Appendix F

Geologic Hazard Evaluation and Soils Engineering Report

This page is intentionally left blank

SHN 812 W. Wabash Avenue, Eureka, CA 95501-2138 707-441-8855
Civil Engineering, Environmental Services, Geosciences, Planning & Permitting, Surveying

Reference: 017203.003

June 14, 2018

Mr. John Miller, Sr. Planner
Planning and Building Department
County of Humboldt
3015 H Street
Eureka, CA 95501

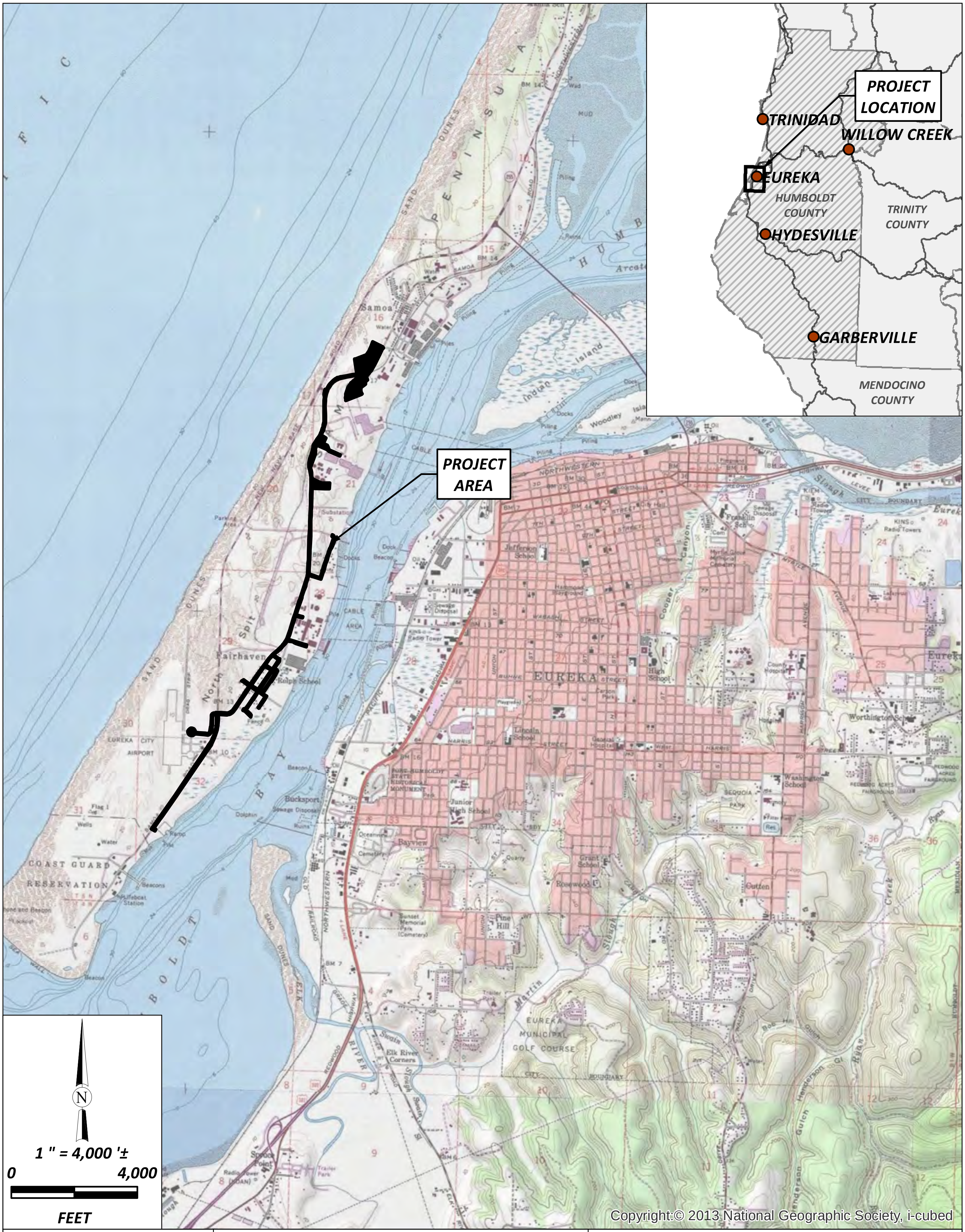
Subject: **Geologic Hazard Evaluation and Soils Engineering Report, Samoa Peninsula Wastewater Project, Humboldt County, California**

Introduction

This report presents the results of our analysis of geologic hazards and geotechnical (soils) conditions along the alignment of the proposed wastewater collection and conveyance system on the Samoa Peninsula in Humboldt County, California (Figure 1). The intent of this investigation is to define geologic hazards that may affect the proposed infrastructure, and to characterize soil conditions in order to inform the design and construction of the system. In this report we evaluate current geologic hazards at the site, as well as the potential for future sea level rise impacts along the Samoa Peninsula, assuming a 50-year economic lifespan for the project.

