AB691 Modified Assessment Criteria

1. Name of AB 691 Trustee/Grantee (i.e. name of jurisdiction):

   City of Eureka

2. Please provide a couple paragraphs summarizing the granted lands area, including total area covered, history of public trust uses on the granted lands, and a brief summary of anticipated SLR impact and vulnerabilities:

   The City of Eureka was granted sovereign waterfront lands in trust in 1857. In subsequent granting statutes, the City was granted other sovereign tide and submerged lands, in trust, for the establishment, improvement and conduct of a harbor, for the construction, maintenance and operation of wharves, docks, piers, slips, quays, and other utilities, structures, and appliances necessary or convenient to promote and accommodate commerce and navigation.

   The City's tidelands include approximately 2,890 acres of water, and approximately 1,000 acres of adjoining shoreline/upland. Uses on the granted tidelands include mariculture, commercial fishing and recreational boating docks, piers, and marinas, as well as natural resource areas.

   Without the ability to maintain and/or reinforce/expand existing dikes, levees, and other natural and artificial shorelines, much of the tideland area will likely be completely inundated by 2050. In many areas, this also means the on-shore/upland supportive services, such as the Waterfront Trail, Fishermen's Terminal Work area, and the industrial parks associated with the Schneider and Schmidbauer docks, for example, will no longer be viable, and those operations that provide and support commercial fishing, visitor-serving uses, and economic resources, will cease. In the interim, the City is also working to define areas where shorelines could be expanded and additional public trust lands could be provided.

3. Using examples from the list below, please identify your primary (critical to your operation) and secondary (important, but not critical) uses.

   - *Commerce (shipping, water-dependent movement of goods and services);*
   - *Safety and navigation (land use to facilitate the safe passage of all water transportation, ensure national security);*
   - *Recreation (visitor-serving facilities, tourism, retail, water-related activities such as boating, fishing, or swimming);*
   - *Fisheries (commercial);*
   - *Environmental Stewardship (coastal habitat preservation and restoration, conservation, etc);*
   - *Other (please explain).*

   Primary uses: **Fisheries (commercial)**
   Commerce (shipping, water-dependent movement of goods and services)
   Safety and navigation (land use to facilitate the safe passage of all water transportation, ensure national security);

   Secondary uses: **Environmental Stewardship (coastal habitat preservation and restoration, conservation, etc)**
   Recreation (visitor-serving facilities, tourism, retail, water-related activities such as boating, fishing, or swimming)

4. Please identify the nearest tidal gauge to your granted lands area (for a map of tidal gauges, please see Appendix 2 of the OPC 2018 Guidance):

    North Spit

5. Please list the SLR projections for the 66% (Likely, or 'Low Risk Aversion') range and the 0.5% ('Medium-High Risk Aversion) range for your nearest tidal gauge. Planning and designing adaptation strategies for the H++, or 'Extreme Risk Aversion' scenario is encouraged, especially for assets that have a design life beyond 2050 that have little to no adaptive capacity, would be irreversibly destroyed or significantly costly to relocate/repair, or would have considerable public health, public safety, or environmental impacts should this level of sea-level rise occur (e.g. coastal power plant). For SLR projections tables for each tidal gauge, please see Appendix 3 of the OPC 2018 Guidance.

	Low Risk Aversion:	Medium-High Risk Aversion:
Year 2030:	**0.7**	**1.0**
Year 2050:	**1.5**	**2.3**
Year 2100:	**3.1/4.1**	**6.3/7.6**

Planning and Designing Adaptation Strategies for H++ (Extreme Risk Aversion):

Refer to*: City of Eureka Sea Level Rise Adaptation Planning Report and Final Adaptation Plan Addendum #1*. (Attached)

6. Please choose one of the following SLR viewers to model the 2030, 2050, and 2100 projections in #5. Please indicate which viewer you used and provide a screen shot for each year.
[Viewer examples: Our Coast Our Future (models SLR and storm impacts); BCDC ART Flood Explorer (suggested for Bay Area trustees); NOAA SLR Viewer; SLC Sea Level Rise Viewer]

7. Identify public trust assets within granted lands area that are vulnerable to SLR between now and 2100.

    Refer to*: Final Sea Level Rise: Assets Vulnerability and Risk Assessment.* (Attached)

8. Estimate anticipated costs of sea-level rise:

    Attached is an Economic Information report dated April, 2015, developed to identify the City's Coastal Dependent Industrial land needs. Also included is a copy of the 2018 Humboldt Bay Maritime Industrial Use report prepared by the County of Humboldt. Although both reports are focused on analyzing how much land is needed for current and anticipated coastal dependent land uses, it provides a snapshot of the existing and anticipated uses of the City's tideland areas. Also attached is an Economic Development Policy Paper from 2015 that was used to inform the City of Eureka 2040 General Plan, which was adopted in 2018.

    Other than the information contained in the Asset Vulnerability and Risk Assessment Reports provided, and the reports noted above, the City is not aware of any other economic forecasts that have been prepared locally for Sea Level Rise impacts. The City is in the process of updating the Land Use Plan portion of the Local

Coastal Program, and additional Sea Level Rise information will be generated to inform that process. For example, we will be using the tideland information contained in the tideland spreadsheet (also attached) to better determine the value of the City's tidelands.

	Current	2030	2050	2100
Repair, Replacement, Maintenance				
Losses in non-market value				
Adaptation costs				

Definitions:

- **Repair, Replacement, Maintenance:** Replacement or repair costs of resources and facilities that could be impacted by sea-level rise and climate change processes
- **Losses in non-market value:** Non-market values, including recreation and ecosystem services, of public trust resources that could be impacted by climate change and sea-level rise processes. For more information, please see https://oceaneconomics.org/nonmarket/.
- **Adaptation Costs:** Include anticipated costs of adaptation/mitigation measures, and potential benefits of such strategies and structures

9. What adaptation measures or strategies are being considered to protect the public trust assets and granted lands area?

The City of Eureka has been holding back the sea for over 150 years, including the 18 inches of sea level rise that has occurred during the last century. The City does this through both natural and artificial barriers, such as the use of dikes, levees, railroad grades, piers, and bulwarks. The City's intent is to maintain the use of our shoreline, and to continue to hold back the sea until the magnitude of Sea Level Rise change is such that protection management strategies can no longer protect the assets.

Much of the City's waterfront is built out, giving little ability to retreat from the existing shoreline. The City has several studies under way that will analyze the potential for managed retreat along discreet portions of its waterfront.

Refer to*: City of Eureka Sea Level Rise Adaptation Planning Report and Final Adaptation Plan Addendum #1* . (Attached)

Adaptation strategies and measures are for year 2100.

10. Please describe any existing or potential partnerships, or collaborations, related to sea-level rise vulnerability assessment or adaptation planning:

County of Humboldt, CalTrans, City of Arcata, North Coast Regional Water Quality Control Board, Northwestern Pacific/Union Pacific/North Coast Railroad Authority, California Coastal Commission, Humboldt Bay Harbor and Recreation District, State Lands Commission

With your submission, please also include attachments in PDF, JPG, PNG or similar formats:

Refer to*: Final Sea Level Rise: Assets Vulnerability and Risk Assessment.* (Attached)

1. One image or map displaying your granted lands area
2. SLR projection maps for years 2030, 2050, and 2100
3. At least one other relevant photo or image. This could include photos of past flooding, images of implemented or planned adaptation examples, maps, or similar
4. Optional: any vulnerability assessments or similar (complete or in progress)

CITY OF EUREKA
Sea Level Rise
Assets Vulnerability and Risk Assessment

Prepared By

Aldaron Laird
Trinity Associates

June 2016

Acknowledgements

Funding by: Ocean Protection Council

Contributors:

- Greenway Partners: Steve Salzman P.E., Jordan King P.E., and Keith Barnard
- McBain Associates: Brian Powell and Sunny Loya

DISCLAIMER: The following Sea Level Rise Assets Vulnerability and Risk Assessment Report was prepared for the City of Eureka. All statements are the sole responsibility of Aldaron Laird of Trinity Associates and do not necessarily reflect the views or policies of the City of Eureka. This assessment is for City-wide planning purposes, and is not a substitute for site-specific analysis of vulnerability and risk from sea level rise.

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GLOSSARY

This report relies on the following terms and definitions that were derived from the California Coastal Commission Sea Level Rise Policy Guidance, adopted August 12, 2015.

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities.

Adaptive capacity: The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences.

Coastal-dependent development or use: Any development or use which requires a site on, or adjacent to, the sea to be able to function at all.

Coastal resources: A general term used throughout the Guidance to refer to those resources addressed in Chapter 3 of the California Coastal Act, including beaches, wetlands, agricultural lands, and other coastal habitats; coastal development; public access and recreation opportunities; cultural, archaeological, and paleontological resources; and scenic and visual qualities.

Development: On land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act (commencing with Section 66410 of the Government Code), and any other division of land, including lot splits, except where the land division is brought about in connection with the purchase of such land by a public agency for public recreational use; change in the intensity of use of water, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility; and the removal or harvesting of major vegetation other than for agricultural purposes, kelp harvesting, and timber operations which are in accordance with a timber harvesting plan submitted pursuant to the provisions of the Z'berg-Nejedly Forest Practice of 1973 (commencing with Section 4511).

Environmentally Sensitive [Habitat] Area (ESHA): Any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.

Flood (or Flooding): Refers to normally dry land becoming temporarily covered in water, either periodically (*e.g.*, tidal flooding) or episodically (*e.g.*, storm or tsunami flooding).

Inundation: The process of dry land becoming permanently drowned or submerged, such as from dam construction or from sea level rise.

Mean sea level: The average relative sea level over a period, such as a month or a year, long enough to average out transients such as waves and tides. Relative sea level is sea level measured by a tide gauge with respect to the land upon which it is situated.

Risk: Commonly considered to be the combination of the likelihood of an event and its consequences – *i.e.*, risk equals the probability of climate hazard occurring multiplied the consequences a given system may experience.

Sea level: The height of the ocean relative to land; tides, wind, atmospheric pressure changes, heating, cooling, and other factors cause sea level changes.

Sea level change/sea level rise: Sea level can change, both globally and locally, due to (a) changes in the shape of the ocean basins, (b) changes in the total mass of water and (c) changes in water density. Factors leading to sea level rise under global warming include both increases in the total mass of water from the melting of land-based snow and ice, and changes in water density from an increase in ocean water temperatures and salinity changes. Relative sea level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence.

Sea level rise impact: An effect of sea level rise on the structure or function of a system.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (*e.g.*, a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (*e.g.*, climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors).

Shore protection: Structures or sand placed at or on the shore to reduce or eliminate upland damage from wave action or flooding during storms.

Shoreline protective devices: A broad term for constructed features such as seawalls, revetments, riprap, earthen berms, cave fills, and bulkheads that block the landward retreat of the shoreline and are used to protect structures or other features from erosion and other hazards.

Still water level: The elevation that the surface of the water would assume if all wave action was absent.

Storm surge: A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes the rise in water level due to atmospheric pressure reduction as well as that due to wind stress.

Subsidence: Sinking or down-warping of a part of the earth's surface; can result from seismic activity, changes in loadings on the earth's surface, fluid extraction, or soil settlement.

Tectonic: Of or relating to the structure of the earth's crust and the large-scale processes that take place within it.

Tidelands: Lands which are located between the lines of mean high tide and mean low tide.

Vulnerability: The extent to which a species, habitat, ecosystem, or human system is susceptible to harm from climate change impacts. More specifically, the degree to which a system is exposed to, susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, including its sensitivity, and its coping and adaptive capacity.

EXECUTIVE SUMMARY

Humboldt Bay has the highest rate of sea level rise in California, approximately 18 inches over the last century, due to tectonic subsidence and sea level rise. Humboldt Bay is unique in that the majority of the land surrounding the Bay is diked former salt marsh. If the earthen dikes around Humboldt Bay are not maintained or enhanced they may breach during extreme tides and storms or be overtopped by sea level rise. If these dikes were to be breached thousands of acres could be tidally inundated, now. If sea level rise is allowed to overtop these dikes, thousands of acres could be tidally inundated as early as 2050, and certainly by 2100. Many critical assets (land uses, developments, and resources) are located on these diked lands. Unfortunately, there is no one entity responsible for maintaining these dikes, so they continue to protect the lands and developments behind them. Many miles of dikes are low in elevation and with eroding banks; these dike areas could and have recently been breached during extreme tides and storms. Many of the assets in the City of Eureka (City) and its Planning Area (PA) are located on low-lying ground that are vulnerable to tidal inundation by the projected sea level rise for 2050 up to two feet and for 2100 with over five feet.

This sea level rise asset vulnerability and risk assessment will identify assets that could be tidally inundated now if shoreline dikes are breached and by projected sea levels for 2030, 2050 and 2100. This report will describe the location and characteristics of these assets, how they might be exposed to sea level rise impacts, when they may be impacted, how susceptible they are to tidal inundation or salt water intrusion and flooding, and the consequences to the community if these assets are impaired or lost. This report assigns a priority ranking to each asset for 2050 and 2100 to facilitate the City and community in selecting assets that they may want to develop adaptation strategies and measures.

The broad classes of assets in the City and its PA that are vulnerable and at risk from sea level rise by 2100 include land uses (Coastal Dependent Industrial, Industrial, Commercial, Public, and Residential), coastal resources (agricultural lands; environmentally sensitive habitat areas, such as marine and freshwater wetlands and dunes; and cultural sites), utilities (waste water, drinking water, storm water, energy, communications, and solid waste), transportation (surface, marine, air, and rail), and open contaminated sites.

Humboldt Bay has been the subject of several sea level rise adaptation planning projects. The City is building on these regional sea level rise adaptation planning efforts to prepare this vulnerability and risk assessment of assets, to develop adaptation goals, strategies, and measures for priority assets, and to update its Local Coastal Plan. Recently prepared inundation models and maps have been used to identify what areas might be tidally inundated, and when based on relative sea level rise projections that have been developed for Humboldt Bay. The Coastal Conservancy's (Conservancy)

2012 LiDAR was also used to determine asset elevations. Existing databases of assets (sewer lines, streets, wetlands, etc.) have been utilized to locate assets in relation to areas that may be tidally inundated. Asset descriptions and evaluations have been prepared, which enabled assets to be prioritized to facilitate subsequent adaptation planning. A full discussion of each major asset class and individual assets may be found in the Appendix.

This assessment of assets vulnerable and at risk from tidal inundation found that protecting the diked lands will be extremely important if high priority assets are to be protected now and from sea level rise projections for 2050. High priority assets protected by these earthen dikes are sewer lines and lift stations that could significantly overwhelm the City's wastewater treatment plant, its primary drinking water transmission lines, natural gas lines, U.S. Highway 101, Murray Field airport, streets, commercial, and agricultural properties, State wildlife refuges and valuable coastal wetlands and wildlife habitats. Other high priority assets in low-lying areas threatened by projected sea levels by 2050 are commercial fishing docks and facilities and recreational boating docks and launches. By 2100, a significant portion (80%) of the Coastal Zone in the City could become tidally inundated threatening land uses and developments, utilities, transportation infrastructure, coastal resources and public access. In the PA, while only 52% of the Coastal zone could become tidally inundated seal level rise could threaten several residential communities, regional electrical power generation, U.S. Highway 101 and even port facilities on Humboldt Bay.

The City presented the Draft Sea Level Rise Assets Vulnerability and Risk Assessment report to: City Council, City Departments, Humboldt County Public Works and Planning Departments, City of Arcata Planning Department, Coastal Commission, Ocean Protection Council, the public, and distributed the draft report to the Humboldt Bay Sea Level Rise Adaptation Planning Group. Comments received have been addressed to the extent possible and incorporated in this final report.

