F. Geology, Soils, and Seismicity[1]

Environmental Setting

Site Topography

The project site is located on relatively flat ground at the edge of Humboldt Bay. Other than the channel of Clark Slough, which crosses the project site within a north-south trending man-made six-foot deep ditch, the project site is associated with minimal topographic relief. Site elevations are on the order of 8 to 12 feet, with some fill mounds reaching up to about 15 feet. The ground surface at the project site is veneered with a variable thickness of fill, which likely masks some of the original site topography (e.g., historical maps suggest the site was once crossed by two sloughs).

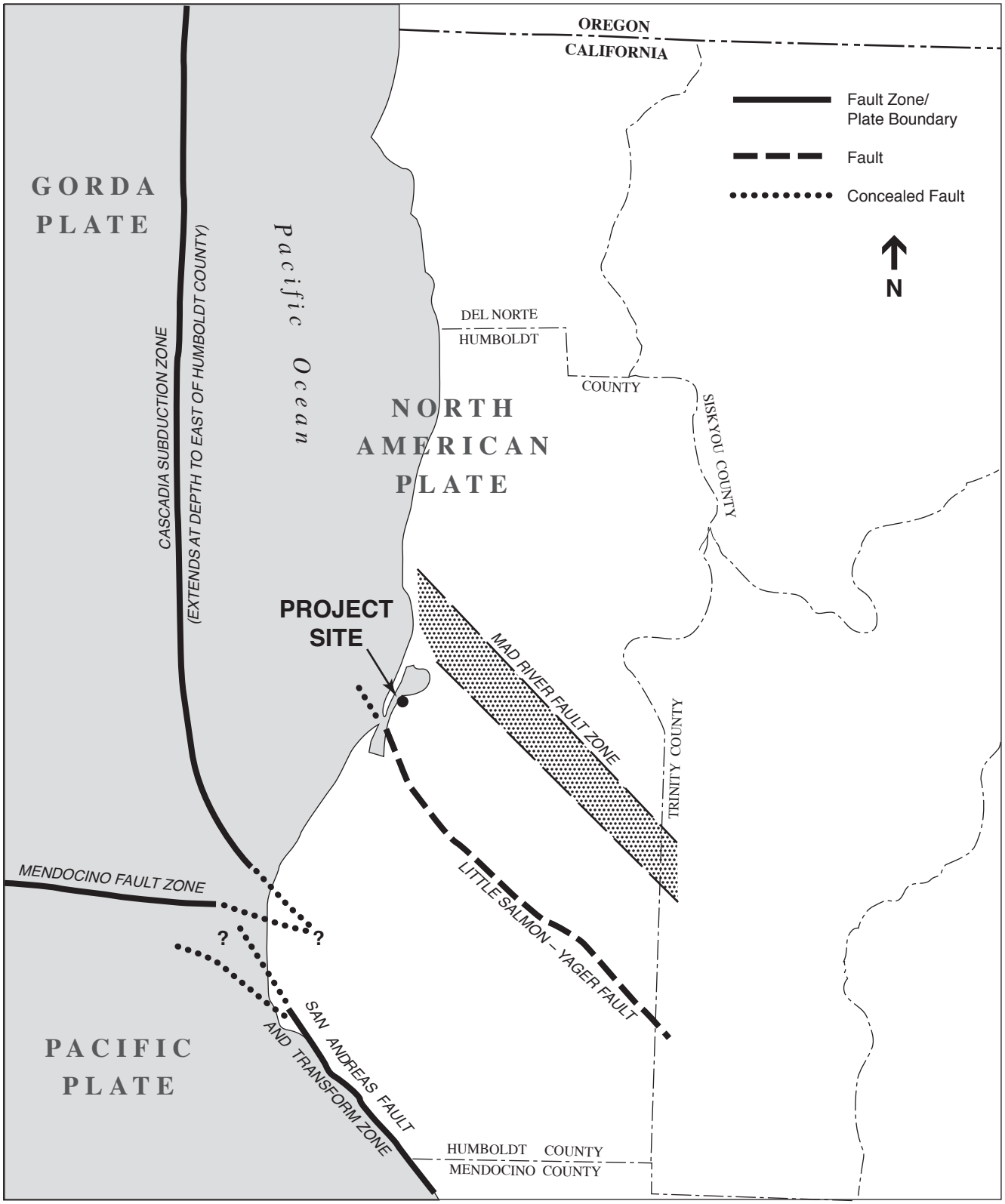
Geologic Setting

The project site is located along the eastern shore of Humboldt Bay. The Humboldt Bay region occupies a complex geologic environment characterized by very high rates of active tectonic deformation and seismicity. The area lies just north of the Mendocino Triple Junction, the intersection of the three crustal plates of the North American, Pacific, and Gorda plates (see Figure IV.F-1). North of Cape Mendocino, the Gorda plate is being actively subducted beneath North America, forming what is commonly referred to as the Cascadia subduction zone. In the Humboldt Bay region, the subduction zone is manifested on-land as a series of northwest-trending thrust faults, and intervening folds (i.e., “fold and thrust belt”). The geomorphic landscape of the Humboldt Bay region is largely a manifestation of the active tectonic processes and the setting in this dynamic coastal environment.