The purpose of the subject project is to develop a wastewater collection, conveyance, and treatment system for communities on the Samoa Peninsula. We understand the proposed project to be in the conceptual design stage, so some elements of the project may change. However, the basic elements of the project include a wastewater treatment facility (WWTF) near the southern edge of the town of Samoa, and a collection and conveyance system extending to the south (Figure 2). The primary conveyance pipeline will be a force main; therefore no specific pipeline gradient is required, and it may vary along the alignment. Wastewater in the communities of Finntown and Fairhaven will be collected by gravity-flow collection systems. Pump stations in these locations will deliver the wastewater into the force main conveyance system. We understand that these collection systems may extend to depths of nearly 12 feet below surface grade in these areas. It is currently proposed to construct the project using open-trench construction ("cut and cover").

In order to evaluate the geologic and geotechnical conditions of the subject alignment, we compiled available information and supplemented it with focused field studies. Geologic/geotechnical reports for the Town of Samoa, the former LP mill site, and a PG&E substation near Finntown were especially useful, because extensive subsurface investigation was completed for each study. We also evaluated published geologic reports, maps, and aerial photographs. Our field investigation was limited to attempting to advance hand-auger borings in Finntown and Fairhaven, in areas where deeper collection system excavations are proposed. These shallow borings were intended to verify inferred subsurface conditions related to loose, flowing sands.



Copyright:© 2013 National Geographic Society, i-cubed

Path: \\eureka\projects\2017\017203-Samoa Peninsula Wastewater design -plan of study\GIS\PROJ_MXD\003_EIR_CEQA\Geotech_Study\Figure1_ProjectLocationMap.mxd User Name: psundberg

SHN
Consulting Engineers
& Geologists, Inc.

County of Humboldt
Geologic Hazard Evaluation
Samoa, California

Project Location
Map
SHN 017203.003

June 2018

Figure1_ProjectLocationMap

Figure 1

Path: \\eureka\projects\2017\017203-Samoa Peninsula Wastewater design - plan of study\GIS\PROJ_MXD\003_EIR_CEQA\Geotech_Study\Figure2_ProposedSystem.mxdUser Name: psundberg

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar
GIS User Community

SHN
Consulting Engineers
& Geologists, Inc.

County of Humboldt
Samoa Peninsula Wastewater EIR-CEQA
Samoa, California

Proposed System

SHN 017203.003

June 2018

Figure2_ProposedSystem

Figure 2

Geologic Setting

Northwestern California is located in a complex tectonic region dominated by northeast-southwest oriented compression associated with collision of the Gorda and North American tectonic plates. The Gorda plate is being actively subducted beneath North America north of Cape Mendocino, along the southern part of what is commonly referred to as the Cascadia Subduction Zone. This plate convergence has resulted in a broad fold and thrust belt along the western edge of the accretionary margin of the North American plate. In the Humboldt Bay region, this fold and thrust belt is manifested as a series of northwest-trending, southeast-dipping thrust faults, including the Little Salmon fault and faults that comprise the Mad River fault zone (MRfz). These faults are active and are capable of generating large-magnitude earthquakes.

Basement rock in the Humboldt Bay region (that is, the regional Franciscan Formation) is unconformably overlain by a late Miocene to middle Pleistocene age sequence of marine and terrestrial deposits referred to as the Wildcat Group. The Wildcat Group, in turn, is truncated at its top by an unconformity of middle Pleistocene age, and is overlain by coastal plain and fluvial deposits of middle to late Pleistocene age. In the Eureka area, these middle and late Pleistocene age deposits are referred to as the Hookton Formation, and may be as much as 400 feet thick. Hookton Formation sediments are widely variable in texture and consistency, and are described as gravel, sand, silt, and clay.

Along the coast of northern California between Cape Mendocino to the south and Big Lagoon, about 60 miles to the north, a sequence of uplifted late Pleistocene age marine terraces is preserved. The City of Eureka, across Humboldt Bay from the Samoa Peninsula, occupies a series of northward-dipping terrace surfaces eroded into the Hookton Formation. Along the margins of Humboldt Bay, the Hookton Formation and marine terrace deposits are overlain by late Holocene age (younger than about 5-6,000 years old) bay muds and associated estuarine deposits, as well as local accumulations of dune deposits.

The project site is located along the Samoa Peninsula, the northern peninsula forming the oceanward side of Humboldt Bay. The location and morphology of Humboldt Bay is largely a result of tectonic processes. Humboldt Bay consists of two principal basins, Arcata Bay and South Bay. These shallow estuarine basins are connected across the bay mouth by the narrow “Eureka Channel.” Each of the principal basins is associated with a tectonic syncline (that is, a crustal down-warp), and appears to represent a filled paleo-river valley. This is especially true in the northern basin, Arcata Bay, which appears to be an erosional feature associated with a former course of the Mad River. In that regard, much of the Samoa Peninsula is the remnant of the western divide of the Mad River drainage, and is underlain by the same earth materials that underlie the Eureka side of the bay. Toward the southern end of the Samoa Peninsula, the peninsula appears to transition into a true sand “spit,” formed by the progradation of littoral sand transported in the longshore current. This is an important point, because the nature of the substrate underlying the Samoa Peninsula is a key consideration in the interpretation of geologic hazard.

