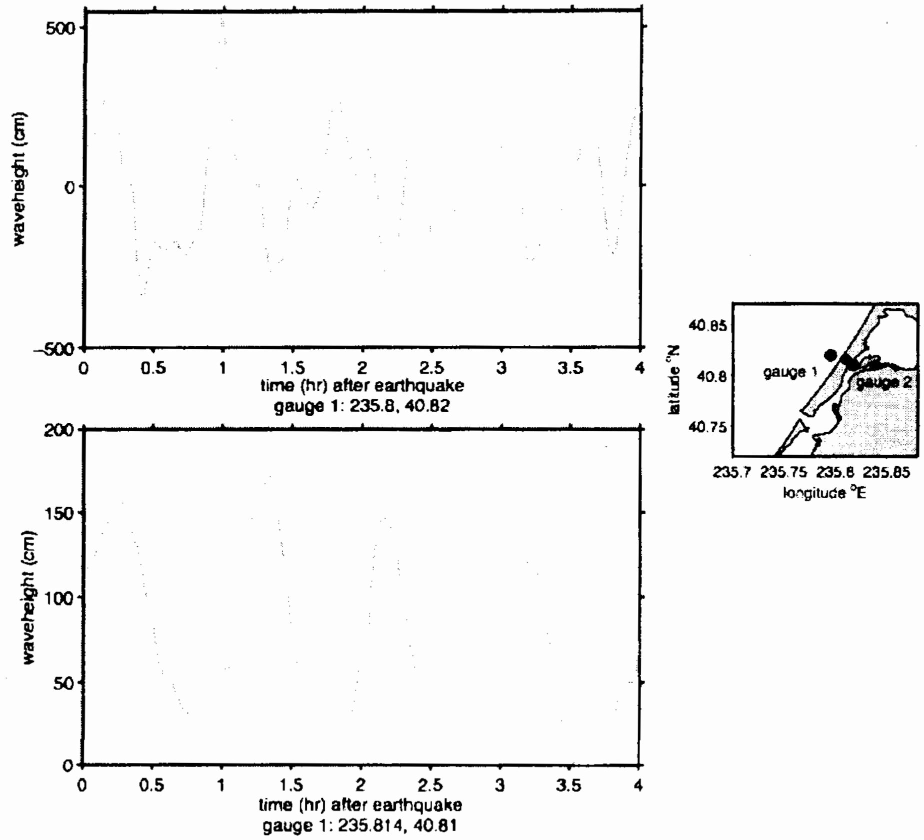


Figure 6: Time histories of water levels on either side of the north spit for the $M_w = 8.5$ event.

$M_W = 9.0$ Scenario

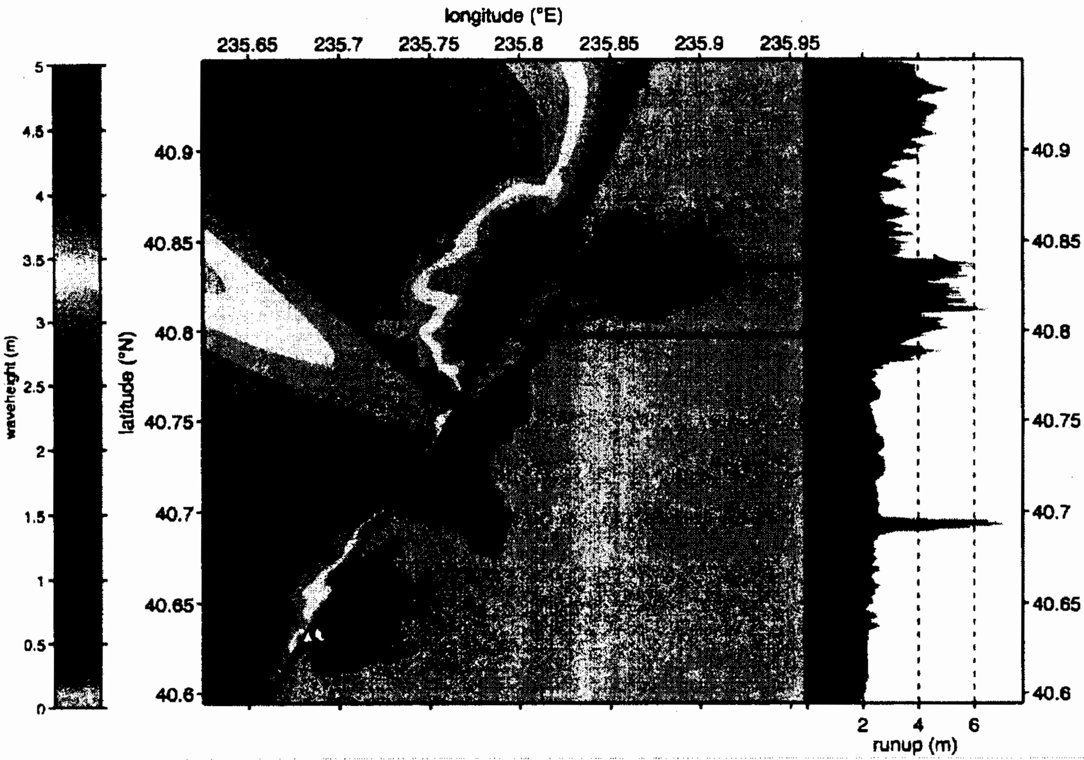


Figure 7: Maximum wave heights offshore, inundated areas and onshore runup for the $M_w = 9.0$ case.

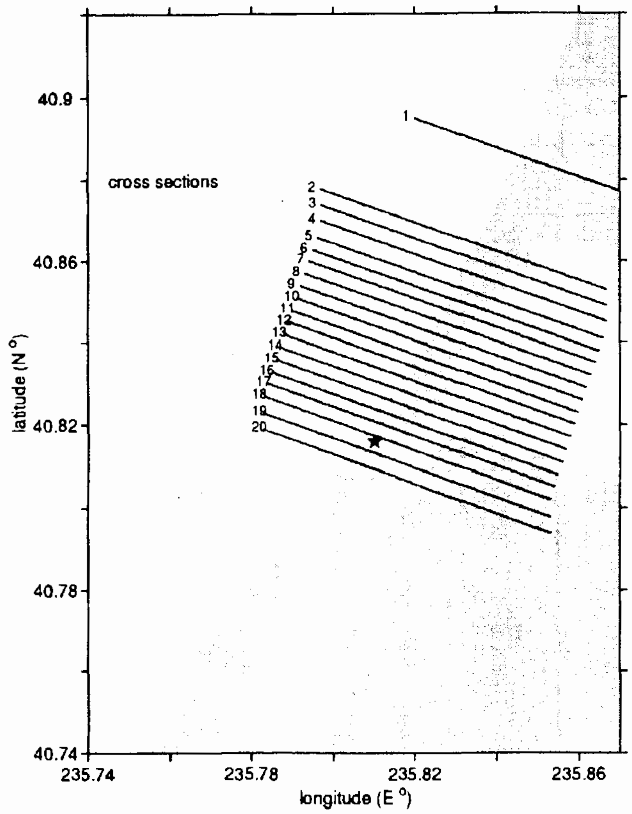
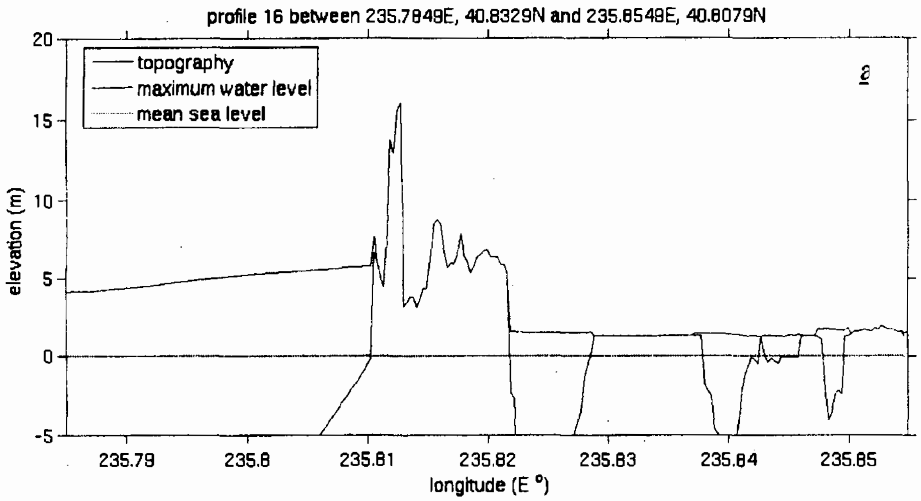