This sea level rise vulnerability and risk assessment of assets completes the first three steps of the adaptation planning process recommended in the California Coastal Commission's (Commission) Sea Level Rise Policy Guidance (2015). The City is updating its General Plan and Local Coastal Program (LCP) and it will be taking this opportunity to develop adaptation goals, strategies, and measures for high priority assets that are vulnerable and at risk from tidal inundation. The City does not own all the assets that are critical to the sustainability of the City. Depending on asset location and ownership the City may want to explore forming asset based stakeholder groups to develop and implement adaptation strategies and measures that would protect assets critical to the City and Humboldt Bay region.

The City has created a sea level rise web viewer that encompasses the City and its PA, to inform the public of which areas are potentially vulnerable and at risk from tidal inundation and extreme floods under current tidal conditions and from sea level rise, in 1.6 foot (0.5 meters) increments up to 6.6 feet (2.0 meters). http://www.arcgis.com/home/webmap/viewer.html?url=http%3A%2F%2Fgis.ci.eureka.ca.gov%2Fags%2Frest%2Fservices%2FSLR_Web_App%2FMapServer&source=sd

The web viewer will be updated to depict assets that are potentially vulnerable and at risk from tidal inundation and extreme floods.

1. BACKGROUND

The City desires to identify which areas in its jurisdiction and PA that may be exposed to sea level rise and when. The City would also like to assess what developments or land uses (assets) may be vulnerable (exposed, susceptible, and unable to cope) to sea level rise. The City is updating its General Plan to guide land use development through 2040. The Coastal Commission's 2015 sea level rise policy guidance recommends considering 2030, 2050 and 2100 as adaptation planning horizons. The City would like to identify when assets may be impacted by sea level rise, particularly by 2050. The City further seeks a risk assessment (likelihood or timing of impact and consequences to the asset) of the effects of sea level rise on assets. Assets that are vulnerable and at risk from sea level rise will be prioritized, based on their exposure (timing), susceptibility, criticality (to the community), and ownership. Addressing these criteria in this vulnerability and risk assessment will enable the City to prepare adaptation measures and strategies that will seek to reduce the City's priority assets' vulnerability and risk from sea level rise.

This report relies on the Commission's Sea Level Rise Policy Guidance (2015) as the definitive reference for conducting this vulnerability and risk assessment of assets in the City and its PA. The Policy Guidance presents a six-step adaptation planning process to address sea level rise (Figure 1). This report will address the first three steps: choose a range of sea level rise projections relevant to Humboldt Bay, identify potential sea level rise impacts in the City and its PA, and assess vulnerability and risk to coastal resources and development in the City and its PA. The City will also be implementing steps 4 and 5: identify adaptation goals, strategies and measures and drafting LCP policy options, and drafting an update of its LCP for certification with the Commission.

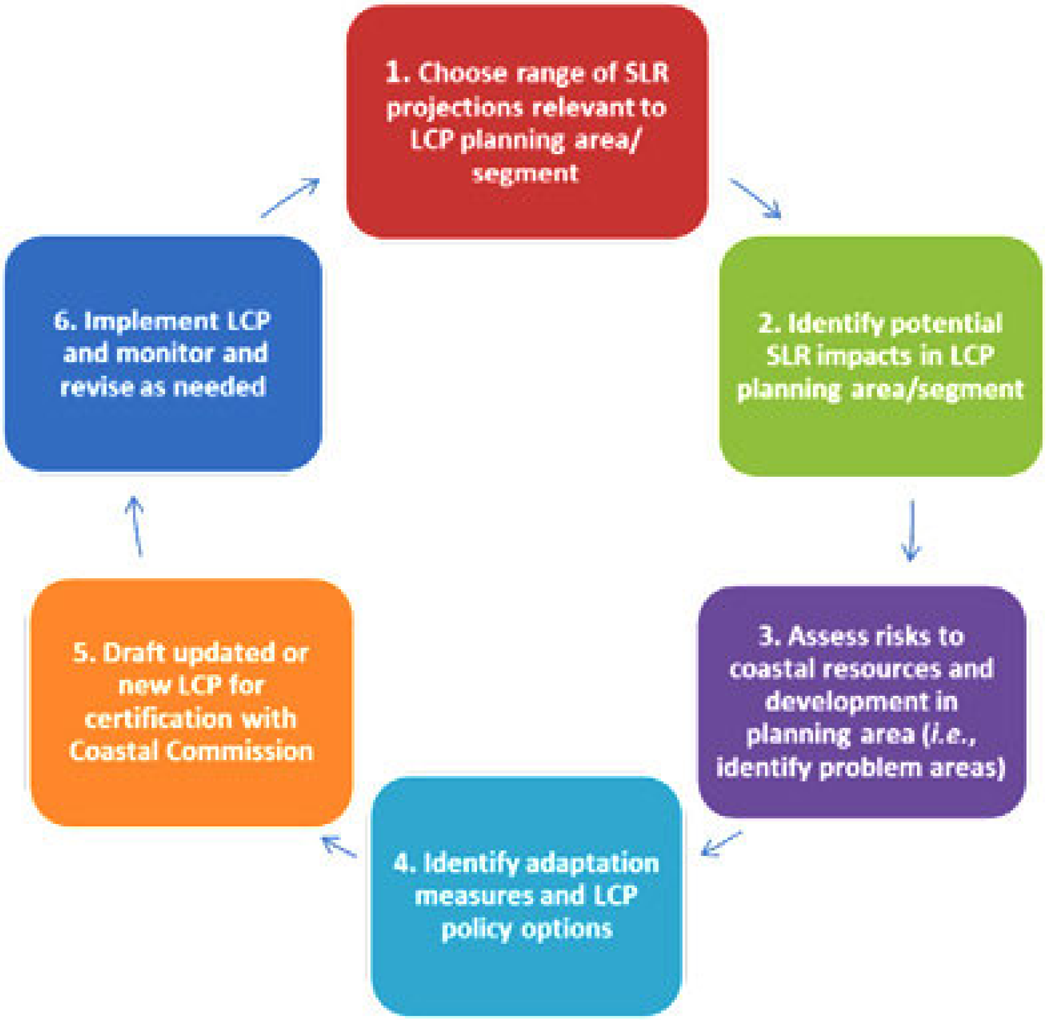

Figure 1. Sea level rise adaptation planning process steps (CCC 2015).

This report will describe sea level rise projections, inundation areas, and shoreline data utilized in this vulnerability and risk assessment that were derived from regional sea level rise adaptation planning efforts on Humboldt Bay. This asset assessment is also based on the sea level rise impact analysis prepared for the City's General Plan Community Background Report (ESA 2014). Essentially, this report will explain how, when, where, and what sea level rise may impact in the City and its PA (Figure 2). The report's findings will help determine which assets are a priority to the City, as well as which areas and assets are not vulnerable to sea level rise through 2100. The methodologies for determining when and where sea level rise will impact assets are described as are the results and conclusions of the vulnerability and risk assessment. Individual asset assessments are presented in the Appendix, individual assets are listed under major asset classes: urban land uses, coastal resources, utilities, transportation modes, and contaminated sites.

Figure 2. Spatial boundaries for the City of Eureka (black) and it's Planning Area (yellow) in the unincorporated area of Humboldt County.

Assets in the City and PA are described and assessed separately, the types of sea level rise exposure and impacts expected are identified, when impacts might occur is projected for 2030, 2050, or 2100. The asset's susceptibility (the degree to which an asset is affected adversely) to the impacts is described, as is the consequence (likely result or effect of impact) if the asset is impaired to the community. Assets are given a priority ranking (evaluation of exposure, susceptibility, and consequence) to facilitate the City in its selection of assets for development of adaptation measures and strategies. Asset ownership, whether the City, other public agencies, or private parties, is important when considering the adaptive capacity to develop or implement adaptation measures.

Since 2010, Humboldt Bay has been the focus of regional sea level rise adaptation planning, specifically the Conservancy funded Humboldt Bay Sea Level Rise Adaptation Planning Project. This planning effort began with inventorying and mapping (structure, cover, and elevation) the 102 miles of shoreline on Humboldt Bay and assigning a vulnerability rating to the shoreline reflecting its vulnerability to erosion or overtopping by extreme tides or projected sea level rise by 2050 (Laird and Powell 2013). The Humboldt Bay sea level rise adaptation planning project (2013-2015) also involved preparing relative sea level rise projections through 2100 (NHE 2014) and a sea level rise hydrodynamic model and potential inundation maps of areas surrounding Humboldt Bay (NHE 2015). These potential inundation maps, as GIS shapefiles and Google Earth kmz files, are available to the public from the Humboldt Bay Harbor, Recreation and Conservation District's (HBHRCD) sea level rise adaptation planning project web site, http://humboldtbay.org/humboldt-bay-sea-level-rise-adaptation-planning-project . The Humboldt Bay sea level rise adaptation planning project also involved the formation of a regional sea level rise adaptation planning group, with which the City and other LCP (Humboldt County and City of Arcata) authorities and Commission staff were involved, that produced a regional adaptation plan for Humboldt Bay (Laird 2015). These planning efforts led the City to request and secure a grant from the Ocean Protection Council (OPC) to address sea level rise while the City updates its Land Use Plan and LCP. In addition, the City's General Plan consultant prepared a sea level rise vulnerability assessment for the City's Community Background report (ESA 2014). This report contains sea level rise predictions for Humboldt Bay, potential effects of rising sea levels, and potential impacts to critical and non-critical assets essential to City functions.

The City agreed with OPC to prepare a sea level rise asset vulnerability and risk assessment report and to develop an adaptation planning report with adaptation strategies and measures for priority assets. In preparation of this sea level rise assets vulnerability and risk assessment report, the City's consultant has engaged Commission staff and relied on the Commission's 2015 Sea Level Rise Policy Guidance and the sea level rise vulnerability assessment in the City's Community Background report.

The City occupies approximately 6,010 acres above mean sea level (MSL) 3.7 feet, North American vertical datum of 1988 (NAVD 88), and its PA occupies approximately 22,034 acres (Figure 2). All elevations in this report are NAVD 88 and measured at the North Spit tide gage (National Oceanic and Atmospheric Agency (NOAA) Station 9418767). The hydrodynamic model of Humboldt Bay prepared in 2014 (NHE 2014b) is the source of potential sea level rise vulnerability area predictions used to assess vulnerability and risk in the current planning effort. The inundation maps identify potential inundation conditions that could occur if shoreline structures are breached or overtopped and if nothing is done to adapt to, or prepare for sea level rise (NHE 2015). The exposure periods that assets will be assessed are for predicted sea level rise elevations in 2030, 2050 and 2100. Potential asset exposure in 2015, from current tidal conditions that could render assets vulnerable and at risk, will also be assessed given that existing shoreline structures such as dikes, and rail or road grades could be breached or overtopped. The exposure of assets at these planning periods will be described, the asset's susceptibility to sea level rise exposure, and the consequence(s) due to asset loss or impairment to the community will be discussed. Based on this analysis, assets will be prioritized for the development of sea level rise adaptation measures and strategy.

2. SEA LEVEL RISE VULNERABILITY & RISK ASSESSMENT

This chapter will describe expected sea level rise impacts in the City and its PA, relative sea level rise projections for the Humboldt Bay region, potential areas of tidal inundation under existing tidal conditions and from sea level rise projections. and methods to assess the vulnerability and risk that assets are likely to experience.

2.1 Sea Level Rise Impacts

Sea level rise is an effect of climate change, specifically from the warming of the atmosphere and oceans up until now. Melting ice from areas like Greenland and Antarctica have the potential to greatly accelerate the rate and elevations of sea level rise, particularly after 2050. Sea levels can also increase or decrease as a result of vertical land movement, from tectonic forces. Rising sea levels will directly affect the shoreline and consequently adjacent lands and developments.

Rising sea level effects:

- Increase the elevation of high tides as well as extreme high tides and 100-year storms.
- Cause shoreline erosion and breaching of dikes from waves, overtopping, and slumping.
- Impede stormwater runoff and floodwaters, increasing backwater flooding.
- Increase the elevation of low tides and increase flooding of low-lying areas by delaying drainage through tide gates.
- Cause saltwater intrusion of adjacent aquifers or underground structures such as sewer lines.
- Increase groundwater elevations, and flooding of low-lying areas.
- Expand the Bay's tidal prism as diked former tidelands become inundated, which could increase wave heights in the entrance channel, and affect sediment movement in and throughout the Bay.

Flooding is the temporary wetting of an area, while tidal inundation is the permanent wetting. Diked shorelines can and have breached under existing tidal and storm conditions, sea level rise will increase the frequency of these breaches until dikes are overtopped.

Sea level rise has the potential to adversely affect assets (land uses, coastal resources, utilities, and transportation modes) located in the coastal zone of the City and its PA. Coastal developments are vulnerable and at risk from tidal inundation, and flooding caused by rising groundwater, stormwater runoff backwater, and increased 100-year flood elevations. For those developments, land uses, utilities and transportation corridors on diked former tidelands, if these dikes are eroded or breached these assets could be tidally inundated now. Low-lying areas are subject to saltwater intrusion, and flooding as the capacity of drainage structures such as tide gates and culverts are reduced by rising low tides. Saltwater intrusion of shallow agricultural wells particularly in areas behind dikes may increase. Coastal habitats such as dunes, seasonal freshwater wetlands may be eroded or converted while other habitats like inter-tidal wetlands may drown if there are no physical pathways for their migration inland in response to sea level rise. Public recreation on beaches such as Elk River Spit, and on City and Regional trails as well as access to the Bay and Sloughs may become impaired by shoreline erosion, tidal inundation, or flooding of boating facilities. There are also tribal cultural resource sites located on the lands around the Bay and on islands in the City and its PA that may become tidally inundated by 2100. Open, or un-treated contaminated sites could become tidally inundated or flooded resulting in pollution of waterways and degradation of water quality.

While not a sea level rise impact, shoreline erosion under the current tidal regime could have significant consequences on Humboldt Bay in the City and its PA. The Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment provided the first comprehensive evaluation of shoreline conditions (Laird and Powell 2013). Seventy-five percent (77 miles) of Humboldt Bay's shoreline is artificial, predominately consisting of earthen dikes (53%, 41 miles) and railroad beds (14%, 11 miles). These two types of linear shoreline structures were constructed between 1890 and 1915, which today, more than a century later, are approximately 1.5 feet lower relative to current sea levels due to tectonic subsidence and global sea level rise (Russell and Griggs 2012). The dikes were built to hold back extreme high tides around the turn of the 20th century; those extreme high tide elevations are currently reached by our annual maximum tides (king tides) due to sea level rise and subsidence of land in and around Humboldt Bay (NHE 2014a). At this time, the railroad has not been used commercially for more than two decades and much of the railroad bed has not been maintained. This helps explain why so much of the diked and railroad beds shoreline is currently vulnerable to overtopping by MAMW, storm surges and stormwater runoff, low pressure systems, wind waves, and El Niño conditions.

The vulnerability of these shoreline structures is compounded by the fact that no single entity is responsible for their improvement or maintenance. Approximately 21 miles of shoreline composed of dikes and railroad beds are rated highly vulnerable to breaching or being overtopped (Laird and Powell 2013; Figure 3).

Figure 3. An example of a diked shoreline segment rated highly vulnerable and at risk of breaching that could tidally inundate former tidelands.

Eureka and Elk River Sloughs are in the City and its PA; they have 17.24 miles of dikes and 9.81 miles (57%) are rated highly vulnerable. In fact, Eureka Slough has the greatest length of dikes shoreline rated highly vulnerable on Humboldt Bay, 7.13 miles (Figure 4). These dikes are a historical legacy that could have a profound effect, tidal inundation of the assets behind these dikes if they are breached, which is happening with increasing frequency on Humboldt Bay. Sea level rise will only increase the risk posed by these dikes on protected assets, unless adaptation measures are employed to increase their ability resiliency.