The location of the inferred transition from an erosional “peninsula” with a core of older Pleistocene age sediment (Hookton Formation or equivalent), to a “spit” formed by prograding sand of late Holocene age, is not known. Based on geomorphic expression, the transition occurs near the southern end of the North Spit. Two subsurface geologic transects have been developed across the bay, and help to constrain the location of the transition. One transect was developed by Caltrans (discussed in Geomatrix, 1994) at the location of the Samoa bridge just to the northeast of Samoa, the other was developed to the southwest at the location of a proposed wastewater treatment plant (Converse Davis Dixon Associates, 1976). Both of these geologic profiles suggest the central Samoa Peninsula is an erosional feature underlain by older sediments contiguous with those underlying the City of Eureka on the opposite side of the Eureka Channel/Humboldt Bay. Interpretation of the available geologic data suggests that the transition to a sand "spit" occurs south of the two profiles.

The entire Samoa Peninsula is covered with a variable thickness of dune sands. As discussed in Leroy (2000), the northern part of the Peninsula is covered with a thick sequence of dunes that can be subdivided into four distinct stratigraphic units. These dunes are typically forested, and reach as much as 60 to 70 feet above sea level. The town of Samoa occupies the southern end of these older, higher dunes. To the south, the Peninsula is covered with a relatively youthful accumulation of dunes that are generally less than 20 feet in elevation.

Groundwater is present at relatively shallow depth through the entire study area. Subsurface investigations have encountered groundwater typically within about 10 feet of sea level. Therefore, in low elevation areas south of Samoa, groundwater is expected to occur within the upper 5 to 10 feet of the ground surface. At the site of the proposed wastewater treatment facility, which is at an elevation above 30 feet, the water table can be expected generally to occur below about 20 feet. Groundwater appears to occur most frequently within the loose dune sands in the upper 15 feet, and most boring logs note heaving sands at this stratigraphic interval (deeper drilling only occurs with drilling muds added to the borehole).

The entire region is one of high seismicity; there are numerous active faults in close proximity to the site. The Samoa Peninsula occurs between the two primary onland fault zones within the fold-and-thrust belt described above–the Little Salmon fault zone and the Mad River fault zone. Although there are no known active faults crossing the Samoa Peninsula, an inferred fault, the North Spit fault has been identified near the southern end of the proposed project area. The North Spit fault has been identified in geophysical transects offshore of the Peninsula, but it has never been identified on land (either on the Peninsula or in Eureka); it is not considered active by the State.

Subsurface Conditions

Our understanding of the subsurface conditions as described below is based on the results of our field and laboratory investigations, review of previous subsurface investigations within the area (SHN, 2004, 2009; Converse Davis Dixon Associates, 1976; Geomatrix, 1994), and our previous experience in the area. In general, the upper 50 feet of the soil profile is consistent across the areas investigated, and can be broken into three units, from top to bottom: 1) loose to medium dense dune sands, 2) medium dense to very dense marine sands and fine gravels, and 3) soft to medium stiff silty clay soils of the Hookton formation. Below, we discuss the geotechnical characteristics of each of these materials and their effect on the proposed project.

Dune Deposits

The surface of the Samoa Peninsula is covered with a 10- to 20-foot veneer of wind-blown sand dune deposits. Dune deposits consist of relatively young (late Holocene age), poorly graded fine sands with minor silts and fine gravel (SP/SM). The dune deposits are loose to medium dense with SPT $N_{1(60)}$ values (normalized blows per foot of sampler advancement) typically ranging from 10 to 45, and dry densities ranging from 94 to 103 pounds per cubic foot (pcf). The loose, unconsolidated nature of these young dune sediments suggests susceptibility to liquefaction where they are saturated. Dunes typically have thin, weakly developed topsoil or no topsoil at all.

Shallow Marine Deposits

Beginning at depths ranging from 10 to 20 feet, dense to very dense poorly graded sands (SP), silty sands (SM) and fine gravels (GP, GW) interpreted to be shallow marine deposits occur. Thin lenses of shelly debris and interbedded fine gravels (beach gravels) were encountered. The marine sands range in thickness from 30 to 40 feet. Based on review of available reports and interpretations, these shallow marine deposits were likely laid down during the most recent marine transgression, and are therefore early Holocene in age. Based on field and laboratory investigations, these marine sands and fine gravels are dense to very dense, with SPT $N_{1(60)}$ values ranging from 36 to 151 and dry densities ranging from 94 to 112 pcf. The materials appear to have a low plasticity and expansion potential (tendency to change volume with changes in seasonal moisture content) and low compressibility. Although these deposits meet the grain size distribution and saturated conditions typical of potentially liquefiable materials, the density of the deposits yields a low liquefaction potential.