Figure 8: Locations of cross shore profiles. Profiles 16 – 20 cover the study area and are shown below for each case.


profile 16 between 235.7849E, 40.8329N and 235.8549E, 40.8079N
topography
maximum water level
mean sea level
a
elevation (m)
longitude (E °)
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0
-5
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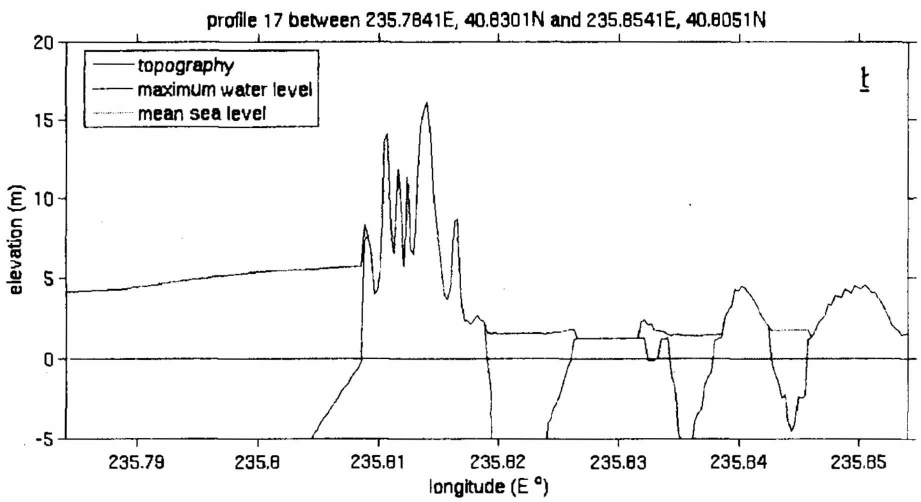
235.8
235.81
235.82
235.83
235.84
235.85


profile 17 between 235.7841E, 40.8301N and 235.8541E, 40.8051N
topography
maximum water level
mean sea level
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elevation (m)
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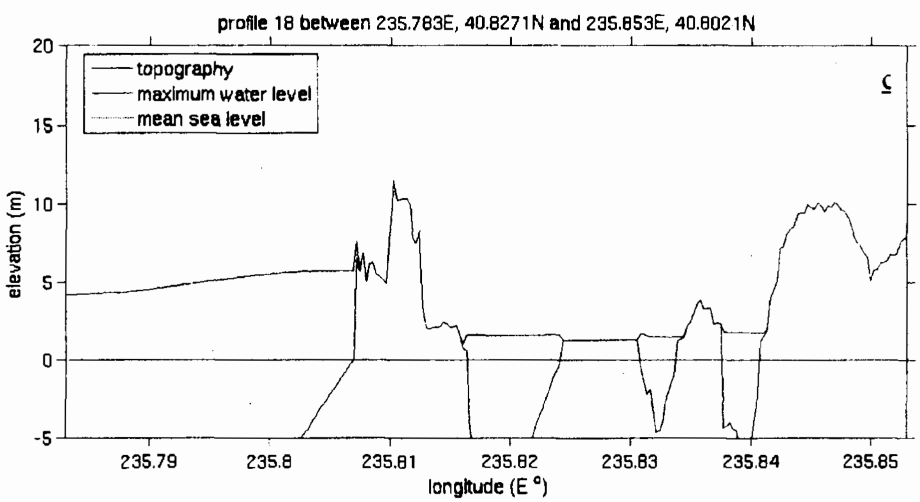
profile 18 between 235.783E, 40.8271N and 235.853E, 40.8021N
topography
maximum water level
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235.85

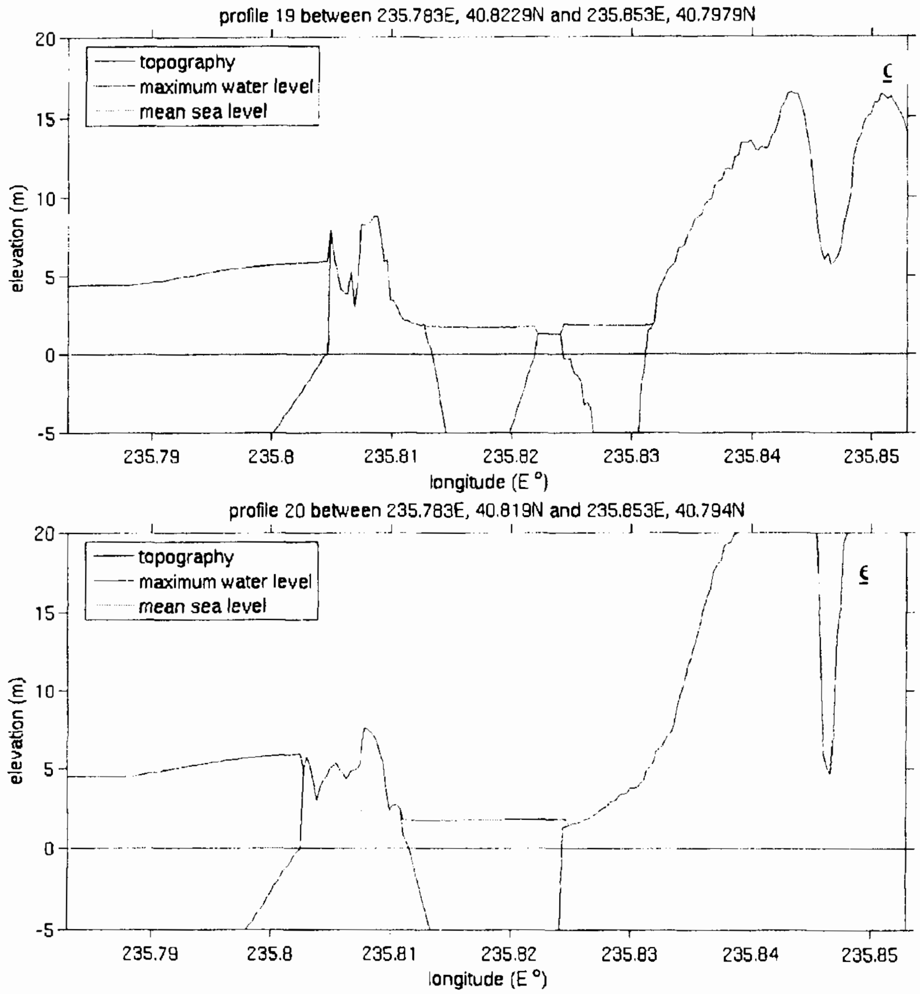


Figure 9 (a-e): Profiles of maximum water levels plotted against mean sea level and local topography for Scenario 2 (M_w = 9.0). Note how dune regions are not overtopped by tsunami surges approaching from the seaward side.

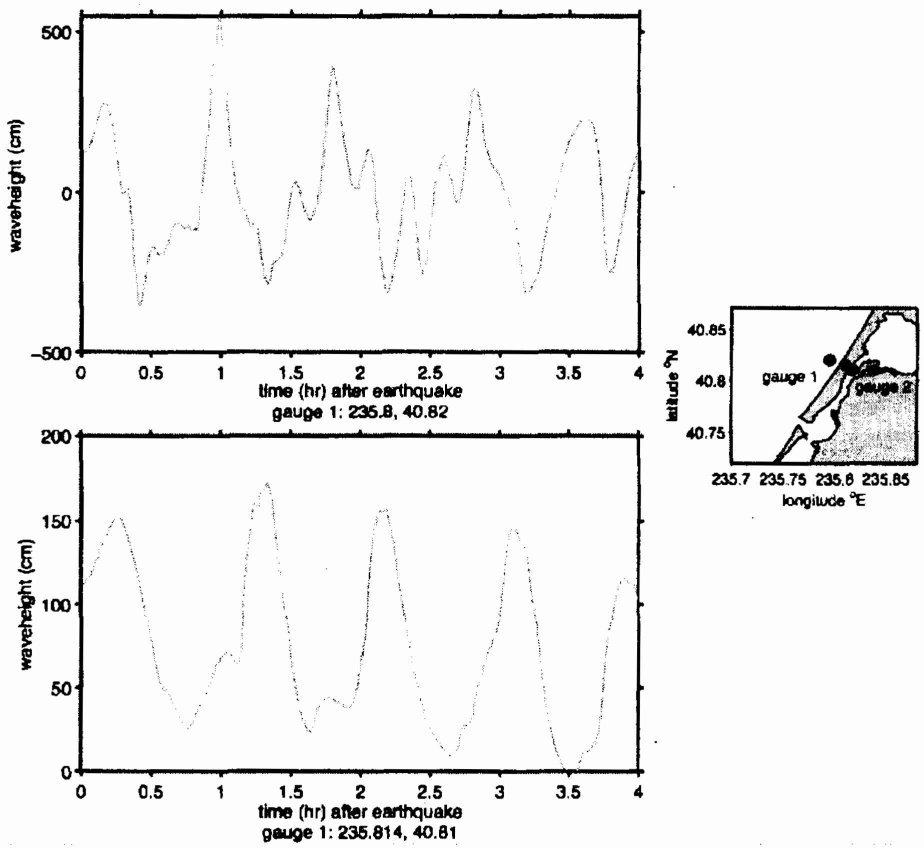


Figure 10: Time histories of water levels on either side of the north spit for the $M_w = 9.0$ event.