Basement rock beneath Humboldt Bay is the Paleocene-Eocene Yager terrane, a part of the Coastal belt of the Franciscan Complex (Blake et al., 1985; Clarke, 1992). The Franciscan Complex is a regional bedrock unit that consists of a series of “terranes,” which are discrete blocks of deformed oceanic crust that have been welded to the western margin of the North American plate over the past 140 million years. The Yager terrane consists of as much as 9,800 feet of well-indurated marine mudstone and thin-bedded siltstone. Yager terrane bedrock is in excess of 1,000 feet below the ground surface in the vicinity of Humboldt Bay.

Basement rock in the Humboldt Bay region is unconformably overlain by a late Miocene to middle Pleistocene age sequence of marine and terrestrial deposits referred to as the Wildcat Group (Ogle, 1953). The marine portion of the Wildcat Group includes 6,000 to 8,000 feet of mudstone and lesser amounts of sandstone that were deposited in a deep coastal basin (i.e., the Eel River basin). Gradationally overlying the marine portion of the Wildcat Group are 2,500 to 3,250 feet of nonmarine sandstone and conglomerate, which represent the uppermost part of the

[1] The project site has been subject to numerous site-specific geologic and geotechnical investigations, and this evaluation draws considerably on these unpublished consultant reports.



SOURCE: Eureka General Plan, 1996 (no scale given); CDMG, 1994

Marina Center Mixed-Use Project EIR . 205513

Figure IV.F-1
Tectonic Plates and Active Faults
in the Vicinity of the Project Site

Wildcat depositional sequence. The Wildcat Group 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 deposits are referred to as the Hookton Formation (Ogle, 1953). Hookton Formation sediments are described as gravel, sand, silt, and clay, which have a characteristically yellow-orange color.

Along the coast of northern California between Cape Mendocino on the south and Big Lagoon, about 60 miles (100 km) to the north, a sequence of uplifted marine terraces is preserved. The terraces are preserved as erosional remnants of raised shore platforms and associated cover sediments. Sea level has fluctuated throughout the late Pleistocene in response to the advance and retreat of large continental ice sheets. Marine terraces preserved along the coast represent surfaces eroded during the highest levels of these sea level fluctuations, superimposed on a coastline being uplifted by regional tectonics. Marine terraces in the region range in age from about 64,000 years old, to as much as 240,000 years old. The City of Eureka occupies a series of northward-dipping marine terrace surfaces eroded onto the Hookton Formation.

Beneath Humboldt Bay, and along its margins, the Hookton Formation and marine terrace deposits are overlain by late Holocene age bay muds and associated littoral and estuarine deposits. Near alluvial sources at the fringes of the bay, bay muds are intermixed with terrestrial alluvial deposits. These youthful, unconsolidated deposits vary in thickness and composition around the bay and in the adjacent coastal valleys, often exhibiting large amounts of lateral variation over very small distances. Bay deposits typically consist of silty clays or clayey silts (i.e., bay muds) interbedded with clean sand lenses and beds. During the latter part of the 1800s and early part of the 1900s, extensive areas of natural marshlands along the eastern margin of Humboldt Bay were "re-claimed" by placement of uncontrolled fill. Natural estuarine channels and pre-existing marsh surfaces were buried by fill (often including significant amounts of timber slash and/or mill waste) and subsequently developed. Because the natural "pre-fill" surface had significant relief, fill thickness varies considerably along the bay margin.

Site Geology

Due to the history of the project site as a long-term rail yard and the necessity to study and document site contamination, extensive subsurface investigations have been completed. The site conditions were most recently reported in a geotechnical report prepared for the project, which included several new core penetration testing (CPT) soundings and analysis of previous machine borings and CPT soundings by others (SHN, 2006). That report describes a veneer of fill (typically about 5 to 8 feet thick) overlying a layer of native soil that consists of very soft clay with organics (“bay mud”). The bay mud is typically 2 to 7 feet thick across the site, and has been observed up to 14 feet beneath the existing ground surface in the central part of the project site. Beneath the bay muds, the native materials grade to sand and gravelly sand that becomes increasingly dense with depth. West of Clark Slough, these sands remain relatively loose to depths of up to 22 feet. This loose material may represent younger alluvial sediment derived from Clark Slough. The conditions at the project site are consistent with the subsurface conditions at other sites around Humboldt Bay.

Groundwater levels at the site are anticipated to be shallow due to the low elevation nature of the site. Subsurface investigations at the project site have confirmed groundwater levels on the order of 4 to 7 feet below ground surface.