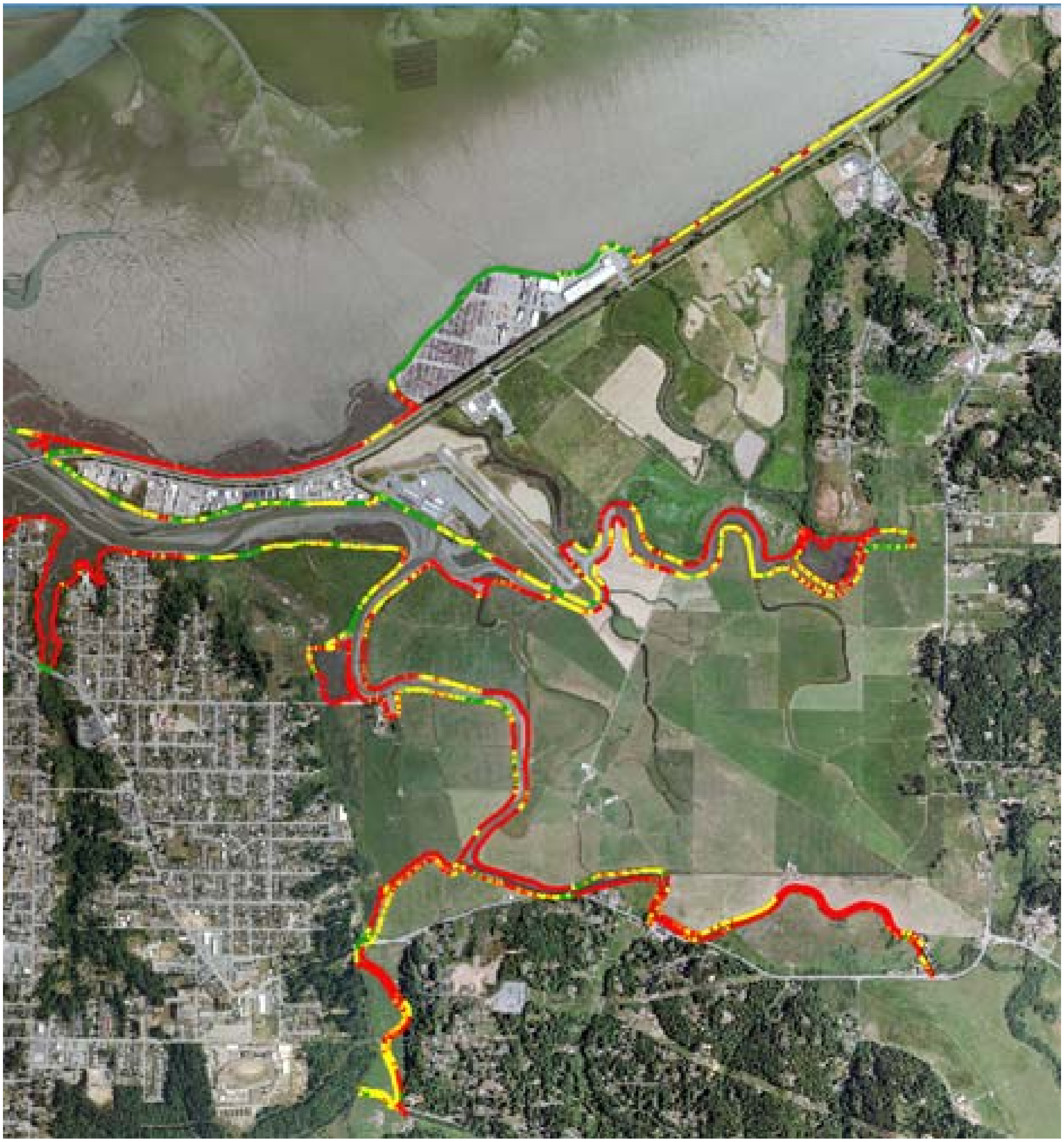

Figure 4. Eureka Slough shoreline vulnerability rating: high (red), moderate (yellow), and low (green) (Laird Powell 2013).

2.2 Sea Level Rise Projections

The City is updating its General Plan to guide land use development through 2040. The City would like to identify when assets may be impacted by sea level rise, particularly by 2050. The National Research Council (NRC) published regional sea level rise projections for 2030, 2050 and 2100 (2012). However, the NRC's regional sea level rise projections need to be modified to account for local vertical land motion on Humboldt Bay (NHE 2015). The Commission's sea level rise policy guidance (2015) recommends these same time periods as sea level rise adaptation planning horizons.

There are a variety of different reference points, or tidal datums, used to measure tidal elevation, depending on the particular tidal phase of interest and on the type of tides present along a shoreline (NOAA 2001). A typical tidal cycle involves two high tides and two low tides within a single cycle. On Humboldt Bay, the two high tides are not equivalent; one is higher than the other. The same is true for the low tides. These types of mixed tidal cycles result in tidal datums such as mean lower low water (MLLW) and mean higher high water (MHHW). Other recognized tidal datums include mean low water (MLW), mean sea level (MSL), mean high water (MHW, considered representative of the shoreline), and mean annual maximum water (MAMW; Table 1). Because sea level is expected to rise in the future in response to climate change, the tidal datum against which sea levels are referenced should be consistent.

The Humboldt Bay Sea Level Rise Adaptation Planning Project utilized mean monthly maximum water (MMMW 7.7 feet NAVD 88), spring tides, as the tidal base elevation to assess shoreline vulnerability and to map areas that could be vulnerable to tidal inundation should the existing shoreline protection be breached. While not an official tidal datum, MMMW was selected because on Humboldt Bay, the tidal and upland boundary is closely associated with the upper elevation of tidally influenced vegetation on natural shorelines, and it is easy to delineate.

Table 1. Tidal datums and their elevations for Humboldt Bay as measured at the NOAA North Spit tide gage.

Tidal datum	Datum name	Elevation (feet, NAVD 88)	Notes
MAMW	Mean annual maximum water	8.78	King tides
MMMW	Mean monthly maximum water	7.74	Tidal base elevation, Spring tides
MHHW	Mean higher high water	6.51	
MHW	Mean high water	5.80	Representative of the shoreline location
MSL	Mean sea level	3.36	
MLW	Mean low water	0.91	
MLLW	Mean lower low water	-0.34	

Sea levels on Humboldt Bay tend to be highest in the winter months. Average annual maximum tides occur in winter and are typically 1.0 foot higher than monthly maximums (MMMW). In addition, El Niño events, low pressure systems, storm water runoff, and storm surges can also add up to 1.0 foot to winter tidal elevations. In 1983, El Niño raised tides to 9.38 feet (NAVD 88). Since 2001, we have had four years where annual maximum tides have reached similar or greater elevations than the last El Niño event: 2001 (9.34 feet NAVD 88), 2003 (9.51 feet NAVD 88), 2005 (9.55 feet NAVD 88), and 2006 (9.49 feet NAVD 88; Figure 5). In 2006, the Governor declared a "state of disaster" on Humboldt Bay in response to the New Year Eve 2005 annual maximum high water elevation of 9.55 feet NAVD 88.

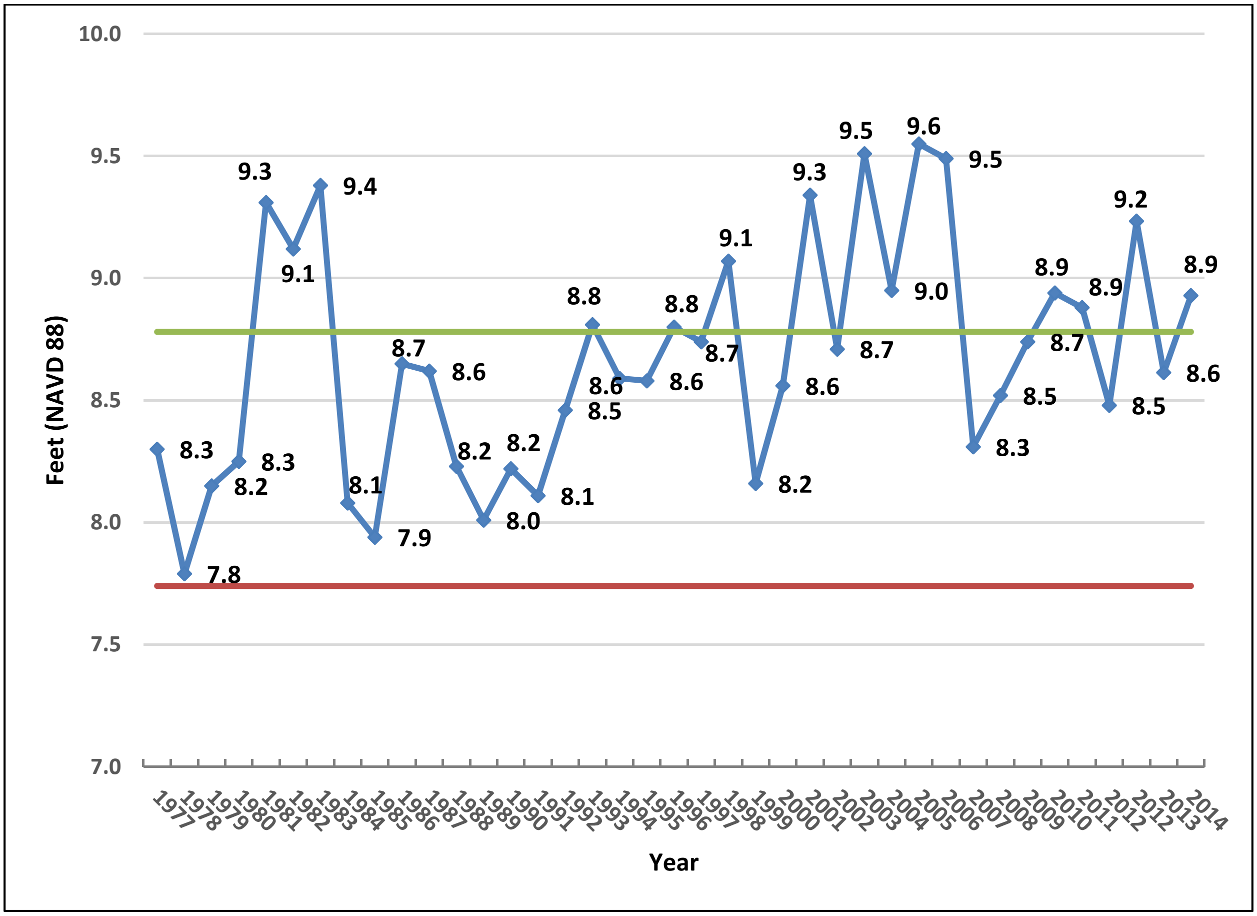

Figure 5. Annual maximum high tide elevations (king tides) at the North Spit tide gage, with a mean monthly maximum tide elevation of 7.7 feet (NAVD 88) (red line) and mean annual maximum tide elevation of 8.8 feet (NAVD 88) (green line).

Currently, tidal elevations in Humboldt Bay are affected by regional sea levels and vertical land motion trends. Water elevations will rise and possibly migrate inland when the shoreline and inland areas subside, which could result from tectonic activity or soil compaction. Combining sea level rise and subsidence may result in a greater net change in water elevations than what would be experienced from sea level rise alone. Conversely, sea level rise combined with tectonic uplift could result in no net change in water elevation, which appears to be what is occurring at Crescent City. Since 1977, based on the North Spit tide gage record (http://tidesandcurrents.noaa.gov/stationhome.html?id=9418767), Humboldt Bay is subsiding (-0.09 inches/yr.) and its average rate of relative sea level rise is 0.18 inches/year (18 inches per century), which is greater than anywhere else in California (Patton 2014). Relative sea level rise projections have been prepared for the North Spit tide gage from 2000 to 2100, including low and high greenhouse gas emission scenarios (Figure 6, NHE 2014). While the Commission's sea level rise policy guidance recommends assessing impacts from sea level rise for: 2030, 2050, and 2100, we also assess potential impacts for 2015 and 2070. Because the potential exists now for these dike structures to breach or be overtopped, and most of the dikes could be overtopped by 2070, due to a structural tipping point associated with current dike elevations.

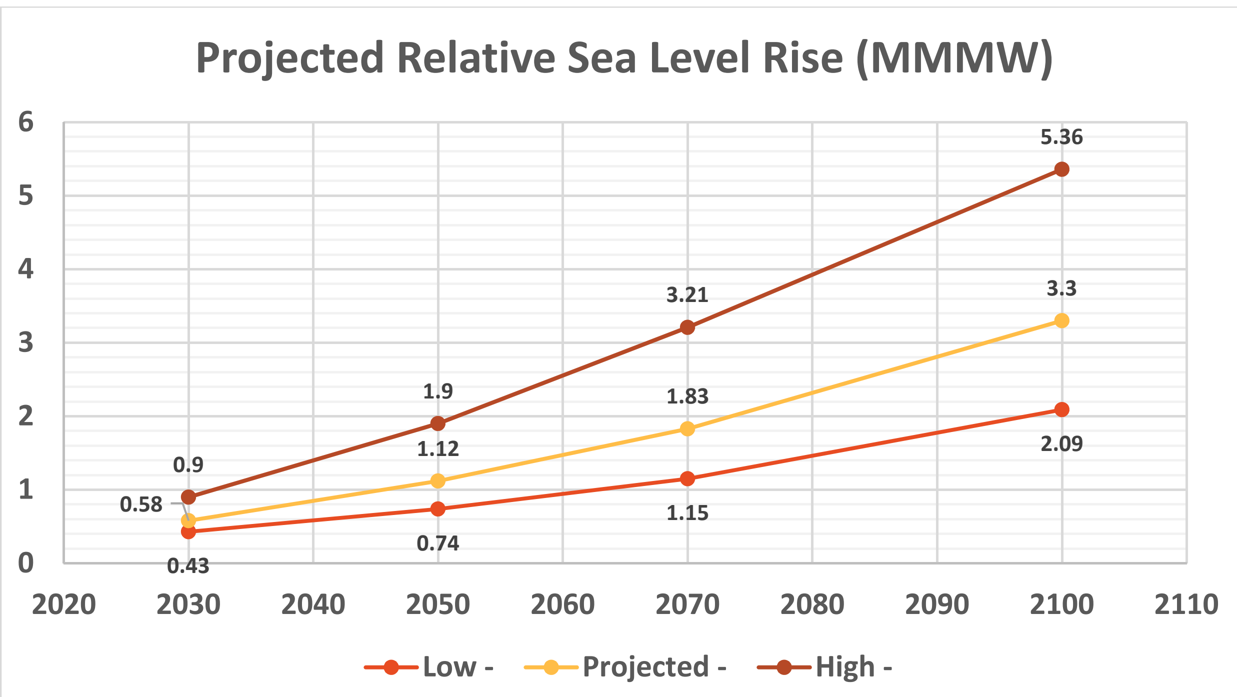

Figure 6. Relative sea level rise projections for four planning horizons (2030, 2050, 2070, and 2100), including low and high greenhouse gas emission scenarios (NHE 2014).

The difference between low and high projections for relative sea level rise are: 0.47 feet in 2030, 1.16 feet in 2050, 2.06 feet in 2070, and 3.27 feet in 2100. The range (low to high) of relative sea level rise projections for MMMW in 2030 (8.17 feet to 8.64 feet NAVD 88), which is within the current range of (MMMW 7.74 feet and MAMW 8.78 feet NAVD 88) tidal elevations experienced on monthly and yearly basis on Humboldt Bay. Sea level elevations that exceed what currently occurs on Humboldt Bay are expected to occur on a monthly basis by 2050 when the high projection for MMMW could be 9.6 feet (NAVD 88), nearly a foot higher than the current MAMW and higher than the maximum water elevation of record (9.5 feet NAVD 88 in 2005). Again, that extreme tide of 9.55 feet resulted in the Governor declaring a state of emergency on Humboldt Bay. The dominant shoreline structures on Humboldt Bay are 41 miles of earthen dikes, of which 21 miles (51%) are less than or equal to 9.7 feet (NAVD 88) in elevation and have been rated highly vulnerable to overtopping by sea level rise. The high projection for MAMW may reach 9.7 feet (NAVD 88), a tipping point for dike structures, by 2030, and MMMW may reach this elevation by 2050 under the high projection. It is important to note that the majority of these dike structures are at risk now from a 100-year storm event (9.99 feet NAVD 88), and may be potentially vulnerable from MAMW between 2030 and 2050, and to MMMW between 2050 and 2070. Therefore, this report takes a precautionary approach to sea level rise projections and utilizes the high projection for each planning period to identify areas that are potentially vulnerable and at risk from sea level rise (Principle #4 CCC 2015). However, it should be noted that using the low projections would reduce the areas encumbered by sea level rise hazard zone restrictions on development. Extreme events, if they occur, as they only have 1% probability of occurring any year, may result in shoreline erosion and flooding much sooner than from even high projections of sea level rise (Figure 7). In the long-term, by 2100, nearly all of the dikes, based on current conditions, on Humboldt Bay could be overtopped by 13 to 14 foot MMMW and MAMW tides.