III. MITIGATION AND SAFETY

GENERAL

The Samoa Town Master Planning approach presents two types of mitigation strategies: a) measures to minimize damage and b) measures to promote safety.

MITIGATION MEASURES

As discussed by the State of California Seismic Safety Commission (2005), there are no U.S. building codes that provide design guidelines to reduce or prevent damage to structures from tsunami hazards. They contrast differences expressed in FEMA's Coastal Construction Manual (FEMA 55) and the National Tsunami Hazard Mitigation Program "Background Paper #5: Building Design" with respect to the feasibility of designing for tsunami impacts. While the FEMA publication states it is impractical, the National Tsunami Mitigation Program paper suggests that proper design can significantly reduce the impact of a tsunami on buildings. This paper also reports that only the City and County of Honolulu have implemented building requirements for tsunami. In lieu of appropriate building codes for the design of structures, avoidance of the hazard by siting structures above the anticipated runup elevation is suggested.

Although there is no established building code for tsunami mitigation, studies of damage from historic tsunamis indicate that building survivability varies with construction type (Yeh et al., 2005). The data show that wood frame construction experienced considerable damage and was frequently destroyed even when the tsunami inundation was small, even only a few feet deep. On the other hand, well-engineered reinforced concrete structures sustained only minor damage for most cases. Recent data, including those of the 2004 Indian Ocean Tsunami, support this conclusion. (Ref: Yeh, H., Robertson, I., and Preuss, J., 2005, Development of Design Guidelines for Structures that Serve as Tsunami Vertical Evacuation Sites, Open File Report 2005-4, Washington Division of Geology and Earth Resources, State of Washington (contract 52-AB-NR-200051), Olympia, Washington.)

The recommendation of siting all structures above the anticipated inundation elevation does not guarantee the safety of the area. It is because the prediction of inundation cannot be made accurately, as we discussed in Section II. Although the west side of the Samoa Town Master Plan site seems protected by dunes, there are several weak spots with marginal elevations as low as 20 ft (6 m). Once a tsunami penetrates such spots, the breached channels could be widened due to scouring action and the currents may rush into the town with significantly speed. Therefore, the entire area of the Samoa Town Plan must be designated as a tsunami risk

zone.

Critical for the protection of the populous is to provide a sufficient number of strategically located tsunami refuge structures (= assembly sites as described by GeoEngineers). Vertical evacuation to the refuge structures should save lives not only for the residents, but also for beach visitors.

Tsunami refuges can be multi-use or stand-alone structures. For example, the new Emergency Services building (recommended by GeoEngineers), Check-in Registration Building near New Navy Base Road, some of the buildings in Business Park and other public facilities can be considered as the multi-use buildings used for vertical evacuation. An example of the stand-alone structure is shown in Fig. 1. Those buildings must be reinforced concrete or steel frame structures in accordance with the proper seismic code, providing sufficiently high elevation of the refuge floor. Because of the locality, careful consideration must be made for their foundation design to protect against tsunami-induced scour and liquefaction caused by the ground shaking.

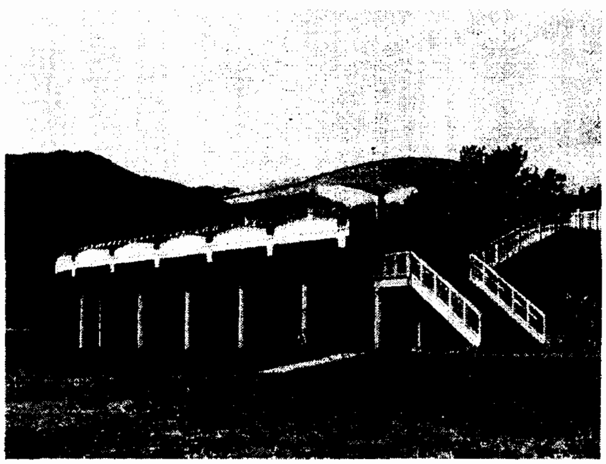


Figure 1 – Tsunami Shelter at Shirahama Beach Resort (Photo by N. Shuto)

Because accurate tsunami behaviors are difficult to predict, tsunami risk areas should be planned so as to provide individuals with every possible opportunity to escape under unexpected circumstance. With such considerations, the reviewers suggest that no fence for the residential houses be allowed in the township (even if allowed, they must be very low picket fences) and the Samoa Town Master Plan area must be graded so that there will be no spot where the grade is steeper than 1V:2H.

Guidelines for Single-family Use

Planning criteria were developed for uses that could prevent potential life loss. Single family occupancy use (lowest habitable floor) will be restricted to above Elevation 30 feet MSL.

Guidelines for Multi-family Use

Habitation uses will be located above Elevation 30 feet msl. In the case of multi-family and resort use buildings the first floor level can be used for non-residential use such as parking. Residential use could occur on the second story.

> **The 30-ft criterion for the maximum tsunami elevation was made by imposing a safety factor of 1.5 to the estimate of the maximum tsunami elevation: the 1.5 safety factor was determined arbitrarily without clear justification.**
>
> **Our numerical simulation for the CSZ events of M_W 8.8 and 9.0 also shows that the maximum tsunami elevation at the ocean-side beach would be approximately 20ft. This agreement with the GeoEngineers' report provides some confidence in their proposed tsunami mitigation elevations.**

Guidelines for Public and Critical Facilities

It is recommended that critical facilities be constructed above Elevation 40 feet because they are centers of population concentrations and/or may be necessary for first response and recovery.

MEASURES TO REDUCE TSUNAMI AMPLITUDE AND VELOCITY

Anecdotal evidence from recent tsunami events including the December 26, 2004 Indian Ocean Tsunami strongly indicates that natural features such as off shore reefs, dunes, dense forested areas and wetlands help to reduce both velocity and inundation. In India, there were reports that dense stands of mangrove forests provided protection and helped to reduce velocity and run up elevations. Conversely, there were numerous reports, such as multiple communities in Sri Lanka, that compared the high damage levels experienced by communities where there had been destruction of dunes and off-shore reefs, with low (or even no) damage levels in communities where such features were present.

> **The above statement is simply a general trend and should not be emphasized. In fact, there are many exceptions found from field observations. Tsunami behaviors are complex and cannot be generalized especially when considering the height of damaging tsunami waves.**

Preservation and/or enhancement of eco-system features by Samoa Town Master Plan to reduce tsunami wave effects include:

- Dune Preservation

  No development is proposed west of New Navy Base Road.

  Designated pathways and trails to Samoa Beach will be constructed in order to avoid creation of non-designated trails. This measure will be stipulated as a condition of subdivision approval.

  Interpretative signage at the parking areas to inform recreation users of sensitive biological resources in the plan area. This measure will be stipulated as a condition of subdivision approval.

The parking area along Navy Base Road appears a weak spot where tsunamis may penetrate. There are a few more low-elevation spots along the dune (west side of Navy Base Road) because of the existing access trail to the beach. Careful considerations must be taken to design the escape routes for beach goers.

- Vegetation

  Preservation and enhancement of vegetation in dune areas adjacent to New Navy Base Road and elsewhere will strengthen existing dunes and reduce likelihood of degradation. Plantings will both reduce effects of tsunami while contributing to soil stabilization. Details are provided in the EIR.