Soils

The area is just outside the mapping included in the *Soils of Western Humboldt County, California* (McLaughlin and Harradine, 1965). Where not identified as Residential/Industrial sites, areas around Humboldt Bay are shown as being underlain by soils of the Bayside series. These soils are typically silty clay loams. The mapped soils nearest the project site are shown as Bayside silty clay loams (Ba6), very poorly drained, zero to 3 percent slopes. Based on site conditions, it is reasonable to assume that this soil type is likely present at the project site as well. As described above, the project site is veneered with a variable thickness of fill materials, such that native soils are no longer exposed at the project site. Fill soils at the project site are highly variable, and include silty sand, clay, gravel, construction debris, and organic materials.

Seismicity

The project site is located in a region of high seismicity. Many earthquakes have produced discernible damage in the region since the mid-1800s. Historic seismicity and paleoseismic studies in the area suggest there are six distinct sources of damaging earthquakes in the Eureka region (see Figure IV.F-1): (1) the Gorda Plate; (2) the Mendocino fault; (3) the Mendocino Triple Junction; (4) the northern end of the San Andreas fault; (5) faults within the North American Plate (including the Mad River fault zone); and (6) the Cascadia Subduction Zone (Dengler et al., 1992).

Earthquakes originating within the Gorda Plate account for the majority of historic seismicity. These earthquakes occur primarily offshore along left-lateral faults, and are generated by the internal deformation within the plate as it moves toward the subduction zone. Significant historic Gorda Plate earthquakes have ranged from magnitude 5 to 7.5. The November 8, 1980, earthquake (magnitude 7.2) was generated 30 miles (48 km) off the coast of Trinidad on a left-lateral fault within the Gorda Plate.

The Mendocino fault is the second most frequent source of earthquakes in the region. The fault represents the plate boundary between the Gorda and Pacific plates, and typically generates right lateral strike-slip displacement. Significant historic Mendocino fault earthquakes have ranged from magnitude 5 to magnitude 7.5. The September 1, 1994, magnitude 7.2 event originating west of Petrolia was generated along the Mendocino fault. The Mendocino triple junction was identified as a separate seismic source only after the magnitude 6.0 August 17, 1991, earthquake. Significant seismic events associated with the triple junction are shallow onshore earthquakes that appear to range from magnitude 5 to 6.

Earthquakes originating on the northern San Andreas fault are extremely rare, but can be very large. The northern San Andreas fault is a right lateral strike-slip fault that represents the plate boundary between the Pacific and North American plates. The fault extends through the Point

Delgada region and terminates at the Mendocino triple junction. The 1906 San Francisco earthquake (magnitude 8.3) caused the most significant damage in the north coast region, with the possible exception of the April, 1992 Petrolia earthquake (Dengler et al., 1992).

Earthquakes originating within the North American plate can be anticipated from a number of faults, including the Mad River fault zone and Little Salmon fault. There has been no large magnitude earthquakes associated with these faults, although the December 21, 1954, magnitude 6.5 event may have occurred in the Mad River fault zone. Damaging North American plate earthquakes are expected to range from magnitude 6.5 to 8. The Little Salmon fault appears to be the most active fault in the Humboldt Bay region, and is capable of generating very large earthquakes.

Regional Faults

As noted above, the project site vicinity is located in a region that has numerous active onshore and offshore faults; however, no known active faults traverse through the project site (Jennings, 1994; Hart & Bryant, 1997). Table IV.F-1 presents fault location relative to the site. Distances measured are map distances.

TABLE IV.F-1
FAULT INFORMATION

Fault Name	Fault Activity Rating	Distance From Site		Upper Bound Earthquake (Mw)[a]
		Miles	Kilometers	
Little Salmon (onshore)	A	7	11	7.0
Table Bluff	A	10	16	7.0
Little Salmon (offshore)	A	7	12	7.1
Cascadia Subduction Zone	A	35	57	9.0
Mad River	A	10	15	7.1
Fickle Hill	A	8	13	6.9
McKinleyville	A	11	18	7.0
Trinidad	A	12	19	7.3
Big Lagoon – Bald Mountain	A	17	27	7.3
San Andreas	A	52	84	7.9

A= active, PA = potentially active, per Peterson et al. (1996).

[a] The Richter magnitude (M) scale was developed by Charles Richter in the 1930's and is a logarithmic measurement of the amount of earthquake released by an earthquake. Today, seismologists are using the Moment Magnitude (Mw) scale, which measures the size of the earthquake's fault, and how much the earth slips at the time of the quake.