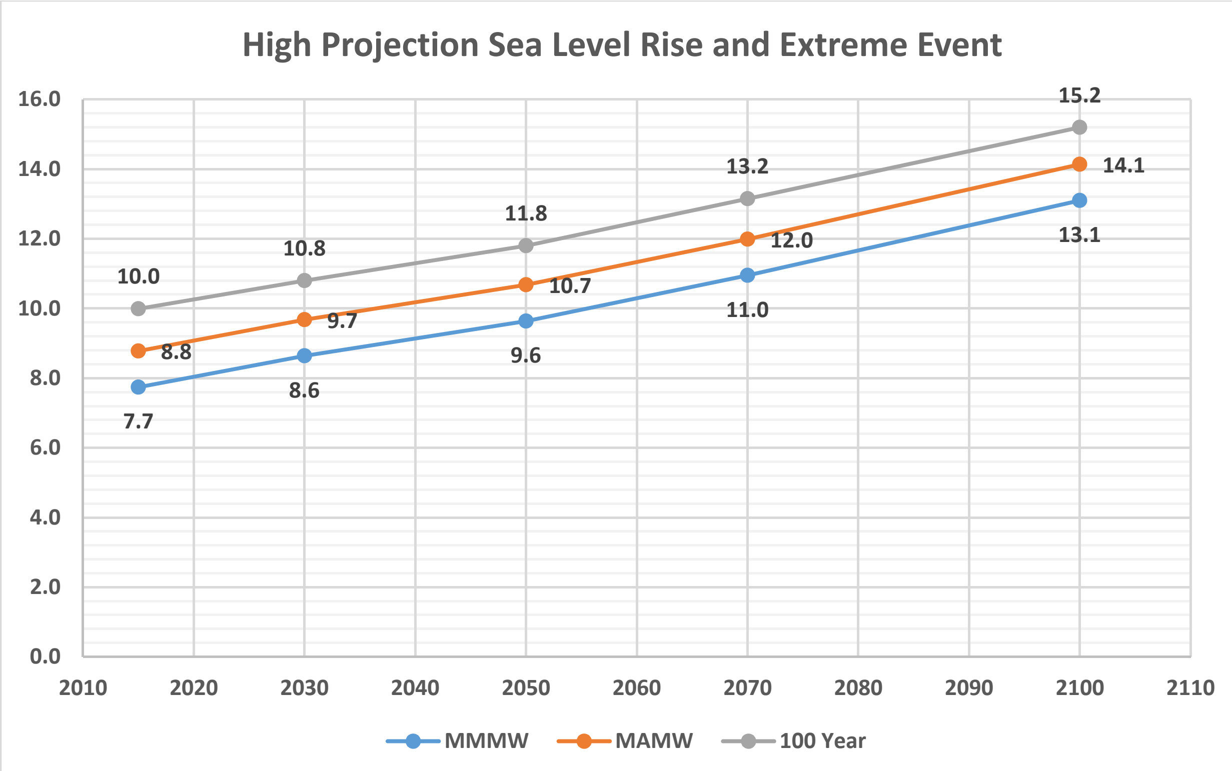

Figure 7. Relative sea level rise estimations for high greenhouse gas emission scenario for mean monthly maximum water (spring tides), mean annual maximum water (king tides), and 100-year extreme storm events (NHE 2014).

2.3 Sea Level Rise Inundation Areas

Northern Hydrology Engineers (NHE) has prepared potential inundation maps of the area surrounding Humboldt Bay (NHE 2014, 2015). In the urban core of the City there is a significant expansion in the scope of the sea level rise hazard zone based on potential tidal inundation by 2050 versus 2100 (Figures 8 and 9). Whereas, in the two low-lying alluvial areas of Eureka Slough and Elk River Slough there is essentially no expansion of the sea level rise hazard zone between 2050 and 2100 (Figures 10 and 11). There is an expansion of the sea level rise hazard zone from 2050 to 2100 in King Salmon and Fields Landing communities (Figure 12). Actually, there is very little difference in what would be the tidal inundation area in these Slough areas for 2015 versus 2050 if the dikes are breached (Figure 13).

Unfortunately, planners and engineer/scientist often use different units of measure. Sea level rise planning documents generally refer to sea level rise in feet while engineers/scientist create models and maps are likely to use meters. This planning report will rely on English units of measure and offer metric conversions to feet to facilitate the public's understanding of the information presented.

Figure 8. Potential tidal inundation area in the City's urban core for the high relative sea level rise projection for 2050 (9.64 feet NAVD 88), and City's boundary (black line) (NHE 2014).

Figure 9. Potential tidal inundation area in the City's urban core for the high relative sea level rise projection for 2100 (13.1 feet NAVD 88), and City's boundary (black line) (NHE 2014).

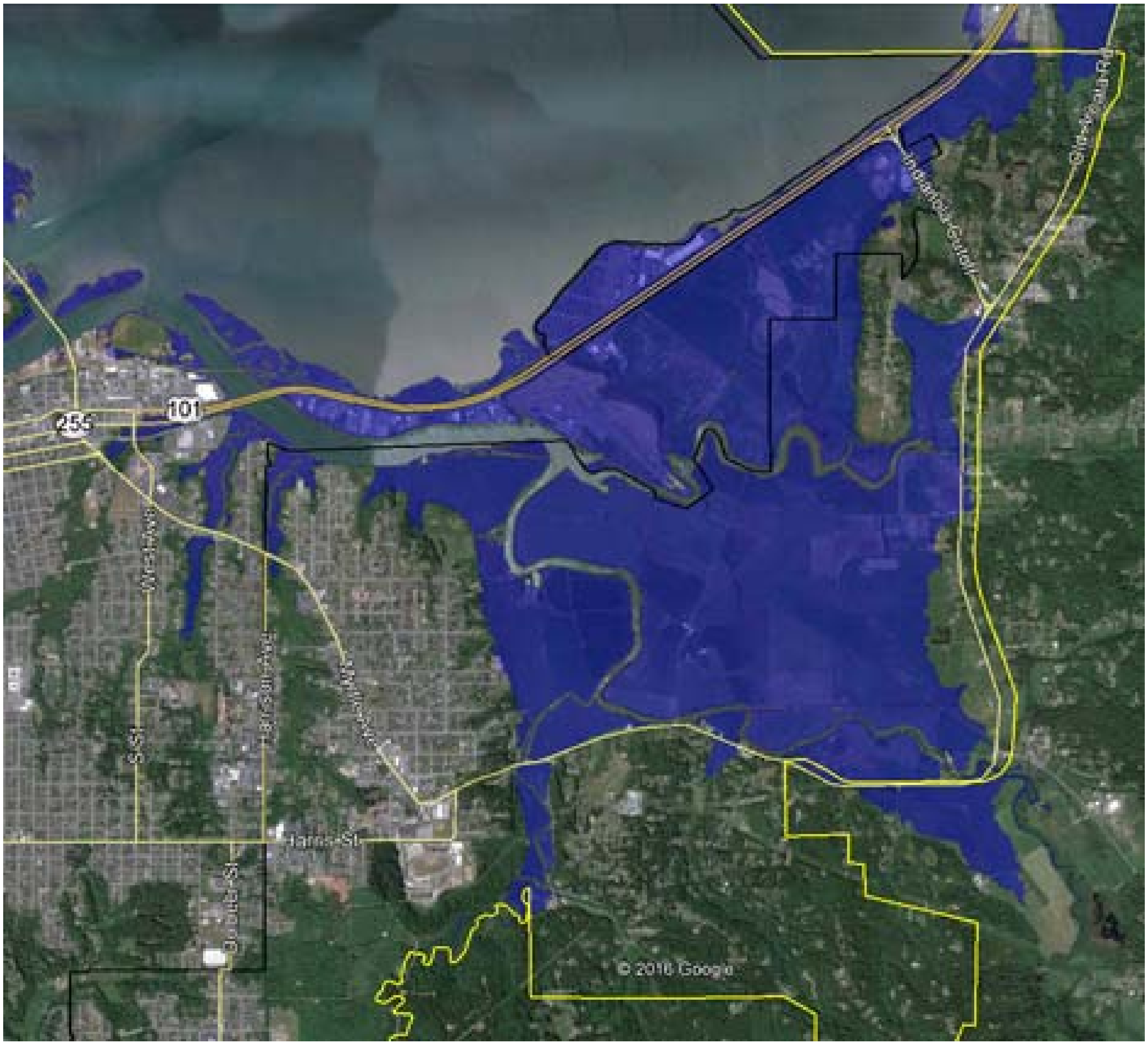

Figure 10. *Potential tidal inundation area in the Eureka Slough area* *<u>now</u>* *if dikes are breached and for the high relative sea level rise projection for 2050, and City's boundary (black line) and its PA (yellow line) (NHE 2014).*

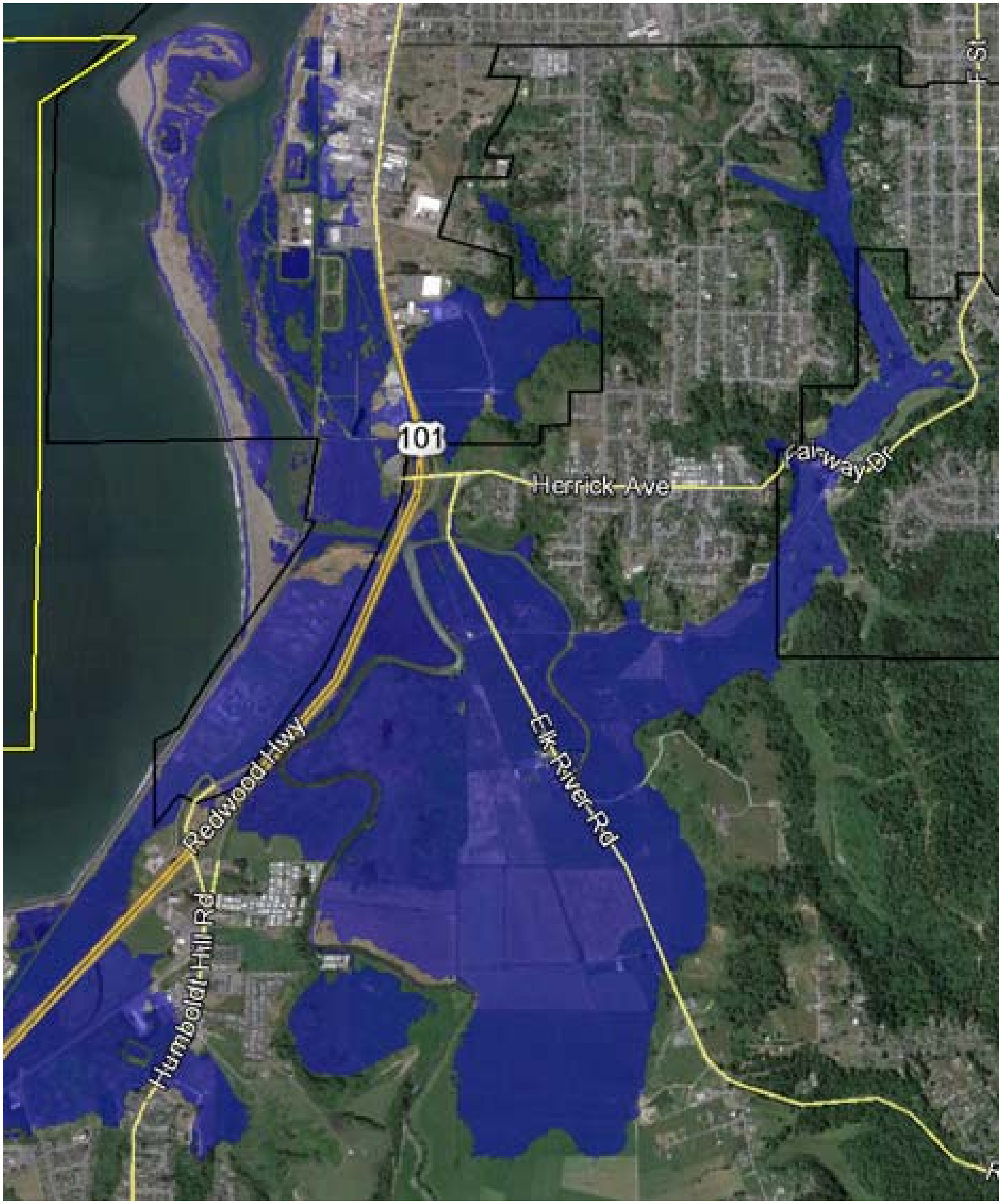

Figure 11. Potential tidal inundation areas in the Elk River Slough area <u>now</u> if dikes are breached and for the high relative sea level rise projection for 2050, and City's boundary (black line) and its PA (yellow line (NHE 2014).

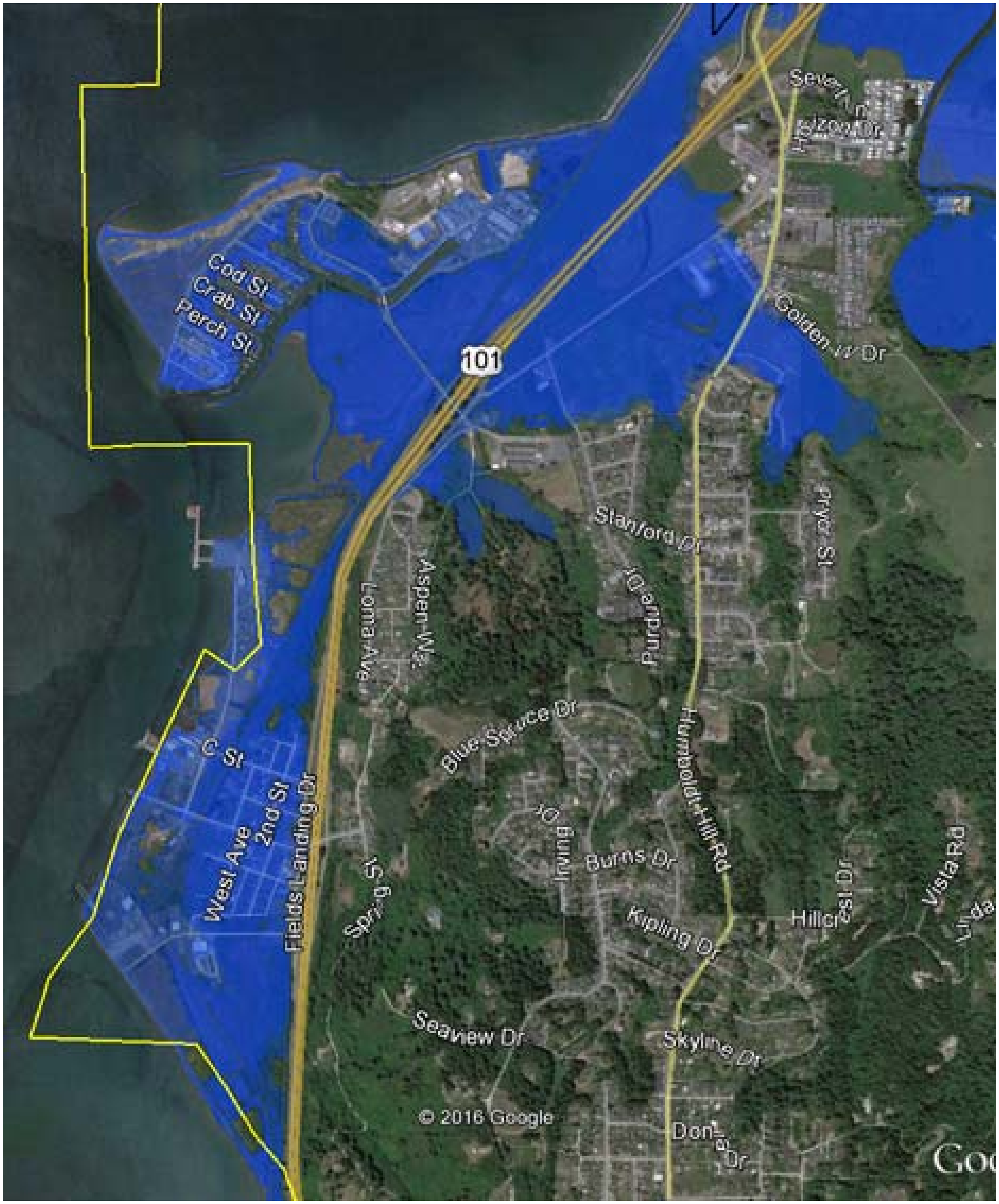

Figure 12. Potential tidal inundation areas in the King Salmon and Fields Landing community areas for the high relative sea level rise projections for 2050 (dark blue) and 2100 (light blue), and the PA boundary (yellow line (NHE 2014).