  For proposed Natural Resource and Public Recreation areas, a vegetation planting plan will be developed to reduce the potential for mobilizing large woody debris that could impact structures below the 26 foot elevation. Planting of deep rooted species such as shore pine and shrubs instead of Eucalyptus trees (which are very brittle) in these areas would reduce potential impacts. Also, some species of Eucalyptus trees are highly flammable. Removal of "danger" species within the plan area is proposed.

The reviewers are puzzled by the criterion of elevation 26 ft that was made for floatable debris. How did the authors determine this elevation?

- Wetlands

  Wetlands create added opportunities for friction as well as for water detention.

  Existing wetlands on the site will be expanded.

  To improve the functional value of the two small wetlands adjacent developed dunes will be restored to native landscapes, fill material will be removed and native vegetations will be panted within the setback area.

SAFETY MEASURES

Because of the concern about the need for public education to promote evacuation and safety planning for a locally generated tsunami from the CSZ, Bernard et al. (1994) completed inundation modeling of a hypothetical wave to evaluate regional impacts to northern California. For Humboldt Bay an offshore wave height of 30 feet (approximately 10 meters) in water 150 feet deep was assumed. The model used a relatively coarse grid with spacing 100 meters and a topographic elevation model that assumed regular/even topography. As such it was unable to take into consideration the effects of dunes and other irregularities characterizing the Samoa Peninsula. The modeling results where used as the basis for a planning scenario of a great CSZ earthquake along the North Coast of California (Toppozada et al., 1995).

More recent safety planning efforts (Lori Dengler and Jay Patton (estimate: 2005) refined the expected tsunami hazard (See Appendix A of this document). This document (like the previous effort) clearly states that it is to be used only for emergency planning purposes; it is not intended to be used for site design. It is also not clear if the authors adjusted the zonation to reflect mean sea level (msl) versus mean low low water (mllw) used for the studies that their map was based on. Dengler and Patton (2005) report that over 150 paleotsunami sediment core samples have been taken along the margins of the bay and in the Mad River Slough. The only places where identifiable tsunami sands have been found are in the South Bay region immediately adjacent to the spit and in the Hookton Slough area.

Safety aspects of the Samoa Town Master Plan are intended to maximize response effectiveness and evacuation opportunities. Four types of Safety Measures have been proposed:

Central location chosen for the Emergency Services Vehicle Storage Facility

The facility housing the Emergency Services Vehicles is centrally located with respect to harbor facilities and to expected response demands. It should be constructed at or above Elevation 40 feet. In the event of a tsunami the vehicles will be removed from the storage facility to assist with response. The building will then become available for assembly.

Designated Assembly Sites

Assembly sites are safe buildings above the expected tsunami run up elevation where people could take refuge and remain until they are notified that it is safe to leave. Assembly sites should be buildings that have sanitary facilities and be large enough to accommodate refugees for several hours. The assembly sites should be located so that people can travel by foot within approximately 5 to 8 minutes.

> **Locations of the assembly buildings must be determined based on the expected tsunami arrival times. Our preliminary numerical simulation indicates that the first tsunami could arrive within 10 minutes after the CSZ earthquake but the largest would be the subsequent wave that would arrive 1 hour after the quake. Also accessibility for handicapped persons must be considered in the design of assembly buildings.**

Specific sites meeting these criteria should be completed during preparation of the Safety Plan and following completion of the peer review. We understand the peer review may include tsunami inundation modeling which could help refine locations of potential evacuation sites.

At this time, we understand that the new Emergency Services building has been identified as one structure to be used for shelter. Therefore, we recommend that the floor elevation for assembly at the new Emergency Services building be constructed above Elevation 40 feet MSL.

> **It is not clear if the ground elevation of the new Emergency Services building should be above 40 ft MSL, or that of the upper floors that will be**

used for evacuation. It must be emphasized that there must be multiple assembly sites; the Emergency Services building alone is insufficient.

In addition, use of the proposed water tower will be prohibited for vertical evacuation because of its proximity to the commercial gas station and potential for a fire hazard. Signage will be installed.

It appears that the location of the Emergency Services building is currently planned right next to the water tower and the same block as the gas station.

Evacuation Routes

Strong ground motion from the earthquake essentially constitutes the warning from a CSZ earthquake. Based on this assumption the amount of time available for evacuation will be very short. An evacuation route plan will be prepared for the plan area which will include information on tsunami warning devices. The plan will be kept on file at the Samoa Peninsula Fire department (SPFD) in the Samoa Block Building. Key SPFD emergency services personnel shall be trained in tsunami evacuation procedures. Throughout the plan area, directional signage will be posted on designated paths that show non-vehicular evacuation routes to designated assembly sites.

Both the residents and visitors must be considered for evacuation planning. This means that the Samoa Town Master Plan should include the evacuation routes from the beach area.

Safety Plan

A Tsunami Safety Plan will be submitted the County as a condition of subdivision approval.

- The tsunami evacuation plan, including designated routes will also include information on tsunami warning devices and techniques and a public information and education program targeted at Samoa residents and visitors.

- The applicant will submit a proportional share of the fee towards a fund for the installation and maintenance of a warning siren in the town of Samoa. (If funding for a warning siren becomes available prior to the collection of sufficient funds from each newly proposed residence, the fund can be used for tsunami education, identification of evacuation routes, signage and subsidized weather radios to residents of Samoa.)

The Safety Plan should include annual evacuation drill and the Plan should be reviewed and updated annually.

General Samoa Site Location

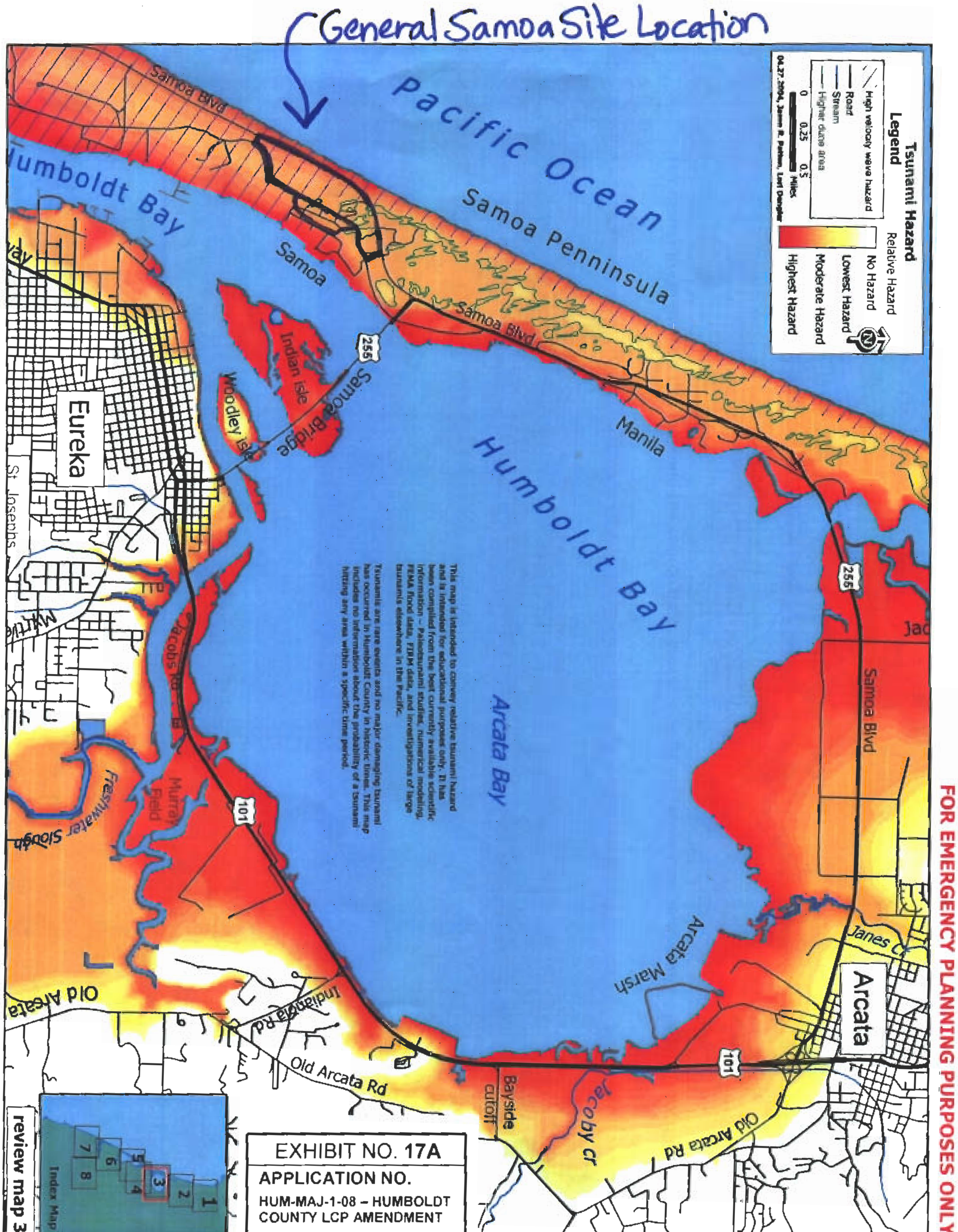


EXHIBIT NO. 17A

APPLICATION NO.