Little Salmon Fault

The Little Salmon fault is the closest known active fault to the project site (Wills, 1990). The Little Salmon fault is a northwest-trending, reverse fault (i.e., the northeast side of the fault slides up and over the southwest side of the fault along a northeast-dipping fault plane). Estimates of the

amount of fault slip for individual earthquakes along the fault have been made ranging from 15 to 23 feet. Radiocarbon dating suggests that earthquakes have occurred on the Little Salmon fault about 300, 800, and 1,600 years ago. Average slip rate for the Little Salmon fault for the past 6,000 years is between 6 and 10 mm/yr (Clarke, 1992). Based on currently available fault parameters, the maximum magnitude earthquake for the Little Salmon fault is thought to be between 7.0 (Peterson, 1996) and 7.3 (Geomatrix Consultants, 1994). Table IV.F-1 notes that the site-to-source map distance is about 7 miles from the project site. The fault, however, dips beneath the site. Assuming a 30 degree fault dip, the fault is likely within about 3 miles beneath the site (WCC, 1980).

Cascadia Subduction Zone

The Cascadia Subduction Zone (CSZ) represents the most significant potential earthquake source in the north coast region. The CSZ is the location where the oceanic crust of the Gorda and Juan de Fuca plates are being subducted beneath the continental crust of the North American Plate. A great subduction event may rupture along 150 miles or more of the coast from Cape Mendocino to British Columbia, may be up to magnitude 9.5, and could result in extensive tsunami inundation in low-lying coastal areas. The April 25, 1992, Petrolia earthquake (magnitude 7.1) appears to be the only historic earthquake involving slip along the subduction zone, but this event was confined to the southernmost portion of the fault. It is estimated that there have been six significant subduction zone events along the CSZ in the last 3,000 years (Darienzo and Petersen, 1995). Paleoseismic studies along the subduction zone suggest that great earthquakes are generated along the zone every 300 to 800 years. Historic records from Japan describing a tsunami thought to have originated along the Cascadia Subduction Zone suggest the most recent great subduction event occurred on January 27, 1700. A great subduction earthquake would generate long duration, very strong ground shaking throughout the north coast region.

The CSZ is located offshore, west of the north coast region. Available mapping indicates that the surface expression of the subduction zone is located some 30 to 35 miles west of the project site (Clarke, 1992; McLaughlin et al., 2000). Seismic profiles suggest that the subduction interface dips landward at an angle of about 11 degrees (McPherson, 1992), which would place it at a depth of about 7 miles beneath the project area (using right angle projection).

North Spit Fault

The North Spit fault was identified in seismic profiles offshore of the North Spit, west of Humboldt Bay. The fault's existence or extent is uncertain, however, because it was not imaged in seismic profiles farther offshore, and it has never been identified on-land. Despite its uncertainty, the fault is relevant to this project because it is mapped within a few miles to the south of the site. The fault is not recognized or zoned by the State as an active or potentially active fault.

Ground Shaking

Earthquakes are typically described by their magnitude and by their intensity. While magnitude is a measure of the energy released in an earthquake, intensity is a measure of the ground shaking effects at a particular location. Ground movement during an earthquake can vary depending on

the overall magnitude, distance to the fault, focus of earthquake energy, and type of geologic material. The composition of underlying soils, even those relatively distant from faults, can intensify ground shaking. The Modified Mercalli (MM) intensity scale (see Table IV.F-2) is common measurement tool that is based on the "felt" effects of an earthquake due to ground shaking. The MM Intensity scale relates ground shaking to effects most people experience during a seismic event. The MM values for intensity range from MM I (earthquake not felt) to MM XII (damage nearly total), and intensities ranging from MM IV to MM X could cause moderate to significant structural damage.[2] An M 8.4 earthquake on the Cascadian Subduction Zone is anticipated to result in ground shaking intensities ranging from very strong (MM VIII) to violent (MM IX) in the project area (CGS, 1995).[3] In contrast, the 1992 Petrolia earthquake, M 7, resulted in only moderate (MM V) ground shaking in Eureka.

Because the subject site is located in a seismically active area, it is subject to the potential for strong seismic shaking during the economic lifespan of the proposed project. Available paleoseismic data on earthquake timing and recurrence for faults in the region is limited, but in most cases appears to be on the order of hundreds of years to a few thousands of years. Because of the large number of potential sources, the combined recurrence interval for earthquakes causing slight to moderate damage is on the order of 5.5 years (Dengler, 1992). Larger earthquakes will have longer repeat times, with the Cascadia Subduction Zone representing the most severe potential hazard with a recurrence interval on the order of 300 to 800 years (the last Cascadia event likely occurred in 1700).