Shallow Marine/Estuarine Deposits

At depths beneath about 35 to 50 feet below grade, soft to firm, fine-grained materials consisting of silty clay (CL) to clayey silt (ML) of low to moderate plasticity have been encountered. The fine-grained sediments contain lenses of shelly debris and organics (including woody debris and logs) and are interpreted to be associated with shallow marine or estuarine environment. We infer these materials to be equivalent to the Pleistocene age Hookton Formation, which extends eastward beneath the Eureka marine terrace. These materials were encountered to depths of 340 feet at the former LP Mill site. Plasticity Index (PI) testing indicated these soils have low to moderate plasticity with PI values ranging from 12 to 22. Laboratory testing indicates silt and clay content ranging from 44 to 99 percent. These materials are not considered liquefiable due to their inferred geologic age, the presence of cohesive clays, and their low sand content.

Geologic Hazards

The primary geologic hazards along the Samoa Peninsula are related to strong ground shaking during earthquakes and secondary seismic effects, including tsunami inundation and the potential for liquefaction and lateral spreading. The ground-shaking hazard is a regional hazard that will vary depending on the proximity to seismic sources and the nature of the substrate underlying a site. Tsunami inundation modeling has been developed for the entire region, and is discussed below. Liquefaction potential is a significant concern for shallow-buried infrastructure below the water table. Surface fault rupture appears to be a low level hazard, given that no known active fault crosses the Peninsula.

Liquefaction Potential

Liquefaction is described as the sudden loss of soil shear strength due to a rapid increase of soil pore water pressures caused by cyclic loading from a seismic event. In simple terms, it means that a liquefied soil acts more like a fluid than a solid when shaken during an earthquake. In order for liquefaction to occur, the following are needed:

- granular soils (sand, silty sand, sandy silt, and some gravels);
- a high groundwater table; and
- a low density of the granular soils (typically associated with young geologic age).

The adverse effects of liquefaction include local and regional ground settlement, ground cracking and expulsion of water and sand, the partial or complete loss of bearing and confining forces used to support loads, amplification of seismic shaking, and lateral spreading. During liquefaction events, pipelines tend to become buoyant due to the loss of confining pressure and “float” toward the ground surface.

Lateral spreading is defined as lateral earth movement of liquefied soils, or competent strata riding on a liquefied soil layer, downslope toward an unsupported slope face, such as a creek bank, or in this case toward the bay. In general, lateral spreading is typically observed on low to moderate gradient slopes, but has been noted on slopes inclined as flat as one degree.

Seismically induced ground failures have been documented on two occasions in the project vicinity following historical moderate to large magnitude earthquakes. Specific accounts of historical ground failures include the following account from the 1906 earthquake:

> *At Samoa…where the Vance Company has its mill and warehouses. At one warehouse, the ground sunk beneath it several feet. The floor of the planing mill sank several inches on the east side and some are of the opinion that the factories settled also at one wall* (Youd and Hoose, 1978).

Historical photographs indicate that the Vance Company mill complex was located along the bayfront, and likely was founded on unengineered, “reclaimed” bay soils. It is, therefore, not surprising that ground deformation occurred during the 1906 earthquake, as similar events were documented in reclaimed soils along the bayfront elsewhere.

In 1954, the following account is recorded:

> *Hammond Lumber Company brought its operations to a sudden halt when several breaks occurred in the underground main of the company's fire protection system. A.O. LeFors, spokesperson for Hammond, stated that the mill will not operate in Samoa or at its Eureka plants until repairs have been made* (Youd and Hoose, 1978).

Humboldt County GIS Hazard maps identify the area as being potentially susceptible to liquefaction hazards. Subsurface investigations have encountered young and unconsolidated clean sands and loose- to medium-dense sands extending to depths of about 15 feet. The lower part of this section of loose Holocene age sand is typically below the water table, which may rise seasonally to within a few feet of the ground surface. When saturated, such soils are predisposed to liquefaction and other related soil behavior. Our attempts at advancing hand auger borings beneath the water table were unsuccessful, due to heaving sand conditions. Quantitative liquefaction assessment conducted at the Town of Samoa identified limited intervals of liquefiable sediments below the water table, as below about 15 feet the material becomes too dense to liquefy. Estimated total settlement values for the upper sediments were on the order of a few inches or less. For the subject project, liquefaction may affect the bearing capacity of subgrade soils beneath above-ground facilities (WWTP and individual pump stations), while also causing buried pipelines to "float" toward the ground surface (this would have the greatest impact on the collection system, which will rely on a specific gradient to allow gravity flow).

Tsunami Inundation

Much of the low-lying Samoa Peninsula is subject to tsunami inundation, and is at significant risk in the event of a large locally-generated tsunami event. As shown on Figure 3, other than isolated high dunes northwest of the town of Samoa, the entire Samoa Peninsula typically is modeled as being subject to inundation during moderate to large tsunami events. If a tsunami were to inundate the Samoa Peninsula, aboveground structures within the proposed wastewater system would be most vulnerable. These structures would be subject to high-velocity flows and surge effects; they would be unlikely to survive, unless designed specifically to do so. Below grade improvements (collection and conveyance pipelines) would have a higher chance for survival, depending on the depth of scour relative to the depth of the pipeline. A tsunami that inundates the Samoa Peninsula would result in catastrophic conditions over the entire project area, a high degree of structural loss, and significant loss of life; as such, the impacts to the proposed wastewater system should be evaluated in the context of the potential impacts to the communities it will serve.