HUM-MAJ-1-08 – HUMBOLDT COUNTY LCP AMENDMENT

TSUNAMI HAZARD MAP HUMBOLDT BAY AREA – EMERGENCY PLANNING

Town of Samoa, California

Draft
Tsunami Safety Plan

EXHIBIT NO. **18A**

APPLICATION NO.

HUM-MAJ-1-08 – HUMBOLDT COUNTY LCP AMENDMENT (SAMOA TOWN PLAN)

COUNTY DRAFT TSUNAMI SAFETY PLAN

Lead Agency:

Humboldt County
Community Development Services Department

September 2007

Draft Samoa Tsunami Safety Plan

Lead Agency:
Humboldt County
Community Development Services

Contact:
Michael Wheeler, Senior Planner
Humboldt County Community Development Services
3015 H Street
Eureka, California 95501
MWheeler@co.humboldt.ca.us

This document printed on recycled paper

TOWN OF SAMOA
Draft TSUNAMI SAFETY PLAN
(September, 2007)

INTRODUCTION
The town of Samoa is located in Humboldt County in Northern California. The town site is on Samoa Peninsula which is the narrow (approximately 1 mile wide) sand spit north of the Humboldt Bay entrance between the Pacific Ocean and Humboldt Bay. Due to the low elevations and isolated location of the town there has been a Tsunami Vulnerability Report conducted on the area. The Vulnerability Report has helped identify the Tsunami Hazard Zone and the potentially safer elevations in the event of a large local earthquake and tsunami event.

The Samoa Town Master Plan is proposing a mixed use development for the town site including additional residential and light industrial uses. With the proposed increase in people residing, working are recreating in the Samoa Town area the need for a Tsunami Safety Plan becomes increasingly important for the safety of the existing residents and visitors as well as the future residents, visitors and businesses.

This Tsunami Safety Plan includes:

- Basic information about and potential generation of tsunamis affecting the Samoa Peninsula.
- Preparation measures for your family and business in the event of a tsunami.
- The community education involved in tsunami preparedness.
- Specific evacuation procedures, routes and maps for during and after a tsunami.
- Publicity and outreach and specific material available.
- Contact information for further information for all agencies involved in the event of a tsunami in the Humboldt Bay Region.

ABOUT TSUNAMIS

What is a tsunami and what causes tsunamis

A tsunami is a series of waves most commonly caused by an earthquake beneath the sea floor. They can be generated by earthquakes that occur locally or far away. If a large earthquake displaces the sea floor near the California north coast the first waves may reach the shore minutes after the ground stops shaking. *There would be no time for authorities to issue a warning.* Such large earthquakes can be generated by the Cascadia Subduction Zone (CSZ). A distantly generated earthquake may take hours for the tsunami waves to reach Humboldt County. In 1964 a magnitude 9.2 earthquake in Alaska generated a tsunami. As a result, a series of four waves took approximately 4 hours to reach Crescent City where 11 people were killed.

How do we know tsunamis have impacted the Samoa Peninsula

Geologic traces can help scientists identify past earthquakes (paleoseismic events) and past tsunamis (paleotsunami) that occurred prior to written records. Over 150 paleotsunami sediment core samples have been taken along the margins of Humboldt Bay and in the Mad River Slough. These samples indicate that earthquakes with tsunami have inundated the coastal area of Northern California, including the two CSZ events: one that occurred 300 years ago and one that occurred 1,100 years ago. More recently, on April 25, 1992, a magnitude 7.1 earthquake which generated a small tsunami occurred near Cape Mendocino near the town of Petrolia. Although not damaging, this earthquake confirmed the CSZ's capability to produce earthquakes that generate local tsunamis.

FAMILY AND BUSINESS PREPARATION

Assemble emergency kits

In the event of a distant tsunami when there is sufficient time to evacuate by vehicle take your emergency kit with you. Otherwise your Disaster Supplies Kit stays at your residence. ***Do not take your Disaster Supplies Kit when evacuating on foot in the case of a CSZ near tsunami event.***

(For Emergency Kit assembly, see Appendix A: American Red Cross Emergency Preparedness Checklist)

Help with tsunami awareness in your community

- Start a tsunami buddy system
- Make and distribute emergency packs
- Initiate or participate in a local preparedness program

COMMUNITY EDUCATION

Education and Curriculum

Education efforts by local authorities for the local residents and visitors are integral in minimizing tsunami damage and deaths. The Samoa Peninsula Volunteer Fire Department (SPVFD) will be responsible for maintaining basic emergency preparedness and tsunami awareness for town residence. The SPVFD will be involved with coordinating and conducting the twice yearly town evacuation drills to the Samoa assembly area.

A curriculum specific to the Humboldt County North Spit should be developed for the local Peninsula School. It is very important that this North Spit specific curriculum is provided in the school and throughout the community. Awareness is crucial in the effort to keep the local residents prepared for a tsunami event.

For tsunami education to be effective it must be implemented town wide and must be consistent throughout the year. Efforts with tsunami education should specifically be targeted at the younger generation. School age children will assimilate the information and are likely to retain it and pass it on to future generations.

Local educators will be developing a school curriculum, oriented to fourth and fifth grades, which will include:

- Printed materials for students
- Instructional materials for teachers
- Display materials for classrooms (thematic posters)

These curriculum materials will be distributed broadly in hazard areas.

For Samoa Peninsula Elementary, more specific North Spit materials/ training will include:

- Samoa Tsunami Ready Brochure
- Instructional materials for teachers
- Display materials for classrooms (thematic posters)
- Twice yearly evacuation drills to Samoa assembly area (see map)

EVACUATION

How do I know when to evacuate

The first clue is often a strong earthquake. ***If you feel strong motion you should immediately move to high ground***. If you notice unusual activity such as a sudden drop or rise in sea level it may be a warning of impending danger. Move to high ground or inland immediately. Often your only warning will be when the waves go farther out than normal.

Waves can kill and injure people and cause great property damage where they come ashore. If you are on the beach and feel an earthquake no matter how small, immediately move inland or to high ground. Get into the habit of counting how long the earthquake shaking lasts. If you count 20 seconds or more of very strong ground shaking and you are in a tsunami hazard zone (below 30 feet) move to high ground immediately.

The first wave is often not the largest; successive waves may be spaced many minutes apart and continue to arrive for several house. Do not return to low land until you are notified that it is safe. In Crescent City in 1964 several people who returned to the hazard zone after the third wave, were killed by the fourth wave.

For an earthquake that occurs far out in the Pacific Ocean the Alaska Tsunami Warning center will alert local NOAA officials who may order evacuation. If an evacuation is ordered the The Samoa Peninsula Volunteer Fire Department (SPVFD) will be responding for the town of Samoa. Isolated areas may not receive official announcement, so it is important to have a plan to evacuate.

How do I get inland or to high ground

When the earthquake is your warning, ***go on foot.*** A tsunami may be imminent and you will not have time to drive.

Evacuation Routes

Follow signs and arrows. The tsunami evacuation map indicates the tsunami hazard zone. The elevation above 30 feet is designated as the Low Tsunami Hazard Zone. However, there is one designated assembly area located at the highest possible elevation for all people in the existing town area to evacuate to. This assembly area is located up the marked trail in the wooded area located north of Fenwick Avenue on the uphill or northwest side of Vance Avenue at the water tank pads.