It is important to note that these inundation maps assume there are no artificial shoreline structures, such as dikes, railroad and/or road grades, and the limits of inundation being delineated is based on 2012 surface elevations. For example, compare the current tidal inundation area with shoreline structures intact along Eureka-Freshwater-Fay Sloughs to the projected tidal inundation areas for 2015 that potentially could be tidally inundated but only if the shoreline structures are breached or overtopped, again, these areas are not presently inundated (Figure 13).

The vulnerability of these diked former tidelands and the assets located on them today to tidal inundation is the result of a historical legacy of diking off these areas around Humboldt Bay, not due to sea level rise. However, if these dike structures are maintained at their current elevations, they are projected to be overtopped by water levels that approach 10.0 feet (NAVD 88), whether the result of current extreme 100-year storms (10.0 feet NAVD 88), or seal level rise projection for MAMW in 2030 (9.68 feet NAVD 88) or MMMW by 2050 (9.64 feet NAVD 88). Again, until these dikes are overtopped or breached now, sea level rise is not projected to overtop these dikes before 2030 based on the high projections for MAMW or 2050 for MMMW.

Inundation maps were produced, ignoring that there are shoreline structures, to illustrate what could be inundated by current MMMW (7.74 feet NAVD 88) and MAMW (8.78 feet NAVD 88) and extreme 100-year storm event (9.99 feet NAVD 88), and for water elevations increasing at half meter (1.6 feet) intervals up to 2.0 meters (6.6 feet). These inundation maps were then used to identify potential tidal inundation areas for MMMW at specific planning horizons: in 2015 (if shoreline structures are compromised), and high projections of MMMW elevations in 2030, 2050, and 2100. In some areas, critical inundation thresholds for shoreline structures are reached when water elevations rise above 10 feet (NAVD 88), which is approximately the high projection for MMMW (10.9 feet NAVD 88) by 2070; therefore, projected MMMW for 2070 is presented for some assets. Inundation maps for MMMW (7.7 feet NAVD 88) represent potential "current" conditions, depicting areas that are vulnerable if shoreline structures are breached or overtopped. Maps depicting potential tidal inundation by MAMW are equivalent to 0.9 feet of projected sea level rise (again without shoreline structures) and were used to depict areas potentially vulnerable during MMMW in 2030 (8.6 feet NAVD 88). Maps depicting areas inundated by 0.5 meters (1.6 feet) were used to delineate areas potentially vulnerable to 1.9 feet of sea level rise during MMMW in 2050 (9.6 feet NAVD 88). Maps for 1.0 meters (3.3 feet) were used to depict areas potentially vulnerable with 3.2 feet of sea level rise during MMMW in 2070 (11.0 feet NAVD 88). Maps of 1.5 meters (4.9 feet) were used to depict areas potentially vulnerable with 5.4 feet of sea level rise during MMMW by 2100 (13.1 feet NAVD 88). The potential inundation maps for 2100, actually depict 0.5 feet less of sea level rise than the high projection but they are the nearest representation available for the 5.4 feet sea level rise projection.

Figure 13. Area currently tidally inundated by mean high water with dikes intact (top) versus potential tidal inundation area by mean monthly maximum water if dikes are breached (bottom).

As described previously, low-lying former tidelands that were separated from Humboldt Bay more than a century ago by the construction of dikes and railroad grade are potentially vulnerable now to tidal inundation by extreme tides, 100-year storms, El Niño events, and in the future sea level rise due to existing conditions of shoreline structures. In the City and its PA, there are approximately 26 miles of highly (actively eroding and elevation less than 10 feet NAVD 88) vulnerable shoreline structures: dikes and railroad grade. If these highly vulnerable shoreline structures are breached, the current tidal inundation footprint of Humboldt Bay could expand by 52% (8,918 acres) (Figure 14). Due to topographic constraints around Humboldt Bay, after the protective artificial shoreline ceases to function due to breaching, sea level rise could incrementally increase the tidal footprint an average of 1,512 acres for each 0.5 meter (1.6 foot) rise in tide elevation, cumulatively 29% by 2100.

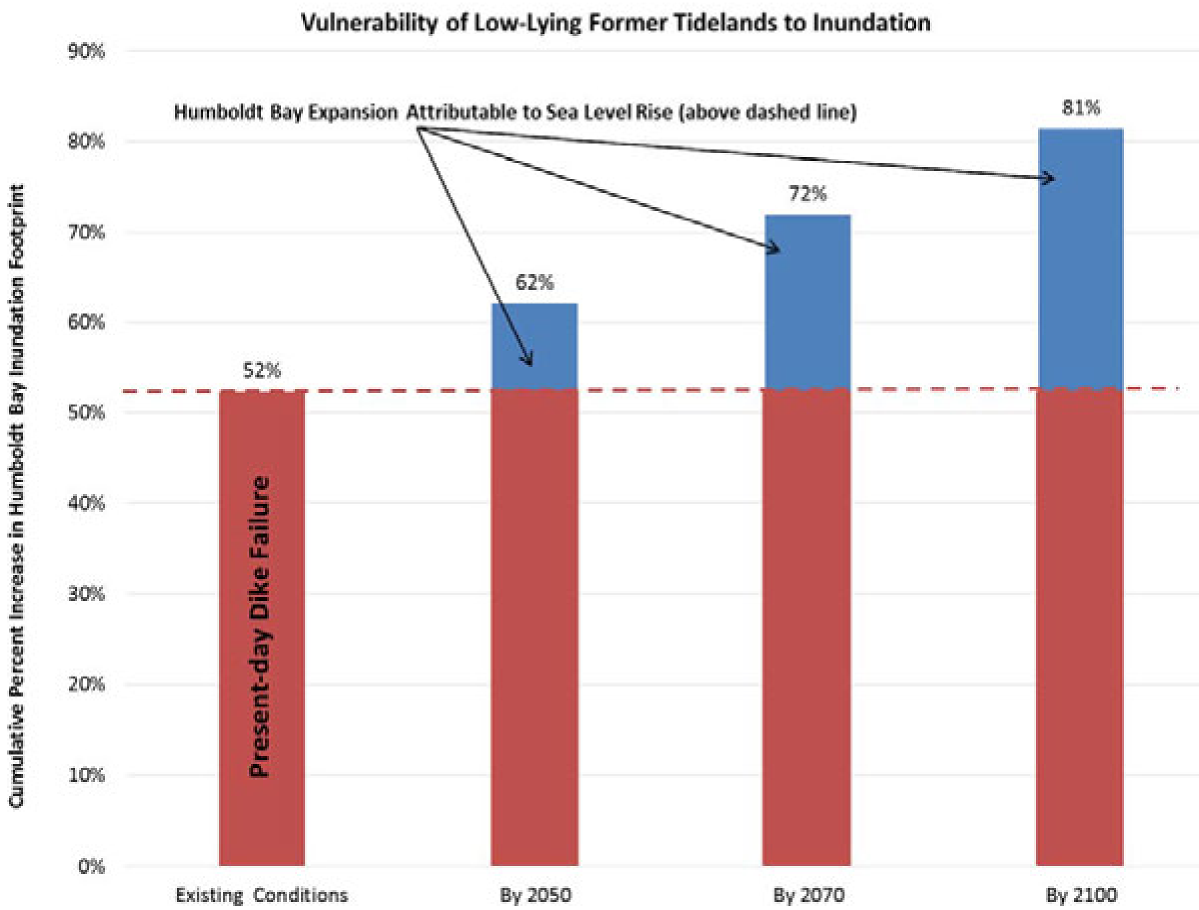

Figure 14. Percent cumulative increase in Humboldt Bay's footprint as a result of shoreline failure and sea level rise. Existing conditions reflects potential vulnerability if artificial shoreline structures were compromised.

The City is located on a marine terrace, which historically was covered by redwood forest, between two low-lying tidal/freshwater alluvial areas: Eureka Slough and Freshwater Creek to the north and Elk River and Slough to the south. Historically, these low-lying alluvial areas were predominately salt marsh with a network of tidal channels. In the City, the waterfront area west of Broadway Avenue and A Street was also historically salt marsh and windblown sand deposits overlaid on tidal mudflats or salt marsh (USDA 1925) (Figure 15). Today these former regions of salt marsh and low-lying sand deposits behind protective shoreline structures are potentially vulnerable now and at risk from tidal inundation as a result of sea level rise.

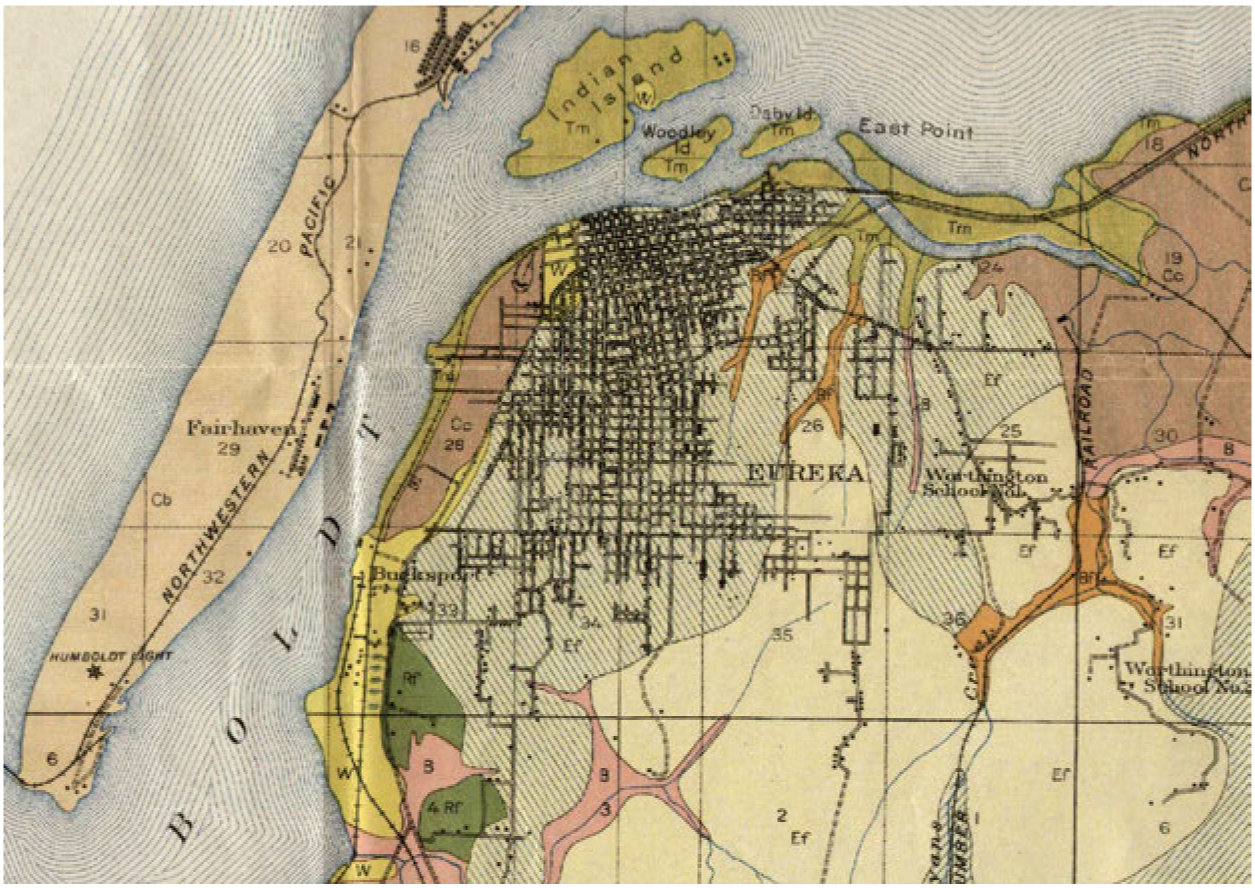

Figure 15. In the City of Eureka, much of the waterfront area west of Broadway Avenue and north of Elk River was historically low-lying zones of inter-tidal wetlands and windblown sand deposits overlaid on tidal mudflats or salt marsh. Soil types include salt marsh (Tm), diked salt marsh (Cc), windblown sand deposits (W), and marine terrace (Ef) (Soil Survey USDA 1925).

In the PA, on the North Spit there is an open coast with beaches, dunes that are also vulnerable to and at risk from extreme storm events and future sea level rise. The inundation modeling produced for areas surrounding Humboldt Bay does not include open coast areas. Therefore, this report does not address shoreline conditions, or sea level rise impacts to assets on the open coast.

2.4 Asset Vulnerability & Risk Assessment

This sea level rise assets vulnerability and risk assessment report describes assets in the City and its PA that are located in areas that are potentially vulnerable and at risk from tidal inundation by the high projection for MMMW elevation of 13.1 feet (NVAD 88) by 2100 (Figure 16).

Figure 16. City of Eureka (black), its Planning Area (yellow) in the unincorporated area of Humboldt County, and area potentially vulnerable to tidal inundation (13.1 feet NAVD 88) by 2100 (blue).

Coastal hazard assessments can occur at many scales: regional, city-wide, or parcel specific. This report provides an assessment of assets vulnerability and risk from sea level rise of the City and its PA. This scale of assessment is useful to inform updates to the City's and County's LCP to address sea level rise vulnerability, risk, and adaptation. Ultimately, assessment of asset vulnerability and risk from sea level rise may be necessary for individual developments that would utilize site-specific surface elevations, identify individual pathways for tidal inundation and flooding, and if appropriate calculate 100-year storm wave run-up elevations. Understanding site-specific conditions will facilitate developing site-specific adaptation standards for buildings and other developments.