Earthquake hazards are typically characterized by assessing the probability of an event occurring within a certain time frame. Most commonly, this probability is now reported as a 10% probability of occurrence in a 50-year period (an annual probability of 1 in 475). Ground motions are typically expressed as a fraction of the acceleration of gravity (g). Ground motion estimates for the site are available from two readily accessible sources. An interactive "probabilistic seismic hazard assessment" is available on the website of the California Geological Survey (CGS), which is dated 2002. The CGS site shows three values for the site, the peak ground acceleration (Pga), and spectral accelerations (Sa) at short (0.2 seconds) and moderately long (1.0 second) periods. Assuming the site is an alluvial or soft rock site, the Pga for the site is on the order of 0.7 to 0.8 g, Sa (0.2 sec) is about 1.7 g, and Sa (1 sec) is between 0.7 and 0.85 g. The 2007 California Building Code (CBC) contains maps showing "maximum considered earthquake ground motions" for 0.2 second and 1 second spectral response accelerations (Figures 1613.5 (3) and 1613.5 (4) in the CBC). The Sa value for 0.2 second period is 2 g; the Sa value for 1 second is on the order of 0.8 to 1.0 g.

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2 The damage level represents the estimated overall level of damage that will occur for various MM intensity levels. The damage, however, will not be uniform. Some buildings will experience substantially more damage than this overall level, and others will experience substantially less damage. Not all buildings perform identically in an earthquake. The age, material, type, method of construction, size, and shape of a building all affect its performance.

3 Although the maximum moment magnitude earthquake estimated to occur on the entire length of the Cascadia subduction zone is 9.0, a severe earthquake on the 150-mile Gorda segment of the Cascadia Subduction Zone is anticipated to produce similar levels of damage in northern California (CGS, 1995).

TABLE IV.F-2
MODIFIED MERCALLI INTENSITY SCALE

Intensity Value	Intensity Description	Average Peak Acceleration
I	Not felt except by very few persons under especially favorable circumstances.	< 0.0017 g[a]
II	Felt only by a few persons at rest, especially on upper floors on buildings. Delicately suspended objects may swing.	< 0.014 g
III	Felt noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly, vibration similar to a passing truck. Duration estimated.	< 0.014 g
IV	During the day felt indoors by many, outdoors by few. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.	0.014–0.039 g
V	Felt by nearly everyone, many awakened. Some dishes and windows broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles may be noticed. Pendulum clocks may stop.	0.039–0.092 g
VI	Felt by all, many frightened and run outdoors. Some heavy furniture moved; and fallen plaster or damaged chimneys. Damage slight.	0.092–0.18 g
VII	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.	0.18–0.34 g
VIII	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motor cars disturbed.	0.34–0.65 g
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.	0.65–1.24 g
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.	> 1.24 g
XI	Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.	> 1.24 g
XII	Damage total. Practically all works of construction are damaged greatly or destroyed. Waves seen on ground surface. Lines of sight and level are distorted. Objects are thrown upward into the air.	> 1.24 g

[a] g (gravity) = 980 centimeters per second squared. 1.0 g of acceleration is a rate of increase in speed equivalent to a car traveling 328 feet from rest in 4.5 seconds.

SOURCE: California Geological Survey, 2003.

Geologic/Seismic Hazards

As described above, the project site is located in a dynamic tectonic region where moderate to large magnitude earthquakes are relatively common. The project site is likely to experience the effects of a significant earthquake(s) within the economic lifespan of the proposed development. It may experience the impacts of a great earthquake should the Cascadia Subduction Zone rupture. The potential impacts associated with earthquakes include surface fault rupture, strong ground shaking, liquefaction or lateral spreading, and soil consolidation or settlement (including differential settlement). Very large earthquakes, most likely originating along the subduction zone, may generate tsunamis that may impact the site. Non-seismic geologic hazards include subsidence, landsliding, and other soil-related hazards.

Surface Fault Rupture

Surface fault rupture involves ground breakage along the surface trace of a fault produced during an earthquake. As seismic ground displacement tends to occur repeatedly along the same planes of weakness (i.e., faults), the potential for future surface rupture is concentrated along known active faults. As described above, there are no known active faults mapped within, or in close proximity to, the project site. The project site is not within an area designated by the State as an Alquist-Priolo Earthquake Fault Zone. Therefore, the potential for surface fault rupture is considered to be very low.

Liquefaction

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 the soil acts more like a fluid than a solid when shaken during an earthquake. In order for liquefaction to occur, the following are needed:

1. Granular, non-cohesive soils (sand, silty sand, sandy silt, and some gravels);
2. A high groundwater table; and
3. A low density of the granular soils (usually associated with young geologic age).

The potential for liquefaction increases with the magnitude and duration of an earthquake. 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.

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 an inclined slope face. In general, lateral spreading has been observed on low to moderate gradient slopes, but has been noted on slopes inclined as flat as 1 degree.