Evacuation Routes are clearly marked on the map by the red arrows. Roadways and pedestrian trails throughout the area are marked as evacuation routes with signs that look like this:

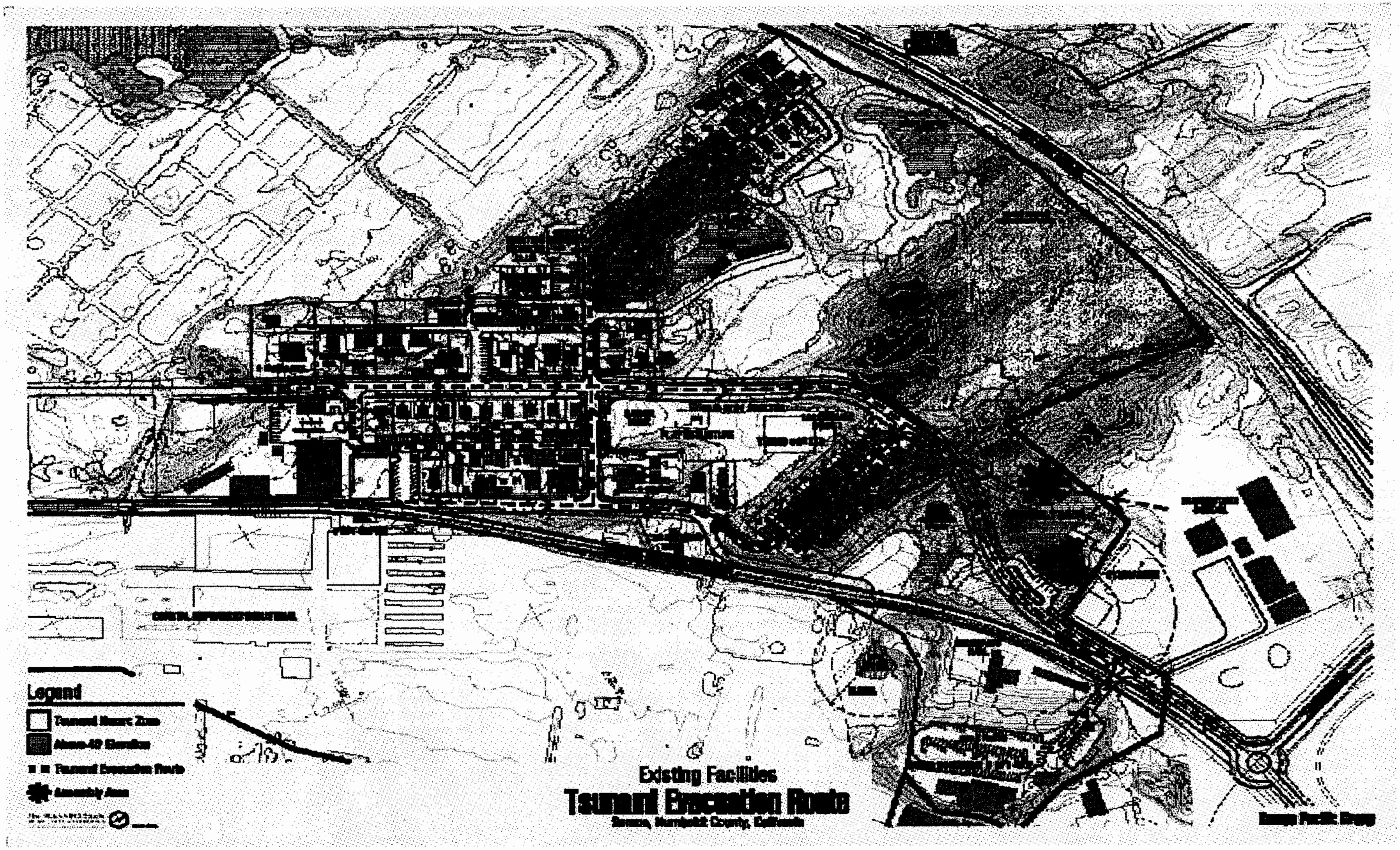
Signs will be strategically placed to ensure no confusion when people need to evacuation quickly. All route signs will have clearly posted directional arrows:

ASSEMBLY LOCATIONS

Where do I go--Designated Assembly sites

Follow the evacuation route signs to the designated site where people can remain until they are notified that it is safe to leave; which could be several hours. The Assembly site for the existing Town of Samoa is located at 58 feet above sea level. The water tank pad is up the marked trail in the wooded area located north of Fenwick Avenue on the uphill or northwest side of Vance Avenue. Look for signage on Vance Avenue to mark the short trail to the assembly area. The water tank pad is designated as the high ground assembly area for the existing Town of Samoa. The assembly site will be marked with a sign:

Evacuation Routes for Existing Town



What if I can't get out of my house

If you need help evacuating, tie something white (sheet or towel) to the front door knob. Make it large enough to be visible from the street. If the emergency is a distant tsunami, then help may arrive. In the event of a local tsunami, it is unlikely that anyone will help you before the waves arrive, so make a plan and be prepared.

How long before I can return to my house

You; should anticipate staying away from the low areas for up to 20 hours. Listen to the NOAA weather radio for the "all clear" notification. Tsunami events consist of many waves that may be 30 to 60 minutes apart. The most damaging waves may be the third or fourth wave. Afterwards there may be strong oscillations in the water.

Earthquakes and tsunamis cause many kinds of damage that continue to be dangerous after the waves have stopped, downed electrical power lines for example. There may also be hazardous spills that are potentially flammable. Fires are also common with tsunamis. Finally, local officials must inspect all flooded or earthquake-damaged structures before anyone can go back into them. Tsunami waters, like flood waters, can undermine foundations, causing buildings to sink and tilt, floors to crack, or walls to collapse. Stay out of buildings if waters remain around it.

Mobilization of Services

The Samoa Peninsula Volunteer Fire Department (SPVFD) will mobilize in the event of a tsunami. The SPVFD will notify all residents in the town of Samoa of the tsunami warning. After the tsunami event the SPVFD will coordinate inspections to determine whether buildings are safe to reoccupy. Other agencies with key responsibilities before, during and after a tsunami event include National Oceanic and Atmospheric Administration (NOAA), the Humboldt County American Red Cross and the Humboldt County Office of Emergency Services (OES). It is important to understand that in the event of a large tsunami multiple coastal communities on the North Spit will be in need of assistance. So a well prepared community will keep community members safe until further assistance arrives

What to do After the Tsunami

Continue listening to a NOAA Weather Radio, Coast Guard emergency frequency station, or other reliable source for emergency information. The tsunami may have damaged roads, bridges, or other structures that may be unsafe.

Use the telephone only for emergency calls. Telephone lines are frequently overloaded in disaster situations. They need to be clear for emergency calls to get through.

Once it is safe to reenter buildings tsunami waters have inundated, open the windows and doors to help dry the building. Shovel mud while it is still moist to give walls and floors an opportunity to dry. Check food supplies. Any food that has come in contact with tsunami flood waters may be contaminated and should be thrown out.

Publicity and Outreach

Outreach

Brochures on tsunami safety will be widely available in such places as the Post Office, the Samoa Cookhouse, the Samoa Block and the Emergency Services Vehicle Storage Building. They could also be available in high traffic places in town such as part of information kiosks on the town history and recreation opportunities on the Samoa Peninsula, and in venues of broader interest such as the tsunami room at the Humboldt County fair.

The tsunami safety brochures will be useful in supplementing the tsunami education programs conducted by NOAA, the Humboldt County American Red Cross, and the Humboldt County Office of Emergency Services.

Conclusion

With the implementation of this Tsunami Safety Plan the Town of Samoa will be eligible for certification as a "Tsunami Ready Community" by the National Weather Service. The basic "Tsunami Ready Community" certification requirements are met and exceeded by this plan. This plan requires coordination between NOAA, the Humboldt County American Red Cross, and the Humboldt County Office of Emergency Services and especially SPVFD. With the coordination of all agencies involved this Tsunami Safety Plan will provide the existing and proposed town of Samoa with an appropriate and concise plan for preparing for and reacting to a local tsunami event.