This report treats sea level rise, or tidal inundation, as a permanent condition and flooding from extreme events (100-year stillwater elevation) as a temporary hazard that has a 1% probability of occurring in any year. Both tidal inundation and flooding are expected in the City and its PA in response to sea level rise, mainly via shoreline structures breaching or overtopping, backwater effects in tributaries draining to Humboldt Bay, reduced efficiency of shoreline water control structures, and rising ground water. The primary impacts from sea level rise in the City and its PA will be flooding and tidal inundation, which indirectly would be caused by erosion and overtopping of shoreline structures that serve as barriers to tidal inundation of lands interior to the shore. We recognize that current high tides (MHHW, MMMW, and MAMW), storms, and extreme 100-year events in any combination are likely to cause shorelines structures to breach by erosion or overtopping, resulting in flooding of low-lying areas prior to sea level rise. Rising tides and extreme events can also cause backwater effects in channels that discharge to the bay, resulting in flooding of lands adjacent to the channels and upstream. The potential inundation maps used in this report do not depict areas that are vulnerable to flooding as a result of backwater effects from sea level rise. Rising sea levels will also increase low tide elevations (MLLW and MLW), which can reduce the efficiency of existing drainage structures, such as tide gates, causing lands behind dikes in the rainy season to remain flooded longer or to become tidally inundated. Depending on the elevation of the ground water in relation to surface elevations and distance from the shoreline, sea level rise could cause ground water to rise to the surface, resulting in longer periods of flooding. Lastly, rising sea levels could cause salt water intrusion into freshwater aquifers or underground structures such as sewer lines.

The assessment of asset vulnerability and risk to sea level rise also builds on the preliminary assessments of the City's infrastructure, assets, and services found in the General Plan Community Background Report (ESA 2015). This assessment report addresses assets located in <u>both</u> the City and its PA. Asset descriptions will identify whether the asset is owned by the City, another public entity, or is privately owned. The function and services provided by the asset will be described. The location of the asset and its general surface elevation derived from 2012 LiDAR will be identified. The asset's exposure to sea level rise will be described as to the type and mode of hazard or impact expected, and timing (e.g., 2015, 2030, 2050, 2070, and 2100) of when the asset is projected to be impacted. The asset's susceptibility to the impact and the consequence (criticality) of the loss or impairment of the asset to the City will also be evaluated. Each asset will be prioritized for the 2050 and 2100 planning horizons based on: the criticality of the asset to the City, its timing of exposure, and susceptibility to expected impacts.

Not all assets are as equally important to the well-being and sustainability of a community like the City; some are more critical than others. An important criterion in evaluating the priority of an asset is its significance to the well-being of the community; how critical is the asset or its services to the community. Assessing consequence considers the level of damage, length of time service would be disrupted, and the cost to repair or replace the asset and the secondary economic and social impacts of the asset being disabled. Assessing age, condition, and materials of an asset would also helpful in determining the consequence of asset impairment or failure. But an asset's criticality to the community, while important when prioritizing assets, the degree and timing of their exposure to sea level rise needs to be considered as well as to what degree would the asset be adversely affected by sea level rise impacts.

Broadly speaking, there are two types of assets at risk from sea level rise: those assets located underground versus those located above ground. Generally, underground assets will be at risk earlier from sea level rise via tidal inundation, rising ground water, and salt water intrusion than most assets above ground, with the exception of current shoreline structures such as dikes and those assets located behind dikes on former tide lands. Diked former tide lands have compacted as much as two to three feet over the last century and are very prone to flooding by rising ground water, stormwater runoff, and rising tides that reduce drainage capacity of water control structures such as dikes and culverts. Further, it is important to note that most of the underground assets are utilities whose functions and services are essential to sustaining above ground developments and land uses, regardless of whether the above ground assets are presently vulnerable to or at risk from sea level rise or flooding.

The assets in the City and its PA that are located in areas that are vulnerable and at risk from sea level rise by 2100 have been grouped into four broad classes: Land uses, coastal resources, utilities, and modes of transportation; a 5th class has been created for open contaminated sites, not really an asset as defined (land use, development and resource) but a hazardous condition and liability in need of remediation to protect public health and water quality. Contaminated sites that have been treated are not considered in this assessment. These asset classes are further stratified into discrete asset types composed of individual assets. For example, in the transportation asset class there are four modes or types of assets: surface, marine, air, and rail, and the surface transportation asset includes local streets, state and federal highways.

1. Land uses
    - Coastal Dependent Industrial
    - Industrial
    - Commercial
    - Public
    - Residential
2. Coastal resources
    - Agricultural lands
    - Environmentally sensitive habitat areas: Marine and freshwater wetlands, and dunes
    - Cultural sites
3. Utilities:
    - Waste water
    - Drinking (Municipal) water
    - Storm water
    - Energy
    - Communications
    - Solid waste
4. Transportation
    - Surface
    - Marine
    - Air
    - Rail
5. Contaminated sites
    - Open-untreated

A detailed assessment of these assets is contained in the Appendix, with the exception of cultural resources which is not being published in this report.

3. ASSESSMENT RESULTS

3.1 Asset Vulnerability and Risk Assessment

As has been described previously, in the City and PA, there are assets, particularly infrastructure whose functions are essential to the City that are vulnerable and at risk now under current tidal conditions (MMMW 7.7 feet and MAMW 8.8 feet NAVD 88) and from extreme 100-year events (10.0 feet NAVD 88) if protective shoreline structures such as dikes are compromised (breached or overtopped). It is important to remember that the high water elevation of record on Humboldt Bay (2005) is 9.5 feet (NAVD 88). Because by 2050, predicted monthly maximum tide elevations (MMMW high projection to 9.6 feet NAVD 88) may exceed the current high water elevation of record and approach today's 100-year storm event elevation, and the annual maximum tide elevations (MAMW high projection to 10.7 feet NAVD 88) may exceed it. The 100-year event (stillwater) elevation is also going to increase by 2050 potentially to 11.8 feet (NAVD 88). By 2100, MMMW could rise to 13.1 feet (NAVD 88) under the high projection and the 100-year storm event could be 15.2 feet (NAVD 88).

The NHE's inundation maps of areas surrounding Humboldt Bay, identify which areas in the City and its PA are potentially vulnerable at various water elevations. GIS databases of asset locations obtained for this assessment were used to identify which assets (land uses, developments and resources) are located in areas potentially vulnerable to inundation. Utilizing inundation maps, high relative sea level rise projections, and asset location files this assessment was able to determine when and how much of an asset might be exposed to tidal inundation. A summary of the results of the exposure assessment of assets in the City's jurisdiction for 2050 and 2100 are presented in Table 2, and for the PA in Table 3. The amount of exposure that an asset may experience from tidal inundation in 2050 and 2100 are expressed as a percentage of the total asset. While it is important to know what is potentially vulnerable and at risk from sea level rise it is also very useful to be aware of what is not vulnerable, which is also presented in these tables under the "not inundated" heading. For planning purposes, it will be useful to know how much of the projected impact to an asset by 2100 might occur by 2050. For example, by 2100 80% of the Coastal Zone in the City may be inundated, but 71% of the Coastal Zone that is vulnerable could be tidally inundated as early as 2050.

City of Eureka

The results of the vulnerability and risk assessment for the high projection of sea level rise by 2050 indicate that the extent of tidal inundation of urban land use zones in the City is not significant (30% or less) (Table 2). Although 63% of the public facility zoned lands (golf course, airport, and marina) that may ultimately be vulnerable to tidal inundation by 2100 could be tidally inundated as early as 2050. Urban land use developments are supported by a multitude of utilities and infrastructure that are in turn themselves vulnerable and at risk from sea level rise. It is important to consider utilities and infrastructure vulnerability and risk when assessing impacts to urban lands and developments. By 2050, the regional waste water collection system and therefore the waste water treatment facility that supports urban land uses could start experiencing inflow/salt water intrusion impacts when 22% (11 of 51) of the lift stations and 6% of the sewer lines may become tidally inundated. Any impairment of the wastewater collection system and/or the wastewater treatment facility could potentially affect nearly all development in the City and in Humboldt Community Service District, which shares use of the treatment plant. Wastewater infrastructure is critical to an urban community and represents a significant capital investment. Approximately 2.4 miles of the City's municipal water transmission lines and its booster station are located in the PA on diked former tide lands that could be tidally inundated now if the dikes protecting them are breached or overtopped and by 2050 from the high projection for MMMW (9.64 feet NAVD 88) and MAMW (10.68 feet NAVD 88) overtopping these dikes. While the municipal water lines may continue to function if they are tidally inundated, maintenance and emergency repairs will be significantly more difficult and expensive in a tidal water environment. With the storm water system there are 17 tide gates in the City that unless modified may not be functioning by 2050 with 1.9 feet of projected sea level rise, potentially resulting in stormwater flooding 1,460 acres. By 2050, nearly all (93%) of the underground gas lines in the City may be tidally inundated, again while they may continue to function their maintenance and emergency repairs may become significantly more difficult and expensive. The only operating bulk fuel terminal for the City and Humboldt Bay region is located on the shoreline of Humboldt Bay and may need additional protection by 2050 when MMMW could reach 9.6 feet (NAVD 88) and MAMW 10.7 feet (NAVD 88). However, the electrical distribution infrastructure and solid waste facilities in the City are projected to not be impacted by sea level rise by 2050. Communications infrastructure such as underground optical fiber lines could have 35% of their lines in the City tidally inundated while just 12% of the electrical transmission towers could be tidally inundated by 2050.

Table 2. Summary of assets potentially vulnerable and at risk from sea level rise in City of Eureka to high relative sea level rise projections for 2050 and 2100, assets not vulnerable, and the percent of assets impacted by 2050 versus what may be impacted by 2100.

City of Eureka	Total	Inundated by 2050		Inundated by 2100		Not Inundated		2050 vs
Coastal Zone		**Units**	**Percent**	**Units**	**Percent**	**Units**	**Percent**	**2100**
City of Eureka above MSL in CZ (acres)	2,454	1394	57%	1974	80%	480	20%	71%
Urban Zones								
Coastal Dependent Industrial (acres)	122	37	30%	113	93%	9	7%	33%
Industrial (acres)	179	47	26%	172	96%	7	4%	27%
Commercial (acres)	751	117	16%	321	43%	430	57%	36%
Public (acres)	735	132	18%	208	28%	527	72%	63%
Residential (acres)	2,888	0	0%	0	0%	2888	100%	0%
Coastal Resources:								
Agricultural Lands (acres)	619	546	88%	569	92%	50	8%	96%
ESHAs-Marine Wetlands (acres)	3,212	371	12%	378	12%	2834	88%	98%
ESHAs-Freshwater Wetlands (acres)	519	498	96%	513	99%	6	1%	97%
ESHAs-Dunes (acres)	1,076	26	2%	47	4%	1029	96%	55%
Waste Water:								
Lift Station	*22*	*4*	18%	*10*	45%	12	55%	40%
Sewer Line (miles)	*120.9*	*7.4*	6%	*17.8*	15%	103.1	85%	42%
Manhole Cover	*1,541*	*54*	4%	*76*	5%	1465	95%	71%
Domestic Water:								
Transmission Line (miles)	*0*	*0*	0%	*0*	0%	0	0%	0%
Pump-Booster Stations	*1*	*0*	0%	*1*	100%	0	0%	0%
Storm Water:								
Tide Gates (number)	*17*	*17*	100%	*17*	100%	0	0%	100%
Inundation Area (acres)	N/A	1460	N/A	2120	N/A	N/A	N/A	69%
Energy:								
Gas Line (miles)	5.6	5.2	93%	6.0	107%	0	-7%	87%
Electric Sub-Stations (number)	2	0	0%	2	100%	0	0%	0%
Bulk Fuel Terminal (number)	1	1	100%	1	100%	0	0%	100%
Communications:								
Optical fiber line (miles)	6.2	0.1	2%	2.7	44%	3.5	56%	4%
Communications Towers (number)	21	1	5%	5	24%	16	76%	20%
Solid Waste Station								
	1	0	0%	1	100%	YES	0%	0%
Surface Transportation:								
U.S. Highway 101 (miles)	6.2	0.0	0%	2.4	39%	3.8	61%	0%
State Highway 255 (miles)	1.4	0.1	7%	0.3	21%	1.1	79%	33%
Streets (miles)	142.2	3.5	2%	12.2	9%	130.0	91%	29%
Marine Transportation:								
Industrial Docks and Property (number)	5	1	20%	5	100%	0	0%	20%
Commercial (number)	8	3	38%	7	88%	1	13%	43%
Recreational (number)	8	8	100%	8	100%	0	0%	100%
Air Transportation:								
Murray Field Airport (number)	1	1	100%	1	100%	0	0%	100%
Rail Transportation:								
Railroad Grade (miles)	7.3	1.3	18%	4.7	65%	2.6	35%	28%
Contaminated Sites:								
Untreated contaminated sites (number)	50	4	8%	23	46%	27	54%	17%

Surface transportation may just be starting to be impacted by 2050 with the high projection for sea level rise of 1.9 “feet,” approximately 3.5 miles (2%) of City streets could become tidally inundated. Highway 255 might have a 0.1-mile segment between bridges become tidally inundated by 2050, while there should be no areas on U.S. Highway 101 in the City that are tidally inundated. Most (80%) of the industrial bulk cargo docks and lands should not be affected by sea level rise in 2050, but 38% of the commercial docks on the City’s waterfront could be tidally inundated. The piers anchoring the recreational boating docks in the City, which provide valuable public access to the Bay may need to be extended by 2050 as potentially 1.9 feet of sea level rise could float most of the docks off during MMMW or MAMW tides. The County’s Murray Field airport is vulnerable and at risk from tidal inundation now if the protective shoreline dikes on Eureka and Fay Sloughs are breached and from tidal inundation by 2050 that may overtop dikes on Fay Slough. There are 1.3 miles (18%) of the railroad grade in the City that could be tidally inundated by 2050.

There are four (8%) untreated contaminated sites in the City that are vulnerable and at risk from tidal inundation by 2050.

The majority of the agricultural lands in the City are currently protected from tidal inundation, flooding, and potentially future sea level rise by a network of earthen dikes. However, a significant portion (96%) of the agricultural lands that may be inundated by 2100 could be inundated as early as 2050. The agricultural lands behind these dikes are former tidelands, and they have compacted, as much as three feet, over the last century since they were isolated from the daily inundation of the tides. As a result, many of these agricultural lands are also protected seasonal freshwater wetlands and wildlife habitat, 97% of these wetlands and habitat in the City are potentially vulnerable and at risk from sea level rise by 2100 but could be tidally inundated as early as 2050. There is also a significant dune ecosystem in the City on Elk River Spit, the majority 96% of this habitat should not be inundated by sea level rise, although shoreline erosion will likely increase. There are cultural Wiyot sites located in the City in areas that are vulnerable and at risk from projected sea level rise. Based on projected MMMW elevations only one site is of concern by 2050. Information on these cultural sites is available from the City or Wiyot Tribe on request.

In 2012, the City opened its Hikshari Trail along the shoreline from Elk River Slough north to Truesdale Avenue. The City is actively engaged in extending Eureka’s Waterfront Trail north (Phase A & B) to tie in with its existing waterfront Boardwalk and on north to Eureka Slough (Phase C). The City’s trails are considered ancillary developments with a life expectancy of approximately 25 years. The City’s designs for its Waterfront Trail would place it at or above 10.0 elevation (NAVD 88) above the high projection for 2050 (9.64 feet NAVD 88). Portions of the existing Hikshari trail could be tidally inundated by 2050 if these sections are not elevated during maintenance or reconstruction activities over the 25-year design life (2037) of the trail.

Ultimately the City's Waterfront Trail would merge with the Regional California Coastal Trail that is being developed along the eastern shoreline of Humboldt Bay between Eureka and Arcata. The exposure assessment for the NWP railroad in the City and its PA indicates that this reach of railroad grade along the eastern shoreline of the Bay is vulnerable and at risk from tidal inundation and wave induced erosion by 2050. Design of the regional trail should account for high projections of sea level rise by 2050 and beyond depending on the design life of this trail segment.