Liquefaction has been documented on numerous occasions in the project vicinity following historic moderate to large magnitude earthquakes. Specific accounts of historic ground failures are presented in an excellent compilation prepared by Youd and Hoose (1978). Pertinent to the

proposed project are a series of accounts involving deformation along the Humboldt Bay shore. These include accounts from the 1906 earthquake:

> *"…at Fields Landing…here the shock opened a fissure over 100 feet long in the middle of the road, which 6 teams spent one day in filling. Pelican Island, as it is commonly called, opposite Fields Landing, dropt 3 feet…".*
>
> *"At Fields Landing around the home of John Johnson, small cracks in the earth became geysers throwing out warm water for several hours… A little beyond the Landing in the county road was a crack about 18 inches wide and twelve to fourteen feet long. A nine-foot stick failed to touch bottom and teams were busy all day to fill up the gulch."*
>
> *"At the home of R.L. Haughey…cracks were in evidence in the earth all around the property when the gentlemen got out of the house, and water was spouting up through them. The cracks were about 10 inches wide, but during the day they closed up, and last evening were only about 4 inches across. At the Eureka Foundry, the ground surrounding the plant was cracked by the tremor of yesterday morning. The ground sank materially also in places."*
>
> *"The large water mains of the Eureka Water Company are badly twisted…"*
>
> *"At Eureka, the wharf sank 4 feet."*

In 1954, the following account is recorded:

> *"The big shaker left this giant-sized fracture in the city's surface on Hawthorne Street near Broadway. The cracks depth was unrecorded, but it measured up to 12 inches wide…"*

These occurrences of ground deformation during historic earthquakes are inferred to have occurred in similar geologic environments as those at the project site. As such, the historic record would indicate a probability of liquefaction and potential impacts to the project during future strong seismic events.

The results of the site geotechnical report confirm the potential for liquefaction at the site (SHN, 2006). Potential liquefiable sand materials were encountered within most of the CPT sounding and machine borings, and groundwater levels are anticipated to be high for most of the year. These materials were typically associated with one- to three-foot thick layers at various depths, and indicate a limited, yet significant, liquefaction potential across most of the project site. The liquefaction potential is greater west of Clark Slough, where liquefiable sands are present at depths between about 7 and 22 feet. Liquefaction potential is high in this area. Lateral spreading risk is also considered highest in the area west of Clark Slough, due to the increased liquefaction potential and natural slope of the ground toward the bay.

Tsunami Hazard

Tsunamis are long-period sea waves caused by sea floor deformation associated with submarine fault rupture or submarine landslides, sometimes from sources hundreds or thousands of miles away. Because the project is located in a low-lying coastal area in a seismically active region, it

could be subject to tsunami inundation. The hazard associated with tsunami inundation is increased in the Humboldt County area due to the proximity of the Cascadia subduction zone and other active offshore seismic sources that are capable of generating very large earthquakes. Although this hazard results from a geologic event, the potential damaging effects are related to flooding and are therefore discussed in Section IV.H, *Hydrology and Water Quality*.

Settlement/Subsidence

Low-density sedimentary materials beneath the project site may be subject to consolidation and post-construction settlement or subsidence. Consolidation, settlement or subsidence may occur in this setting due to seismic shaking or due to the introduction of a load (either a structure or fill). Settlement or subsidence may occur differentially due to subsurface variations or due to an uneven distribution of loading. Geotechnical studies of the site indicate that excessive settlement is a high risk within the area west of Clark Slough (SHN, 2006). Within the remainder of the parcel, the amount of estimated settlement or subsidence can be addressed with the implementation of standardized engineering practices (which are included in typical foundation work), the risk of adverse consolidation, ground settlement or subsidence is considered low.

Slope Instability or Landslides

Landslides are movements of a mass of rock, debris, or earth down a slope that may be initiated by either static (i.e., gravitational) or dynamic (i.e., seismic) forces. The susceptibility for mass failure in a landslide is dependent on a number of factors, including material characteristics (strength, variability, presence and orientation of discontinuities, etc.), slope gradient, soil moisture, and management-induced changes in either the driving or resisting forces (usually due to excavation or vegetation removal). As described above, the project site is a relatively flat bayshore surface. Therefore, the project site has a very low potential for landslide hazards.

Soil Erosion

Erosion is the general process whereby earth materials are detached and transported from one place to another, usually by wind or water. Susceptibility to erosion is a function of material characteristics (i.e., soil texture, consolidation or cohesion all affect erosion potential), vegetation cover, slope, and drainage patterns. Because the project site is flat, it is not subject to significant erosion hazards. In addition, the past history of the project site as rail yard resulted in placement of a variable thickness of fill materials across the entire site. Therefore, there is a low risk of significant erosion or loss of topsoil resource.

Expansive Soils

Expansive soils are those clay-rich soils subject to volumetric fluctuations (“shrink-swell”) due to changes in moisture levels. Particular clay minerals are susceptible to expansion potential, and typically site-specific soils testing is required to determine the level of risk. Highly expansive soils can damage structures built on them unless appropriate engineering mitigation is incorporated into design. The project geotechnical report identifies clay-rich soils at the site, but notes they are typically 5 or more feet deep (SHN, 2006). As such, they are typically not at a

stratigraphic level that would be expected to experience wetting and drying, and therefore, the risk of adverse consequences associated with soil expansivity are considered low.