Flooding Due to Sea Level Rise

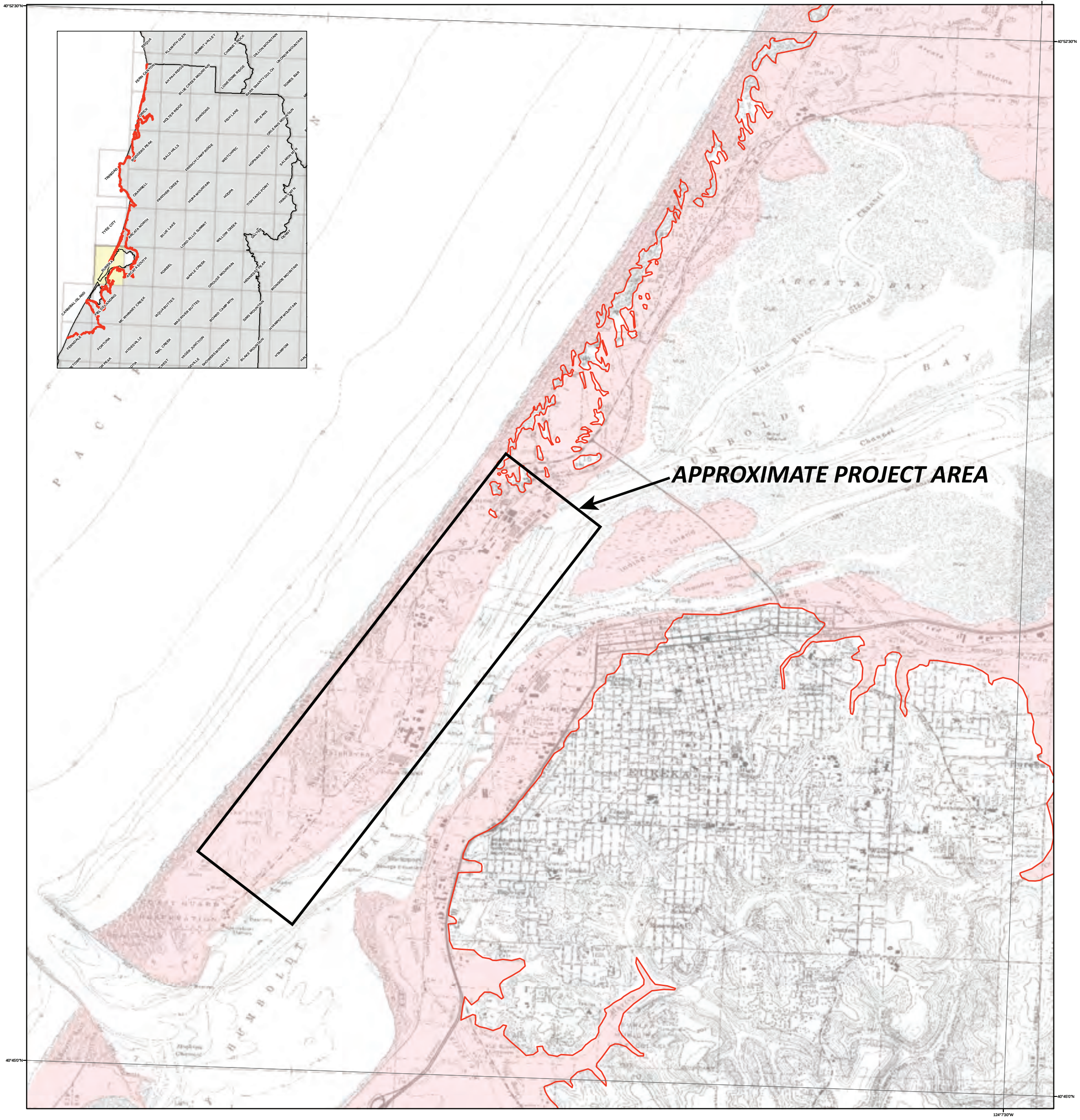
Recent State-funded studies have identified areas in Humboldt Bay that are subject to inundation due to interpreted levels of future sea level rise (Trinity Associates, 2015, 2018; NHE, 2015). These studies have identified sea level rise scenarios for different periods, up to the year 2100, and areas subject to inundation under these various scenarios. For this study, we assume a project life span of 50 years. Based on the data provided in the "vulnerability assessment" report by Trinity Associates (2018), we use 3.2 feet as the

Path:\\eureka\projects\2017\017203-Samoa Peninsula Wastewater design -plan of study\GIS\FIGURES\003_EIR_CEQA\Geologic_Hazard_Evaluation\Figure3_Tsunami.ai User Name: psundberg

California Emergency Management Agency
California Geological Survey
University of Southern California

Tsunami Inundation Map for Emergency Planning
Eureka Quadrangle

State of California
County of Humboldt



METHOD OF PREPARATION

Initial tsunami modeling was performed by the University of Southern California (USC) Tsunami Research Center funded through the California Emergency Management Agency (CalEMA) by the National Tsunami Hazard Mitigation Program. The tsunami modeling process utilized the MOST (Method of Splitting Tsunamis) computational program (Version 0), which allows for wave evolution over a variable bathymetry and topography used for the inundation mapping (Titov and Gonzalez, 1997; Titov and Synolakis, 1998).