By 2100, the number of assets in the City that are vulnerable and at risk to the high projection for sea level rise (5.4 feet) increases significantly. The Coastal Zone encompasses both urban and rural areas, and fully 80% may be tidally inundated by 2100. As much as 93% of the Coastal Dependent Industrial and 96% of the Industrial lands and developments could be tidally inundated. Approximately 35% of sewer lift stations and 14% of the sewer lines that serve the wastewater treatment facility may be tidally inundated. This level of impact could overload the collection and treatment system and cause a breakdown of the treatment process. By 2100, the shoreline dikes in the City are likely to have been overtopped by the high projection for sea level rise of 13.1 feet (NAVD 88) for MMMW and 14.1 feet (NAVD 88) for MAMW. Most of the diked former tidelands in the City are agricultural lands (92%) and freshwater wetlands or ESHA (99%). If dikes protecting these lands and wetlands have not already breached, they are likely to become tidally inundated between 2050 and 2100 when the dikes could be overtopped, along with those assets located on the diked lands: 38% of the municipal water transmission lines, both municipal water booster pump stations, 100% of the gas lines, and 39% of Highway 101. The two electrical sub-stations in the City may be inundated by 2100 based on the high projection for sea level rise. Underground optical fiber lines and communications towers are located in areas that may limit tidal inundation by 2100, affecting just 2.7 miles of the fiber lines and five communications towers. Portions of Highway 255 could be tidally inundated and 12 miles of City streets. All of the bulk cargo docks and adjoining properties except one CDI parcel owned by the City, as well as local streets servicing these waterfront properties are projected to be tidally inundated, along with 88% (7 of 8) commercial fishery docks and facilities are projected to be tidally inundated. There could be 4.7 miles of railroad grade that are tidally inundated. As much as 46% (23) of the currently untreated contaminated sites may become tidally inundated.

Planning Area

In the City's PA, as much as 48% (4,852 acres) of the Coastal Zone may not be inundated by 2100, but 77% of the area that ultimately may be tidally inundated could be as early as 2050 (Table 3).

Looking at potential tidal inundation of urban land use zones in the PA by 2050 we see that much less than half of urban zone areas are vulnerable and at risk: 12% of Coastal Dependent Industrial, 17% of the Industrial, 22% of commercial and 35% of commercial recreation, and just 8% of public facility zoned land are vulnerable and at risk. But by 2050, while only 4% of the residential lands could be tidally inundated, that represents as much as 262 acres of mostly disadvantaged communities that are vulnerable and at risk from tidal inundation. Similar to the City, urban land use developments in the PA are supported by a multitude of utilities and infrastructure. The waste water collection system in the PA will be impacted by tidal inundation: 7 lift stations and 4 miles of sewer line could be inundated by 2050 increasing to 8 lift stations and 7.5 miles of sewer line by 2100. Any impairment of the wastewater collection system and/or the wastewater treatment facility could potentially affect development throughout the HCSD, which shares use of the treatment plant with the City. The City's two municipal water transmission lines traverse diked former tidelands in the PA and City's sole pump-booster station is also located on diked lands that may be tidally inundated by 2050 when the dikes are projected to start being overtopped by high projections for MMMW of 9.64 feet (NAVD 88) and MAMW of 10.68 feet (NAVD 88). In fact, if these protective dike shorelines are compromised now, the land that these water lines traverse would become tidally inundated. HCSD has three municipal wells; one could become tidally inundated by 2050 while the other two are above the high projection for sea level rise by 2100 of 13.1 feet (NAVD 88).

In the PA, there are 26 tide gates that may need to be modified by 2050 if two feet of sea level rise occurs, potentially resulting stormwater flooding affecting 4,270 acres. There are approximately 14 miles of underground gas lines in the PA that may be inundated by 2100, 86% of which could be inundated by 2050 or sooner if protective shoreline dikes are compromised. One out of three electrical sub-stations, and more significant to the Humboldt Bay region, the Humboldt Bay Generating Station in the PA may be tidally inundated by 2100 based on the high projection for sea level rise of 13.1 feet (NAVD 88). Underground optical fiber lines and communications towers in the PA are located in areas that based on their surface elevations may limit tidal inundation by 2050 to just 1.9 miles of the fiber lines and two communication towers, however by 2100 that may increase to 3.5 miles of the fiber lines and three towers. In the PA, 7.7 miles of local roads and 1.9 miles of U.S. Highway 101 may be inundated by 2050, by 2100 nearly 17.6 miles of local roads, and again of regional importance 3.4 miles of U.S. Highway 101 that traverses diked lands may become tidally inundated. By 2100, only two industrial docks and adjacent lands may be inundated while three docks (60%) on the Samoa Peninsula are predicted to not be inundated. However, two of the five commercial fishing fleet docks and facilities in the PA may experience inundation by 2050 and four (80%) by 2100. Two of the three recreational boat launches in the PA could be tidally inundated by 2050, and all by 2100.

Table 3. Summary of assets potentially vulnerable and at risk from sea level rise in the Planning Area to high relative sea level rise projections for 2050 and 2100, assets not vulnerable, and the percent of assets impacted by 2050 versus what may be impacted by 2100.

Planning Area	Total	Inundated by 2050		Inundated by 2100		Not Inundated		2050 vs
Coastal Zone		Units	Percent	Units	Percent	Units	Percent	2100
Planning Area above MSL in CZ (acres)	10,199	4092	40%	5347	52%	4852	48%	77%
Urban Zones								
Coastal Dependent Industrial (acres)	975	121	12%	418	43%	557	57%	29%
Industrial (acres)	587	99	17%	158	27%	429	73%	63%
Commercial (acres)	240	53	22%	60	25%	180	75%	88%
Commercial Recreation (acres)	220	76	35%	94	43%	126	57%	81%
Public (acres)	370	13	4%	31	8%	339	92%	42%
Residential (acres)	6,522	262	4%	378	6%	6144	94%	69%
Coastal Resources:								
Agricultural Lands (acres)	4,675	2,007	43%	2,164	46%	2511	54%	93%
ESHAs-Marine Wetlands (acres)	3,732	458	12%	469	13%	3263	87%	98%
ESHAs-Freshwater Wetlands (acres)	3,078	2,615	85%	2,752	89%	326	11%	95%
ESHAs-Dunes (acres)	2,101	30	1%	58	3%	2043	97%	52%
Waste Water:								
Lift Station (number)	29	7	24%	8	28%	21	72%	88%
Sewer Line (miles)	65.6	3.8	6%	7.5	11%	58.1	89%	51%
Domestic Water:								
Transmission Line (miles)	6.3	2.4	38%	2.4	38%	3.9	62%	100%
Pump-Booster Stations (number)	4	1	25%	1	25%	3	75%	100%
Municipal Wells (number)	3	1	33%	1	33%	2	67%	100%
Storm Water:								
Tide Gates (number)	26	26	100%	26	100%	0	**0%**	100%
Inundation Area (acres)		4,270	N/A	5,700	N/A	N/A		
Energy:								
Gas Line (miles)	23.2	8.3	36%	9.7	42%	13.5	58%	86%
Electric Sub-Stations (number)	3	0	0%	1	33%	2	67%	0%
HB Generating Station (number)	1	0	0%	1	100%	0	0%	0%
Communications:								
Optical fiber line (miles)	5.5	1.9	35%	3.5	64%	2.0	36%	54%
Communications Towers (number)	17	2	12%	3	18%	14	82%	67%
Surface Transportation:								
U.S. Highway 101 (miles)	5.5	1.9	35%	3.4	62%	2.1	38%	56%
State Highway 255 (miles)	0.5	0	0%	0.03	6%	0.5	94%	0%
Streets (miles)	162.7	7.7	5%	17.6	11%	145.1	89%	44%
Marine Transportation:								
Harbor-Jetties (miles)	3.00	0.2	7%	2.15	72%	0.9	28%	9%
Industrial Docks and Property (number)	5	0	0%	2	40%	3	60%	0%
Commercial (number)	5	2	40%	4	80%	1	20%	50%
Recreational (number)	3	2	67%	3	100%	0	0%	67%
Air Transportation:								
Samoa Field Airport (number)	1	1	100%	1	100%	0	0%	100%
Rail Transportation:								
Railroad Grade (miles)	5.1	2.0	40%	3.7	73%	1.4	27%	54%
Contaminated Sites:								
Untreated contaminated sites (number)	12	1	8%	6	50%	6	50%	17%

The City's Samoa Field Airport is located in the PA and it could become partially inundated as early as 2050 based on the high projection for sea level rise of 9.64 feet (NAVD 88). While there is a railroad grade paralleling the Bay in the PA, it is no longer used commercially or maintained, but 82% or 3.7 miles of the railroad could be tidally inundated by 2100, with two miles that could be inundated as early as 2050. There are 12 untreated contaminated sites in the PA, half (6) could be tidally inundated by 2100, and just one by 2050.

The agricultural lands in the PA are also protected from tidal inundation, flooding and potentially sea level rise by a network of earthen dikes. A host of underground utilities (sewer lines, municipal water lines, and gas lines) that serve development in the City and PA also traverse these lands behind dikes. A significant portion (93%) of the agricultural lands in the PA that could be tidally inundated by 2100 may be inundated as early as 2050. The agricultural lands behind these dikes are former tidelands, and they have compacted, as much as three feet, over the last century since they were isolated from the daily inundation of the tides. As a result, many of these agricultural lands are also protected seasonal freshwater wetlands and wildlife habitat, 95% of the wetlands and habitat that are vulnerable and at risk from sea level rise by 2100 could be tidally inundated as early as 2050, or now if the shoreline dikes are compromised.

There is a significant dune ecosystem on Humboldt Bay located in the PA on North Spit, fortunately 97% of this habitat should not be inundated by sea level rise although shoreline erosion will likely increase. There are cultural Wiyot sites located in the PA in areas that are vulnerable and at risk from projected sea level rise by 2050 and 2100. Information on these cultural sites is available from the City or Wiyot Tribe on request.

3.2 Asset Prioritization

Each asset has been prioritized for the 2050 and 2100 planning horizon based on its: exposure to sea level rise impacts, susceptibility (the degree to which an asset is affected adversely) to expected impacts, and the consequence (result or effect of impact) of the loss or impairment of the asset to the City, its criticality (Table 4). Assets have been given a priority ranking to facilitate the selection of priority assets for development of adaptation strategies and measures. The process for prioritizing assets has purposefully been simplified. There is an element of subjectivity in determining how critical is an asset to the community, particularly projecting to the future in 2050 and 2100, that would best be derived through community and stakeholder forums. Unfortunately holding such forums was beyond the scope of this project.

To assign a priority ranking for an asset each of the elements: exposure, susceptibility, and consequence for 2050 and 2100 was given a value, for example with exposure, 0 if there is no exposure, one if less than 50% of an asset was exposed, and two if greater than 50% of an asset could be exposed. Cumulative value totals for an asset of 0-1-2 would be considered a low priority, 3-4 medium priority, and 5-6 high priority (Table 4). Assigning a value for the consequence to an exposed asset, that is susceptible to sea level rise impacts, as mentioned earlier can be subjective and the effect on the priority ranking significant. For example, by 2050 there are 7.4 miles out of 121 miles of sewer lines in the City that are exposed and susceptible to sea level rise impacts of salt water intrusion (inflow), which is just 6% of the sewer lines and if assigned a value of one for exposure, the value for susceptibility is given two as electrical component of the lift station could be adversely impacted, and a value of one for consequence because of the limited exposure results in a priority ranking of just four, a medium ranking. But if tidal inundation and inflow/salt water intrusion of 7.4 miles of sewer line is considered a significantly impact to the capacity or biological process of the treatment facility the value for consequence should be two, raising the ranking to five, a high priority asset. Another example could be the railroad, it was given a ranking of 3 by 2050 and 4 by 2100 as exposure increased but the consequence did not change as it has not been used for several decades. However, if by 2050 the railroad right-of-way supports a regional coast trail between Eureka and Arcata then the consequences of its exposure in 2050 could be high (2) resulting in its overall ranking becoming a 5, making it a high priority asset. Agricultural lands were ranked a high priority (6) for 2050, but only three for 2100. The difference being that the consequences from tidal inundation is projected to occur by 2050 and additional tidal inundation would not change the consequences experienced in 2050.

Dikes, are shoreline structures that while they have not been treated as an asset in this assessment they serve a critical function in protecting many high priority assets from tidal inundation, today. Dikes are exposed to high tides and wind waves. Many miles of earthen dikes are currently in an eroded state and of insufficient elevation to accommodate tides greater than our current king tides (MAMW 8.78 feet NAVD 88) (Laird and Powell 2013). If dikes in the City and its PA are breached, before sea level rise increases monthly maximum tides, spring tides to 9.64 feet (NAVD 88) by 2050, 6 of the 10 high priority ranked assets for 2050 would be adversely effected by tidal inundation. Approximately 9.8 miles of dikes (57%) in the City and PA are rated highly vulnerable and at risk from sea level rise projected for 2050. Dikes, primarily on Eureka and Elk River Sloughs are currently protecting these high priority assets: waste water collection system components, municipal water transmission lines, U.S. Highway 101, Murray Field Airport, environmentally sensitive habitat areas-coastal seasonal freshwater wetlands, and coastal agricultural lands, from tidal inundation.

Table 4. Summary of assets exposure, susceptibility, consequence and priority ranking for 2050 and 2100 in the City and its PA.

CITY and PA ASSETS	Exposure	Susceptibility	Consequence	2050	Exposure	Susceptibility	Consequence	2100
Coastal Dependent Industrial-City	1	2	1	**4**	2	2	2	**6**
Coastal Dependent Industrial-PA	1	2	0	**3**	1	2	1	**4**
Industrial-City	1	2	1	**4**	2	2	2	**6**
Industrial-PA	1	2	0	**3**	1	2	1	**4**
Commercial-City	1	2	1	**4**	1	2	1	**4**
Commercial-PA	1	2	1	**4**	1	2	2	**5**
Public-City	1	2	2	**5**	1	2	2	**5**
Public-PA	1	2	2	**5**	1	2	2	**5**
Residential-PA	1	2	2	**5**	1	2	2	**5**
Agricultural lands-City	2	2	2	**6**	1	2	0	**3**
Agricultural lands-PA	2	2	2	**6**	1	2	1	**4**
Freshwater ESHA-City	2	2	2	**6**	0	2	0	**2**
Freshwater ESHA-PA	2	2	2	**6**	0	2	0	**2**
Waste Water-Lift Stations-City	1	2	2	**5**	2	2	2	**6**
Waste Water-Lift Stations-PA	2	2	2	**6**	1	2	0	**3**
Waste Water-Sewer Lines-City	1	2	2	**5**	1	2	2	**5**
Waste Water-Sewer Lines-PA	1	2	2	**5**	1	2	2	**5**
Municipal Water	1	2	2	**5**	2	2	2	**6**
Storm Water	2	1	2	**5**	2	2	2	**6**
Electric System	1	1	0	**2**	2	2	1	**6**
Gas System	1	0	2	**3**	2	1	2	**5**
Bulk Fuel Terminal (number)	0	0	0	**0**	2	2	1	**5**
Optical Fiber	1	1	1	**3**	2	2	2	**6**
Communication Towers	1	1	0	**2**	1	2	0	**3**
Solid Waste	0	0	0	**0**	2	2	0	**4**
Streets	1	2	1	**4**	1	2	2	**5**
State Highway	1	2	0	**3**	2	2	2	**6**
US Highway	1	2	2	**5**	2	2	2	**6**
Jetty-Channels	0	0	0	**0**	2	2	2	**6**
Bulk Cargo Docks	1	1	1	**3**	2	2	2	**6**
Commercial Fishing	1	2	2	**5**	2	2	2	**6**
Recreational Boating	2	2	2	**6**	1	2	1	**4**
Murray Field Airport	2	2	2	**6**	2	2	1	**5**
Samoa Field Airport	0	0	0	**0**	2	2	0	**4**
Railroad	1	2	0	**3**	2	2	0	**4**
Contaminated Sites	1	2	1	**4**	2	2	2	**6**

By 2050, there are 10 assets ranked high priority and by 2100 there are 18 (Table 5).