Further Information

NOAA
National Weather Service Office
Eureka Office (Woodley Island)
300 Startare Drive
Eureka, CA 95501
(707) 443-6484
http://www.wrh.noaa.gov/Eureka

Humboldt County Sheriff's Department
Office of Emergency Services, (County Courthouse)
826 4th Street, Eureka, CA 95501
Phone (707) 268-2500

Humboldt Earthquake Education Center
Geology Dept., Humboldt State University
Arcata, CA 95521; Phone (707) 826-6019
Earthquake Hot Line (707) 826-6020
http://www.humboldt.edu/~geodept/earthquakes/eqk_info.html

Humboldt County American Red Cross
406 11th St., Eureka, CA 95501
Phone (707) 443-4521

Samoa Peninsula Volunteer Fire Department
1982 Gass Street
Fairhaven, CA 95564
(707) 443-9042

Governor's Office of Emergency Services
3650 Schriever Ave, Mather, CA 95655
(916) 845-8510
www.oes.ca.gov

State of California
Seismic Safety Commission
1755 Creekside Oaks Drive, Ste. 100
Sacramento, CA 95833
(916) 263-0583
http://www.seismic.ca.gov/

Appendix A

TORNADO • FLASH FLOOD • EARTHQUAKE • WINTER STORM • HURRICANE • FIRE • HAZARDOUS MATERIALS SPILL

Emergency Preparedness Checklist

American Red Cross

Federal Emergency Management Agency

The next time disaster strikes, you may not have much time to act. Prepare now for a sudden emergency.

Learn how to protect yourself and cope with disaster by planning ahead. This checklist will help you get started. Discuss these ideas with your family, then prepare an emergency plan. Post the plan where everyone will see it—on the refrigerator or bulletin board.

For additional information about how to prepare for hazards in your community, contact your local emergency management or civil defense office and American Red Cross chapter.

Emergency Checklist

Call Your Emergency Management Office or American Red Cross Chapter

- ❑ Find out which disasters could occur in your area.
- ❑ Ask how to prepare for each disaster.
- ❑ Ask how you would be warned of an emergency.
- ❑ Learn your community's evacuation routes.
- ❑ Ask about special assistance for elderly or disabled persons.

Also...

- ❑ Ask your workplace about emergency plans.
- ❑ Learn about emergency plans for your children's school or day care center.

Create an Emergency Plan

- ❑ Meet with household members. Discuss with children the dangers of fire, severe weather, earthquakes and other emergencies.
- ❑ Discuss how to respond to each disaster that could occur.
- ❑ Discuss what to do about power outages and personal injuries.
- ❑ Draw a floor plan of your home. Mark two escape routes from each room.
- ❑ Learn how to turn off the water, gas and electricity at main switches.
- ❑ Post emergency telephone numbers near telephones.
- ❑ Teach children how and when to call 911, police and fire.
- ❑ Instruct household members to turn on the radio for emergency information.
- ❑ Pick one out-of-state and one local friend or relative for family members to call if separated by disaster (it is often easier to call out-of-state than within the affected area).
- ❑ Teach children how to make long distance telephone calls.
- ❑ Pick two meeting places.
  1) A place near your home in case of a fire.
  2) A place outside your neighborhood in case you cannot return home after a disaster.
- ❑ Take a basic first aid and CPR class.
- ❑ Keep family records in a water and fire-proof container.

Prepare a Disaster Supplies Kit

Assemble supplies you might need in an evacuation. Store them in an easy-to-carry container such as a backpack or duffle bag.

Include:

- ❑ A supply of water (one gallon per person per day). Store water in sealed, unbreakable containers. Identify the storage date and replace every six months.
- ❑ A supply of non-perishable packaged or canned food and a non-electric can opener.
- ❑ A change of clothing, rain gear and sturdy shoes.
- ❑ Blankets or sleeping bags.
- ❑ A first aid kit and prescription medications.
- ❑ An extra pair of glasses.
- ❑ A battery-powered radio, flashlight and plenty of extra batteries.
- ❑ Credit cards and cash.
- ❑ An extra set of car keys.
- ❑ A list of family physicians.
- ❑ A list of important family information; the style and serial number of medical devices such as pacemakers.
- ❑ Special items for infants, elderly or disabled family members.

Appendix B
Signs to be Used

Tsunami Sign Needs

Ordered By: ______________________
Jurisdiction:

	TYPE/ USE OR APPLICATION	QUANTITY
	**Evacuation Route Sign** Place on main roadways (i.e. Vance Avenue)	
	**Directional Arrows** Would accompany evacuation route sign	
	**Assembly Area** Place at water tank	
	**Foot Evacuation Trails**	

SAMOA'S TSUNAMI RISK
A tsunami (incorrectly called a tidal wave) is a series of waves most commonly caused by an earthquake beneath the sea floor. In the open ocean, tsunami waves travel as fast as a jet airplane. As the waves enter shallow water, they slow down and may rise to several feet or, in rare cases, more than 50 feet. Tsunamis can cause great loss of life and property damage where they come ashore. The first wave is almost never the largest; successive waves may be spaced 10 or more minutes apart and continue arriving for many hours.

Over 150 paleotsunami sediment core samples have been taken along the margins of Humboldt Bay and in the Mad River Slough. These samples indicate that earthquakes with tsunami have inundated the coastal area of Northern California, including the two CSZ events: one that occurred 300 years ago and one that occurred 1,100 years ago. In 1964 a magnitude 9.2 earthquake in Alaska generated a tsunami. As a result, a series of 4 waves took approximately 4 hours to reach Crescent City where 11 people were killed.

Two kinds of tsunami could affect Humboldt County:

Local-source tsunami: If a large earthquake strikes nearby the first waves may reach the coast within minutes. There is no time for authorities to issue a warning. Strong ground shaking is your warning. If you feel more than 20 seconds of strong ground shaking, move immediately to higher ground and go on foot. Follow designated tsunami evacuation routes or go to an area 100 feet above sea level and stay there.

Distant-source tsunami: Very large earthquakes in other areas of the Pacific may also cause tsunamis. Tsunami Warning Centers will contact local officials who may order an evacuation. Expect to be notified of an evacuation by emergency service personnel, TV and radio stations (through the Emergency Alert System), and on NOAA weather radios. If you do not hear an announcement, but notice a sudden drop or rise in sea level or hear a loud noise coming from the ocean, nature may be warning you of impending danger. Move away from open water and head to high ground immediately.

WHAT AREAS ARE AT RISK?
The map on the inside shows areas of relative tsunami hazard in the Town of Samoa. Green areas indicate higher ground. The high dunes above 40 feet in elevation are the safest areas. Be aware of areas that are indicated as being within the Tsunami Hazard Zone.

WHAT IF I AM OUTSIDE THE MAP AREA?
Go to an area 100 feet above sea level, if possible, or go 2 miles inland, away from open water. If you cannot get this high or far, go as high as possible. Every foot inland or upwards can make a difference.

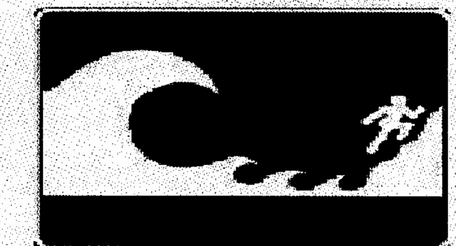
HOW CAN I SAVE MYSELF FROM A LOCAL-SOURCE TSUNAMI?
If you are near open water and feel an earthquake, no matter how small, immediately move inland or to high ground. COUNT how long the earthquake shaking lasts. If you count 20 seconds or more of very strong ground shaking, and you are located in a tsunami hazard zone on the map, evacuate to the ASSEMBLY AREA as soon as it is safe to do so.

DO NOT USE A CAR TO EVACUATE. Roads and bridges may be damaged by the strong ground shaking. **GO ON FOOT** because of traffic, damage to roads, downed power lines and other debris. If your only evacuation route is blocked by downed power lines carefully cross without touching the lines.

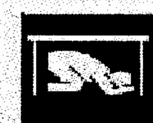
If evacuation is impossible, go to the upper floors of sturdy building or climb a tree. The upper floors of buildings or a tree may offer protection, but should only be used as a last resort.

NOAA Weather Radio
The best way to stay informed of official tsunami alerts is to have a NOAA weather Radio. They're inexpensive and available at most electronic stores.

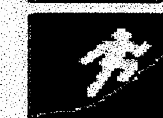
TSUNAMI!
HOW TO SURVIVE THIS HAZARD IN SAMOA



IF YOU FEEL A STRONG EARTHQUAKE:

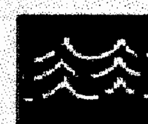


1. Drop, cover, and hold on and watch for falling objects until the earthquake is over.

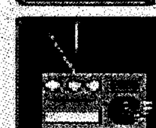


2. Move to higher ground or inland away from bodies of water immediately. A tsunami may be coming. Go on foot, don't drive.