The bathymetric/topographic data that were used in the tsunami models consist of a series of nested grids. Near-shore grids with a 3 arc-second (75- to 90-meters) resolution or higher, were adjusted to "Mean High Water" sea-level conditions, representing a conservative sea level for the intended use of the tsunami modeling and mapping.

A suite of tsunami source events was selected for modeling, representing realistic local and distant earthquakes and hypothetical extreme undersea, near-shore landslides (Table 1). Local tsunami sources that were considered include offshore reverse-thrust faults, restraining bends on strike-slip fault zones and large submarine landslides capable of significant seafloor displacement and tsunami generation. Distant tsunami sources that were considered include great subduction zone events that are known to have occurred historically (1960 Chile and 1964 Alaska earthquakes) and others which can occur around the Pacific Ocean "Ring of Fire."

In order to enhance the result from the 75- to 90-meter inundation grid data, a method was developed utilizing higher-resolution digital topographic data (3- to 10-meters resolution) that better defines the location of the maximum inundation line (U.S. Geological Survey, 1993; Intermap, 2003; NOAA, 2004). The location of the enhanced inundation line was determined by using digital imagery and terrain data on a GIS platform with consideration given to historic inundation information (Lander, et al., 1993). This information was verified, where possible, by field work coordinated with local county personnel.

The accuracy of the inundation line shown on these maps is subject to limitations in the accuracy and completeness of available terrain and tsunami source information, and the current understanding of tsunami generation and propagation phenomena as expressed in the models. Thus, although an attempt has been made to identify a credible upper bound to inundation at any location along the coastline, it remains possible that actual inundation could be greater in a major tsunami event.

This map does not represent inundation from a single scenario event. It was created by combining inundation results for an ensemble of source events affecting a given region (Table 1). For this reason, all of the inundation region in a particular area will not likely be inundated during a single tsunami event.

References:

Intermap Technologies, Inc., 2003, Intermap product handbook and quick start guide: Intermap NEXTmap document on 5-meter resolution data, 112 p.

Lander, J.F., Lockridge, P.A., and Kozuch, M.J., 1993, Tsunamis Affecting the West Coast of the United States 1806-1992: National Geophysical Data Center Key to Geophysical Record Documentation No. 29, NOAA, NESDIS, NGDC, 242 p.

National Atmospheric and Oceanic Administration (NOAA), 2004, Interferometric Synthetic Aperture Radar (IfSAR) Digital Elevation Models from GeoSAR platform (EarthData): 3-meter resolution data.

Titov, V.V., and Gonzalez, F.I., 1997, Implementation and Testing of the Method of Tsunami Splitting (MOST): NOAA Technical Memorandum ERL PMEL – 112, 11 p.

Titov, V.V., and Synolakis, C.E., 1998, Numerical modeling of tidal wave runup: Journal of Waterways, Port, Coastal and Ocean Engineering, ASCE, 124 (4), pp 157-171.

U.S. Geological Survey, 1993, Digital Elevation Models: National Mapping Program, Technical Instructions, Data Users Guide 5, 48 p.

Note:

The inundation line for portions of Humboldt County were developed with the assistance of Jay Patton, Lori Dengler, and other members of the Redwood Coast Tsunami Work Group. The inundation line represented on this map is a product of both the methodology outlined above, as well as the method and local knowledge described in the following references:

Patton, J.R., and Dengler, L.A., 2006, Relative tsunami hazard mapping for Humboldt and Del Norte Counties, California: Proceedings of the 8NCEE/EERI Eighth Earthquake Engineering Conference.

Patton, J.R., and Dengler, L.A., 2004, GIS-based relative tsunami hazard maps for northern California, Humboldt and Del Norte Counties: (abs.) Eos Trans. American Geophysical Union, Vol. 85, No. 47, Fall Meeting Supplement.

TSUNAMI INUNDATION MAP FOR EMERGENCY PLANNING

State of California ~ County of Humboldt

EUREKA QUADRANGLE

June 1, 2009

SCALE 1:24,000

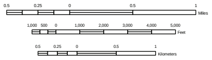


Table 1: Tsunami sources modeled for the Humboldt County coastline.