Environmental Analysis

Significance Criteria

For the purposes of this EIR, implementation of the proposed project would have a significant effect related to geology, soils or seismicity if, based on Appendix G of the CEQA Guidelines, it would:

1. Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:

    a. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault. Refer to Division of Mines and Geology Special Publication 42.

    b. Strong seismic ground shaking.

    c. Seismic-related ground failure, including liquefaction.

    d. Landslides.

2. Result in substantial soil erosion or the loss of topsoil;

3. Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse;

4. Be located on expansive soil creating substantial risks to life or property; or

5. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater.

Regulatory Framework

The following standards and regulations govern geology, soils and seismicity and are used to measure impacts.

State Regulations Related to Seismic Hazards

Alquist-Priolo Earthquake Fault Zoning Act (California Public Resources Code, Chapter 7.5, Division 2)

The Alquist-Priolo Earthquake Fault Zoning Act of 1972 is intended to regulate development on or near active fault traces to mitigate the potential for damage due to surface fault rupture. The Act requires the State Geologist to delineate zones along “sufficiently well-defined and

active faults" in California. Within these zones, special studies are required to determine the potential for surface fault rupture. The project site is not included in any Alquist-Priolo Earthquake Fault Zone.

Seismic Hazards Mapping Act

The Seismic Hazards Mapping was developed to mitigate the hazard potential associated with a variety of secondary seismic impacts, namely strong amplified ground motion, liquefaction, and seismically induced landsliding. This Act requires the State Geologist to delineate various seismic hazard zones and requires responsible agencies or municipalities to regulate certain developments within these zones. At this time, Seismic Hazard zones have not been developed for the Humboldt County region.

California Building Code Standards

The California Building Code is contained in Title 24 of the California Code of Regulations. Under state law, all building codes must be centralized in Title 24 or they are not enforceable.

The 2007 California Building Code is based on the 2006 International Building Code published by the International Code Council. The California Building Code requires extensive geotechnical analysis and engineering for grading, foundations, retaining walls, and structures.

General Plan and Local Coastal Program

The City of Eureka's adopted General Plan and adopted Local Coastal Program together formalize a long-term vision for the physical evolution of Eureka and they outline the policies, standards, and programs that guide day-to-day decisions concerning Eureka's development in the coastal zone. The Policy Consistency Analysis, found in Section IV.I, *Land Use and Planning,* provides an evaluation of the Marina Center project's conformity with the policies of the adopted General Plan and Land Use Plan portion of the adopted Local Coastal Program.

Coastal Zoning Regulations

The Coastal Zoning regulations which implement the policies of the Land Use Plan portion of the adopted Local Coastal Program are codified in Chapter 156 of the Eureka Municipal Code (EMC), and are also referenced as Article 29, Part 1, Section 10-5.29 et. seq. of the zoning regulations of the City for the coastal zone.

Zoning Regulations

The Zoning Regulations of the City of Eureka are found in Chapter 155 of the EMC and are adopted pursuant to the City Charter to protect the public health, safety, peace, comfort, convenience, prosperity and general welfare.

Project Impacts

Impact F-1: Would the Marina Center project expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault; strong seismic ground shaking; seismic-related ground failure, including liquefaction; and/or landslides?

The City of Eureka is a region of significant seismic activity. The project site could experience a range of ground shaking effects during an earthquake on the Cascadia Subduction Zone, Mad River Fault Zone, or other regional active faults.

Earthquakes and ground shaking in the Eureka area are unavoidable and expected to occur at some time in the near future. Although some structural damage is typically not avoidable, building codes and local construction requirements have been established to protect against building collapse and major injury during a seismic event.

Adherence to the California Building Code and the recommendations made by the project geotechnical engineer presented in the geotechnical engineering report would reduce potential seismic impact associated with the proposed project to a less-than-significant level.

Mitigation

> **Mitigation Measure F-1a:** The proposed project shall comply with requirements of the most recent California Building Code which include the completion of a site-specific, design level geotechnical report that examines and assesses the potential for the proposed project to be subject to ground shaking, liquefaction, and other seismic hazards associated with the occurrence of a maximum credible earthquake anticipated to affect the Eureka region. The project-specific geotechnical report shall include specific measures to address these hazards including, at a minimum, measures for the design and construction of foundations, underground utilities, and paved areas. These specific measures shall meet or exceed the requirements set in the most recent California Building Code. The project applicant shall implement the specific recommendations included in the project-specific geotechnical report as part of the project.

Finding of Significance

The recommended mitigation measure would minimize the potential of the Marina Center project to expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, strong seismic ground shaking, seismic-related ground failure (including liquefaction), and/or landslides, reducing the impact to a ***less-than-significant*** level.