DO NOT WAIT FOR OFFICIAL WARNING

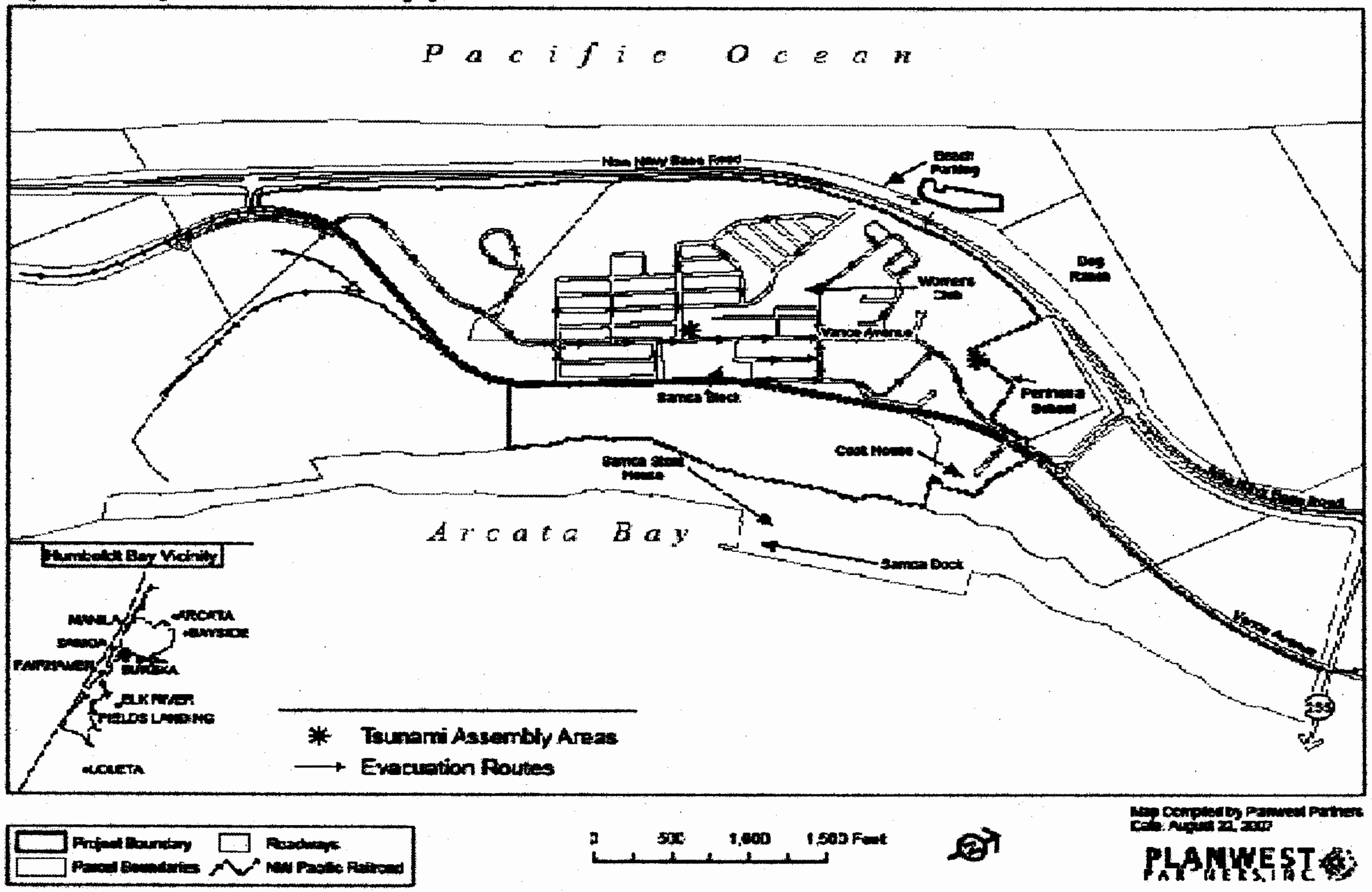


3. Stay away from bodies of water. Do not return to shore after the first wave. Waves may continue to arrive for hours.



4. Listen to your radio for instructions. Do not return to the beach before an official "all clear".

Figure 4.7.3 - Proposed Plan Tsunami Warning System and Main Evacuation Routes



Appendix D – Safety Evacuation Drill Preparation

Planning and execution outline

Event narrative:

The basic plan is for community members to listen for the siren and then walk to the evacuation site, where event staff will be waiting for them. At the evacuation site, there will be three stations. The first station will be for time stamping their evaluation forms. If they didn't bring their form, we'll have blank ones for them to use. It's going to be critical to keep people moving quickly through this station. Next, they'll be given a pencil and clip board and asked to fill out their evaluation form. This is where it will help to have lots of event staff on hand to answer questions. The final station is where they turn their form in and get a coupon for a 20% discount at the Cook House.

The community participation in the drill could be as low as 20 people and as high as 100. It's impossible to know in advance. If turn out is good, the evacuation site could get hectic because most people should arrive within the first 15 minutes.

Notifications:

1. Samoa Cookhouse
2. Harbor District
3. Coast Guard
4. Op area
5. Oyster companies
6. Small cluster of homes north of bridge onramp)
7. RCTWG
8. Samoa residents
9. Coastal Comm., Planning folks, Board of Supervisors
10. Evergreen Pulp
11. Maritime Museum)

Prepare well ahead of event:

1. Make signs for Samoa Beach.)
2. Build PSA for NWR)
3. Write and distribute news release
4. Test inverter with time clock
5. Make flyer for Cook House to hand out to patrons from 4:00 on
6. Settle on route sign locations
7. Prepare 15 temporary evacuation. signs

The day before the event

1. Dry run at 9:00 AM. Meet at Samoa Gym
2. Media reminders

The day of the event

1. Post signs at Samoa Beach parking area by 3:00 p.m.
2. Install temp evac route and evac site signs by 3:00 p.m.
3. Synchronize time of time clock and siren activator's watch.
4. Stage at evacuation site and Samoa Gym by 4:30 p.m.
5. Call key radio stations and ask them to remind listeners about the drill and siren

Event Execution (in no order):

1. Fire department staff to control and calm auto traffic at entrance to town and corner of Vance and Rideout, starting at 5:45 p.m.
2. Fire department to stand by with medical aid equipment and personnel.
3. Photograph event – Cybelle Immitt
4. At ~ 5:45 p.m., everyone goes to evac site to help process evacuees.
5. Brad to activate siren at 6:00 p.m.
6. Debbie to start time clock when she hears the siren.

Miscellaneous details:

1. Wear dark blue shirts, if possible, to help identify you as event staff.
2. Park your cars at the Fireman's Hall that is just west of the Samoa Cookhouse.

Media Talking points:

Disclaimer: Developing talking points before an event is useful because it allows you to give some thought to what you will say when confronted with an uncomfortable or challenging question. The wording I have below might seem a bit manipulative, but that is not the point. The goal is to choose our words carefully to ensure that the educational value of this event is preserved – instead of, for example, being overshadowed by a fumbling of some part of the drill.

1. If the drill is a disaster, our position to the media and others:
    a. "you learn more when things go wrong than when they go right"
    b. "That's why we have drills – to find the weak areas"
    c. "The things that went wrong today are the things that would go wrong during a real event. Therefore, this has been a valuable exercise"
    d. Any other comment you want to make that this is about practicing and learning, not perfection in drills.
2. If the drill goes off perfectly:
    a. "The success of this drill demonstrates the effectiveness of people working together to prepare their community…"
    b. Use the rest of your time with the media to get the same old messages out: "If you feel an earthquake, go to high ground", etc.

Materials and equipment to Bring to the event:

Event Organizer/ Sponsor

1. Tables
2. Refreshments at Samoa Gym and at evacuation site.
3. clip boards – as many as possible
4. 10 folding chairs
5. Congrats banner and balloons

6. Cabana
7. Signs
8. T-posts
9. -post driver
10. Inverter for time clock
11. Time clock
12. 50 extra evaluation forms in case participants forget theirs
13. 100 pencils
14. clip boards (~10)
15. Self stick name tags with tsunami logo to identify "staff"
16. Extra tri-fold brochures for Samoa
17. Masking tape

Fire Department
1. PA system
2. Engines
3. Medical aid staff
4. Orange cones for traffic calming
5. clip boards

Redwood Coast Tsunami Working Group
1. Posters
2. clip boards
3. Standard educational information

Red Cross
1. Cip boards (~10)
2. Examples of evacuation bags
3. Standard Red Cross information