Sources (M = moment magnitude used in modeled event)		Areas of Inundation Map Coverage and Sources Used				
		Yurok	Orick	Trinidad	Humboldt	Shelter Cove
Local Sources	Cascadia Subduction Zone-full rupture (M9.0)	X	X	X	X	
	Cascadia Subduction Zone-south segment, narrow rupture (M8.4)	X	X		X	X
	Cascadia Subduction Zone-south segment, wide rupture (M8.5)	X	X	X	X	X
	Cascadia Subduction Zone-south segment and Little Salmon Fault #1 (M8.5)			X	X	
	Cascadia Subduction Zone-south segment and Little Salmon Fault #2 (M8.5)	X	X	X	X	X
Distant Sources	Central Aleutians Subduction Zone #1 (M8.9)		X		X	
	Central Aleutians Subduction Zone #2 (M8.9)		X		X	
	Central Aleutians Subduction Zone #3 (M9.2)	X	X	X	X	X
	Chile North Subduction Zone (M9.4)		X		X	
	1960 Chile Earthquake (M9.3)		X		X	
	1964 Alaska Earthquake (M9.2)	X	X	X	X	X
	Japan Subduction Zone #2 (M8.8)		X		X	
	Kuril Islands Subduction Zone #2 (M8.8)		X		X	
	Kuril Islands Subduction Zone #3 (M8.8)		X		X	
	Kuril Islands Subduction Zone #4 (M8.8)		X		X	
	Marianas Subduction Zone (M8.6)	X	X	X	X	X

MAP EXPLANATION

〰	Tsunami Inundation Line
🟥	Tsunami Inundation Area

PURPOSE OF THIS MAP

This tsunami inundation map was prepared to assist cities and counties in identifying their tsunami hazard. It is intended for local jurisdictional, coastal evacuation planning uses only. This map, and the information presented herein, is not a legal document and does not meet disclosure requirements for real estate transactions nor for any other regulatory purpose.

The inundation map has been compiled with best currently available scientific information. The inundation line represents the maximum considered tsunami runup from a number of extreme, yet realistic, tsunami sources. Tsunamis are rare events; due to a lack of known occurrences in the historical record, this map includes no information about the probability of any tsunami affecting any area within a specific period of time.

Please refer to the following websites for additional information on the construction and/or intended use of the tsunami inundation map:

State of California Emergency Management Agency, Earthquake and Tsunami Program:
http://www.oes.ca.gov/WebPage/oeswebsite.nsf/Content/B1EC
51BA215931768825741F005E8D80?OpenDocument

University of Southern California – Tsunami Research Center:
http://www.usc.edu/dept/tsunamis/2005/index.php

State of California Geological Survey Tsunami Information:
http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/index.htm

National Oceanic and Atmospheric Agency Center for Tsunami Research (MOST model):
http://nctr.pmel.noaa.gov/time/background/models.html

MAP BASE

Topographic base maps prepared by U.S. Geological Survey as part of the 7.5-minute Quadrangle Map Series (originally 1:24,000 scale). Tsunami inundation line boundaries may reflect updated digital orthophotographic and topographic data that can differ significantly from contours shown on the base map.

DISCLAIMER

The California Emergency Management Agency (CalEMA), the University of Southern California (USC), and the California Geological Survey (CGS) make no representation or warranties regarding the accuracy of this inundation map nor the data from which the map was derived. Neither the State of California nor USC shall be liable under any circumstances for any direct, indirect, special, incidental or consequential damages with respect to any claim by any user or any third party on account of or arising from the use of this map.

Consulting Engineers
& Geologists, Inc.

County of Humboldt
Geological Hazard Evaluation
Samoa, California

Tsunami Inundation Map
for Emergency Planning
SHN 017203.003

June 2018 | Figure3_Tsunami | Figure 3

amount of projected sea level rise by the year 2070, which we use as a proxy for the 50-year economic project life span. We add the projected sea level rise onto the modern limit of high tide, the "Highest Astronomical Tide," which at the Samoa tide gauge is 9.32 feet. Areas subject to flooding due to sea level rise are, therefore, those areas below an elevation of 12.52 feet (9.32 feet + 3.2 feet). Figure 4 shows the project areas susceptible to inundation due to sea level rise of 3.2 feet. Elevations are corrected to the North American geodetic datum (NAVD 88).

Geotechnical Considerations

Seismic Design Parameters

Based on the results of our field investigation and knowledge of the regional geology, we classify the geologic subgrade at the project site as Site Class D (stiff soil profile), in accordance with Table 20.3-1 in American Society of Civil Engineers ASCE 7-10 (ASCE, 2010).

Based on the Site Class, Risk Category (III), and the project latitude and longitude (we use the coordinates for the WWTF), we obtained the "code based" design spectral response acceleration parameters using the United States Geological Survey (USGS) "U.S. Seismic Design Maps tool," v. 3.1.0, updated January 30, 2017 (USGS, 2017). Calculated values are presented in Table 1.