Impact F-2: Would the Marina Center project result in substantial soil erosion or the loss of topsoil?

The relatively flat topography of the project site significantly reduces the potential for erosion during and after construction of the proposed project. Most of the original topsoil on the project site has previously been removed, reworked, or buried with a veneer of fill that covers the entire site. Erosion of site soils or fills could be effectively mitigated through basic erosion control measures.

Since Best Management Practices have been recognized as effective methods to prevent or minimize erosion, and the project applicant shall adhere to erosion control measures outlined in the Storm Water Pollution Prevention Plan as required by law and Mitigation Measure H-3a in Section IV.H, *Hydrology and Water Quality*, the potential for erosion impacts during construction would be less-than-significant.

Mitigation

See recommended Mitigation Measure H-3a

Finding of Significance

The recommended mitigation measure would avoid or minimize the potential for substantial soil erosion or the loss of topsoil, reducing the impact to a ***less-than-significant*** level.

Impact F-3: Would the Marina Center project be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?

The previous geotechnical investigations at the project site have consistently shown that the project site is susceptible to liquefaction. Liquefaction causes ground failure that can potentially damage roads, pipelines, underground cables, and buildings with shallow foundations. The liquefaction potential was found to be highest west of Clark Slough, an area that would be rehabilitated as a wetland under the proposed project. As described above, some structural damage is typically not avoidable during a major earthquake; however, building codes and current foundation design standards have been established to protect against the adverse effects of ground failure such as liquefaction and lateral spreading.

Soft soils underlying the project site are subject to both consolidation and settlement under static and dynamic conditions. The hazard is relatively manageable over most of the project site; however, the area west of Clark Slough may be subject to excessive settlement under dynamic loading. Since no development is proposed west of Clark Slough, and the remainder of the site would be subject to the geotechnical engineering report required in recommended Mitigation Measure F-1a, the impact would be less-than-significant.

Mitigation

See recommended Mitigation Measure F-1a.

Finding of Significance

The recommended mitigation would minimize the potential impact of the Marina Center project being located on a geologic unit or soil that would become unstable as a result of the project and potentially result in an on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse. With the recommended mitigation, the impact would be ***less-than-significant***.

Impact F-4: Would the Marina Center project be located on expansive soil creating substantial risks to life or property?

Highly expansive soils can damage structures built on them unless appropriate engineering mitigation is incorporated into the design. The project geotechnical report identifies clay-rich soils at the site but notes they are typically 5 or more feet deep (SHN, 2006). As such, they are typically not at a stratigraphic level that would be expected to affect the building foundation, and therefore the risk of adverse consequences associated with soil expansivity is considered low.

Mitigation

None recommended

Finding of Significance

The potential impact of the Marina Center project being located on expansive soil creating substantial risks to life or property would be ***less-than-significant***.

Impact F-5: Would the Marina Center project have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?

The Marina Center project would connect to city utilities. The project does not propose septic tanks or other alternative wastewater disposal systems.

Mitigation

None recommended

Finding of Significance

The Marina Center project would not use septic tanks or alternative wastewater disposal systems, and therefore would have ***no impact*** in relation to soil capability for these systems.

Cumulative Impacts

Impact F-6: Would the Marina Center project, together with other developments in the immediate vicinity, contribute to potential cumulative geologic and seismic hazards including increased soil erosion, slope failure, ground shaking, soil settlement, and liquefaction?

Preparation of the routine site-specific, design-level geotechnical engineering report and implementation of its recommendations (see Mitigation Measure F-1a) would address the above-mentioned geologic and seismic impacts associated with the proposed project. Geotechnical engineering reports prepared for other developments in the immediate vicinity of the project site would also be required to include recommendations to offset any potential impacts. The entire area is within a seismically active region with a wide range of geologic and soil conditions that can vary widely within a short distance, making the cumulative context for potential impacts resulting from exposing people and structures to related risks one that is more localized or even site-specific. The project in combination with other past, present, and foreseeable future developments, is unlikely to result in any significant cumulative impacts because newer construction is typically built to higher seismic standards as the industry's understanding of how structures behave in a seismic event advances. Even if there were an impact, the project's contribution would be reduced to a less than cumulatively considerable level through the implementation of the recommendations and measures of the project specific geotechnical report and the implementation of the Storm Water Pollution Prevention Plan.

Thus, the cumulative geologic and seismic impact associated with the proposed project, together with other existing and foreseeable development in the surrounding area, is considered less-than-significant.

Mitigation

See recommended Mitigation Measures F-1a and H-3a

Finding of Significance

The recommended mitigation measures would reduce the potential impacts of the Marina Center project related to geologic and seismic hazards including increased soil erosion, slope failure, ground shaking, soil settlement, and liquefaction, to ***less-than-significant*** levels, and the project would not make a cumulatively considerable contribution to cumulative geology-related impacts

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