Table 1 Seismic Design Criteria
Samoa, CA

Criteria	Calculated Value
S_S	2.881
S_1	1.150
F_a	1.0
F_v	1.5
S_{MS}	2.881
S_{M1}	1.724
S_{DS}	1.921
S_{D1}	1.150
Seismic Design Category	D

Feasibility of Open Trench Construction

The primary geotechnical consideration for this project is the presence of loose, saturated sands in the shallow subgrade. Where these materials occur below the water table, they are highly susceptible to "flowing" when exposed in excavations, which will significantly complicate the ability to construct the project as currently proposed. The susceptibility to flowing sands was confirmed in our shallow hand auger borings, which were unable to penetrate below the water table. The groundwater elevation along the

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar (
GIS User Community

Path: \\eureka\projects\2017\017203-Samoa Peninsula Wastewater design -plan of study\GIS\PROJ_MXD\003_EIR_CEQA\Geotech_Study\Figure4_SeaLevelRise.mxdUser Name: psundberg

Consulting Engineers
& Geologists, Inc.

County of Humboldt
Samoa Peninsula Wastewater EIR-CEQA
Samoa, California

Sea-Level Rise
Year 2070
SHN 017203.003

June 2018

Figure4_SeaLevelRise

Figure 4

project alignment is on the order of 3 to 6 feet below the ground surface, although it may be higher in proximity to several wet areas identified in the field. We understand that the collection system pipelines in Finntown and Fairhaven will be on the order of 12 feet deep, well below the water table.

Based on these soil conditions, it will not be feasible to excavate stable trenches without considerable effort. Deeper trenches may not be feasible. A significant de-watering effort would be required, and the use of trench support systems (trench boxes or shields) would be imperative. Similar recent efforts in Eureka required multiple well points over a much smaller area that generated large quantities of water, in materials less permeable than the dune sands along the Samoa Peninsula.

Due to the depth of proposed trenches, the presence of loose (highly permeable) sands, and high groundwater table, it would be prudent to develop a de-watering test program to determine the feasibility of open trenching in the project area. If, as we expect, it is excessively difficult to de-water an area sufficiently to facilitate open trench work below the water table, an alternative approach may be necessary.

Closure

We hope that this report provides the information that you need at this time. If you need additional information, or clarification of the information herein, please call me at 707-441-8855. We appreciate the opportunity to assist with this important project.

Respectfully,

SHN Engineers & Geologists, Inc.

REGISTERED GEOLOGIST
GARY D. SIMPSON
No. 2107
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

Gary D. Simpson, CEG
Geosciences Director

GDS:lms

References

American Society of Civil Engineers. (2010). "ASCE 7-10: Minimum Design Loads for Buildings and Other Structures." Reston, VA:ASCE.

Converse Davis Dixon Associates. (1976). *Geotechnical Investigation for Bay Crossing, Lift Stations and Slough Crossings, Humboldt Bay Wastewater Project, Eureka, California*. Unpublished consultants report for Humboldt Bay Wastewater Authority. Seattle, WA:Converse Davis Dixon Associates.

Geomatrix. (1994). "Seismic Ground Motion Study for Humboldt Bay Bridges on Route 255." Unpublished consultants report for the California Department of Transportation. Eureka, CA:Geomatrix.

Humboldt County Planning and Building Department. (2015). "Humboldt County GIS Portal," accessed at: http://gis.co.humboldt.ca.us/Freeance/Client/PublicAccess1/index.html?appconfig=podgis4

Leroy, T. H. (2000). *Holocene Sand Dune Stratigraphy and Paleoseismicity of the North and South Spits of Humboldt Bay, Northern California*. (M.S. Thesis). Arcata, CA:HSU.

Northern Hydrology & Engineering. (2015). "Humboldt Bay: Sea Level Rise, Hydrodynamic Modeling, and Inundation Vulnerability Mapping." Prepared for the State Coastal Conservancy and Coastal Ecosystems Institute of Northern California. 106 pages. McKinleyville, CA:NHE.

SHN Consulting Engineers & Geologists, Inc. (2009). "Geologic Feasibility Report: Proposed Expansion of the Town of Samoa, Samoa Peninsula, Humboldt County, California." Unpublished consultants report produced for Samoa Pacific Group. Eureka, CA:SHN.

---. (2004). "Geotechnical Report, Proposed ACRC Sorting Facility, Samoa Peninsula, Humboldt County, California." Unpublished consultants report produced for Samoa Pacific Group. Eureka, CA:SHN.

Trinity Associates. (2108). "Humboldt County, Humboldt Bay Area Plan: Sea Level Rise Assessment." Prepared for the State Coastal Conservancy. 175 pages. Arcata, CA: Trinity Associates.

---. (2015). "Humboldt Bay Sea Level Rise Adaptation Planning Project: Phase II Report." Prepared for State Coastal Conservancy. 31 pages w/ Appendices. Arcata, CA: Trinity Associates.

United States Geological Survey. (2017). "U.S. Seismic Design Maps," v. 3.1.0. Accessed April 11, 2017 at: <https://earthquake.usgs.gov/designmaps/us/application.php>.

Youd, T.L., and S.N. Hoose. (1978). *Geological Survey Professional Paper Number 993: Historic Ground Failures in Northern California Triggered by Earthquakes*. Washington, D.C.: United States Government Printing Office.