Table 5. Summary of high priority asset ranking for 2050 and 2100 in the City and its PA.

HIGH PRIORITY ASSETS	Exposure	Susceptibility	Consequence	2050	Exposure	Susceptibility	Consequence	2100
Waste Water-Collection System	1	2	2	5	2	2	2	6
Municipal Water-Transmission System	1	2	2	5	2	2	2	6
Residential Zoned Property & Communities-PA	1	2	2	5	1	2	2	5
US Highway 101	1	2	2	5	2	2	2	6
Storm Water System	2	1	2	5	2	2	2	6
Commercial Fishing Facilities-Property	1	2	2	5	2	2	2	6
Recreational Boating	2	2	2	6	1	2	1	4
Murray Field Airport	2	2	2	6	2	2	1	5
Agricultural Zoned Lands	2	2	2	6	1	2	0	3
Freshwater ESHA	2	2	2	6	0	2	0	2
Electric System	1	1	0	2	2	2	1	5
Natural Gas System	1	0	2	3	2	1	2	5
Optical Fiber Transmission	1	1	1	3	2	2	2	6
Jetty-Channels	0	0	0	0	2	2	2	6
State Highway 255	1	2	0	3	2	2	2	6
Coastal Dependent Industrial Zoned Property-City	1	2	1	4	2	2	2	6
Industrial Zoned Property-City	1	2	1	4	2	2	2	6
Bulk Cargo Docks-City	1	1	1	3	2	2	2	6
Contaminated Sites	1	2	1	4	2	2	2	6
Bulk Fuel Terminal	0	0	0	0	2	2	1	5
Streets	1	2	1	4	1	2	2	5

It is important to note that while only 262 acres by 2050 rising to 378 acres of residential areas by 2100 are vulnerable and at risk from tidally inundation, developing adaptation goals, strategies and measures for these communities is considered a high priority.

By 2050, key infrastructure components could be adversely affected by sea level rise. Maintaining the capacity and operation of the regional wastewater collection system, in the sea level rise hazard zone for 2050, is critical to the function of the waste water treatment facility. The facility in turn is essential as it supports nearly all of the urban development in the City and much of its PA. While the City's municipal water supply is not directly impacted by sea level rise, the City's capacity to maintain or conduct emergency repairs of its main transmission lines could be impaired significantly by tidal inundation either from breaching of protective dikes before 2050 or by sea level rise overtopping the dikes. The storm water system's outlet structures at the shoreline of the Bay are vulnerable and at risk of being tidally inundated by nearly two feet if sea level rise by 2050. Backwater flooding of urban areas will be exasperated as a result.

By 2050, U.S. Highway 101 a significant transportation asset for the Humboldt Bay Region is vulnerable and at risk from tidal inundation between Eureka Slough and Bracut on Arcata Bay if the dikes on Eureka-Fay Sloughs are breached or overtopped. This highway is the most important transportation asset on the north coast and its vulnerability to sea level rise will require a coordinated multi-agency effort to develop and implement adaptation strategies and measures. The County's Murray Field airport is also a high priority asset locally; like the highway it is vulnerable should the protective dikes on Eureka-Fay Slough fail now or be overtopped by 2050. On the City's waterfront 3 of 8 commercial fishing docks/properties could become tidally inundated. Nearly all of the recreation boating facilities in the City could be adversely impacted by 1.9 feet of sea level rise as boat berths, floating docks, and boat launches could float off their pilings unless their dock structures are modified to accommodate higher tides. Agricultural lands, wetlands, and wildlife habitats are high priority coastal resources that are also located behind the Eureka-Fay Slough dikes and vulnerable now and by 2050.

By 2100, the number of high priority assets that are vulnerable and at risk from sea level rise increases substantially from 2050, 10 to 21. Figures 8 and 9 illustrate the increase in scope of the sea level rise hazard zone in the City's urban area. All of the utilities with the exception of communication towers, and transportation modes, due to their exposure and criticality are ranked high priority for development of adaptation strategies and measures. All of the City's existing Coastal Dependent Industrial docks and nearly all (93% and 96%) of its CDI and Industrial properties could become tidally inundated and are also designated as high priority assets. Only three existing bulk cargo docks could still be in service by 2100, all reside on Samoa Peninsula in the PA. The magnitude of change as a result of sea level rise is significant that the City, County and others on Humboldt Bay will need to address before 2100.

To summarize there are two asset classes and seven high priority assets that if impaired or eliminated by tidal inundation, due to dike failure, and sea level rise would have significant impacts on the City and Humboldt Bay Region:

1. Utilities:
    - Waste water
    - Municipal water
    - Energy (electricity and fuel)
    - Communications (optical fiber lines and wireless for internet and telephone)
2. Transportation:
    - U.S. Highway 101
    - Highway 255
    - Local streets and roads

4. CONCLUSIONS

In the City and its PA, coastal hazards planning has relied on FEMA's 100-year flood zone mapping and the state's tsunami run-up mapping. Going forward coastal hazard mitigation planning will be able to utilize sea level rise inundation mapping (NHE 2015) and this vulnerability and risk assessment report. Sea level rise planning horizons, 2030-2050-2100, are useful for LCP planning purposes particular for new assets (uses and developments). For existing developments, the design life of structures and their exposure to sea level rise is important when developing adaptation strategies and measures. The expected design life of a structure may span several if not all of the planning horizons being used today.

The City may want to focus on developing adaptation strategies and measures for high priority assets by the 2050 planning horizon that are located in its jurisdiction, and particularly on those assets that it owns, or for which it is responsible. Like most municipalities, the City only owns and controls some critical assets (waste water treatment facilities, sewer lines and lift stations, municipal water lines and pump stations, storm water infrastructure, streets, some waterfront and adjacent properties with commercial and recreational docks, marina, and coastal resources) that are vulnerable and at risk from sea level rise. Other assets, are privately owned (electrical power generating plants, natural gas transmission lines, electric distribution infrastructure, bulk fuel terminals, and communications facilities, bulk cargo docks, commercial docks, and waterfront property), or owned by other agencies (U.S. Highway 101, Highway 255, Harbor/Port facilities, marina, sold waste disposal facilities, waterfront properties and recreational docks, wildlife refuges-ESHA, and cultural resources). For those high priority assets that the City does not own but are critical to the City (Highway 101, Humboldt Bay Power Plant, and optical fiber lines, etc.) it may be advantageous for the City to form partnerships and collaborate with owners of these and other assets.

An example of the need for the City to form partnerships and collaborations is the maintenance and improvement of shoreline dikes that protect assets in the City (wastewater collection system, stormwater system, and local streets) and access to City owned assets like its Mad River Pipelines. The City could provide the leadership for a collaboration of property and asset owners to develop appropriate adaptation goals, strategies, measures and secure funding to increase the resiliency of dikes on Eureka and Elk River Sloughs, particularly in the Eureka-Fay Slough hydrologic area (Figure 17).

Figure 17. *Eureka-Fay Slough hydrologic area (white boundary) potentially could become tidally inundated (blue shading) now if dikes fail or by 2050 during mean annual maximum and mean monthly maximum tides if existing dikes elevations are not increased, and City limit (red line).*

The Eureka Slough agricultural landscape is an area where nearly its entire shoreline consists of earthen dikes that are vulnerable and at risk from tidal inundation now if the dikes are breached and from sea level rise by 2050. This area hosts a large number of high priority assets not owned by the City: HCSD sewer lines and lift stations, PG&E's gas transmission lines and electrical distribution towers and poles, Humboldt County's Murray Field Airport, U.S. Highway 101, County streets/roads, numerous commercial properties and residential areas, DFW's Fay Slough Wildlife Area, and numerous private agricultural properties. With such a diverse assemblage of asset interests and property owners there is a need for a unified and collaborative stakeholder driven planning effort to understand property/asset management goals, and identify adaptation strategies, develop adaptation measures and implement adaptation projects to increase the resiliency and extend the sustainability of these critical assets and land uses in the face of sea level rise. A vulnerability and risk assessment of assets is an important step in the process of planning for adaption to sea level rise. This asset assessment can naturally lead to developing greater awareness of the community's vulnerability and risk to sea level rise as well as gaining an understanding of potential adaptation strategies and measures.

5. REFERENCES

California Coastal Commission. 2015. Sea Level Rise Policy Guidance: interpretive guidelines for addressing sea level rise in local coastal programs and coastal development permits.

Environmental Services Associates (ESA). 2015. City of Eureka: Community background report; Sea level rise appendix. Prepared for City of Eureka.

Russell, Nicole, Gary Griggs. 2012. Adapting to Sea Level Rise: A Guide for California's Coastal Communities. University of California, Santa Cruz.

Humboldt Bay Harbor, Recreation and Conservation District. 2007. Humboldt Bay management plan.

Laird, Aldaron, Brian Powell. 2013. Humboldt Bay shoreline inventory, mapping, and sea level rise vulnerability assessment, with an Addendum: Shoreline Vulnerability Ratings. Prepared for the California State Coastal Conservancy.

Laird, Aldaron. 2015. Humboldt Bay sea level rise adaptation planning project: Phase II report. Prepared for the California State Coastal Conservancy.

National Oceanic and Atmospheric Administration. 2001. Tidal Datums and Their Applications. NOAA Special Publication NOS CO-OPS 1. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Center for Operational Oceanographic Products and Services, Silver Spring, MD.

Northern Hydrology and Engineering. 2014a. Estimates of local or relative sea level rise for Humboldt Bay region. Prepared for the California State Coastal Conservancy and Coastal Ecosystems Institute of Northern California.

Northern Hydrology and Engineering. 2014b. Data release for the Humboldt Bay sea level rise vulnerability assessment: Humboldt Bay sea level rise inundation mapping. Prepared for the California State Coastal Conservancy.

Northern Hydrology and Engineering. 2015. Humboldt Bay Sea Level Rise Hydrodynamic Modeling and Inundation Vulnerability Mapping. Prepared for the California State Coastal Conservancy.

USDA. 1925. Soil Survey of the Eureka Area, California. U.S. Department of Agriculture, Bureau of Soils. Washington, D.C.

CITY OF EUREKA

Sea Level Rise
Assets Vulnerability and Risk Assessment

Appendix

Prepared By

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Acknowledgements

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DISCLAIMER: The following Sea Level Rise Assets Vulnerability and Risk Assessment Report was prepared for the City of Eureka. All statements are the sole responsibility of Aldaron Laird of Trinity Associates and do not necessarily reflect the views or policies of the City of Eureka. This assessment is for City-wide planning purposes, and is not a substitute for site-specific analysis of vulnerability and risk from sea level rise.

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1 Introduction

Since 2010, Humboldt Bay has been the subject of several sea level rise adaptation planning projects. The City of Eureka (City) is building on these regional sea level rise adaptation planning efforts to prepare a vulnerability and risk assessment of assets and to develop adaptation measures and strategies for priority assets, and Local Coastal Plan policies. This vulnerability and risk assessment will describe assets in the City and its Planning Area (PA) that are potentially vulnerable and at risk from tidal inundation or salt water intrusion. Humboldt Bay tectonically is subsiding and its average rate of relative sea level rise of 0.15 inches/year (15 inches per century) is greater than anywhere else in California. Relative sea level rise estimates have been prepared for the North Spit tide gage from 2000 to 2100, including low and high greenhouse gas emission scenarios (NHE 2014). Sea level rise elevations that exceed what currently occurs on Humboldt Bay are expected between 2030 and 2050. Sea level rise estimates include 0.9 feet of sea level rise by 2030 (8.6 feet NAVD 88), 1.9 feet by 2050 (9.6 feet NAVD 88), 3.2 feet by 2070 (11.0 feet NAVD 88), and 5.4 feet by 2100 (13.1 feet NAVD 88).

The broad classes of critical assets in the City and its PA that are at risk from sea level rise by 2100 include land uses (Coastal Dependent Industrial, Industrial, Commercial, Public, and Residential), coastal resources (agricultural lands; environmentally sensitive habitat areas, such as marine and freshwater wetlands and dunes; and cultural sites), utilities (waste water, drinking water, storm water, energy, communications, and solid waste), transportation (surface, marine, air, and rail), and open contaminated sites. Not all assets are equally important to the well-being and sustainability of a community like the City. An asset is deemed critical if there would be an immediate impact on a community if its services were impaired or lost. Critical assets in the City and PA include utilities (energy–electricity and fuel, communications–optical fiber lines and wireless for internet and telephone, municipal water, and waste water) and all transportation systems (City streets, State Highway 255, and U.S. Highway 101).

Electrical infrastructure and facilities in the City and PA include five electrical substations, overhead and underground high voltage lines, transmission towers, distribution power poles, the natural gas-powered Humboldt Bay Generating Station (HBGS), the DG Fairhaven Power Company's biomass plant, and several smaller facilities throughout the PA. In the potential mean monthly maximum water (MMMW) inundation zone for 2100 (13.1 feet NAVD 88), electrical facilities, generating stations, and sub-stations are vulnerable and at risk from tidal inundation and flooding. Rising ground water could also cause flooding of underground infrastructure. The electrical generation capacity and transmission from the HBGS has a low probability of being impacted by shoreline erosion or tidal inundation in the 2015 to 2050 planning periods. By 2070, tidal inundation of electrical equipment, facilities, and substations is a significant impact that may affect electrical transmission. Tidal inundation of electrical transmission towers and distribution poles may also impact maintenance and repairs. Current access to the HBGS via King Salmon Avenue could become tidally inundated. By 2100, large portions of the King Salmon facility are predicted to be tidally inundated, significantly impacting the HBGS. It is not known if the HBGS facility has been designed to withstand the impacts of direct tidal inundation, and whether emergency response procedures will be sufficient to safeguard employees from arc fault and additional hazards associated with high voltage electricity generation. The King Salmon electrical facilities (HBGS and Humboldt Bay substation) are less than 13.1 feet (NAVD 88) in elevation and are therefore in the predicted tidal inundation zone for 2100.

The Humboldt Bay Power Plant (HBPP), a former nuclear power site, is located at the King Salmon site in an area ranging in elevation between 9.6 to 10.9 feet (NAVD 88). Tidal inundation of this site could occur when the shoreline is overtopped. Nuclear contamination of the site could be mobilized and discharge into Humboldt Bay; however, the level of contamination is currently unknown, as decommissioning and remediation of the site has commenced. The site that contains the spent nuclear fuel rods of the HBPP is located above 14.3 feet (NAVD 88) elevation, well above the elevation of projected sea level rise for 2100, and that facility should not be impacted by tidal inundation.

In the City, there are two bulk fuel marine terminals; one is active and the other is not. Chevron's Eureka Terminal (an active terminal) is located along the bay, just north of the mouth of the Elk River Slough (property elevation less than 11 feet NAVD 88) and Tosco Eureka Terminal (inactive), located on the bay just northwest of 14^{th} Street (property elevation 10 to 12 feet). Approximately 80% of the fuel used in the City and PA is delivered via barge to the Chevron Terminal. Fuel is delivered to end use stations by truck via surface streets. Access to the property is from Truesdale Street to Christie Street, both of which are less than 11.0 feet (NAVD 88) elevation in this area. The north and eastern perimeters and northern portion of the Chevron Terminal property may become tidally inundated during MMMW of 9.6 feet (NAVD 88) predicted by 2050. By 2100, MMMW of 13.1 feet (NAVD 88) at these facilities could result in up to three feet of tidal inundation. Tidal inundation of the bulk fuel properties could cause corrosion of metal storage tanks and likely result in the degradation of water quality by petroleum products. Access and maintenance could be impacted by regular tidal inundation. The sustainability of the City and PA is currently dependent on petroleum products delivered via bulk fuel terminals but alternative energy such as electricity may reduce that dependency in the future.

Communications infrastructure and operations within the City are critical assets for daily operation of businesses, government agencies, utilities, emergency responders, educational institutions, and public and social connectivity. The communications industry is privately owned and operated; infrastructure includes underground optical fiber cables, microwave towers, AM/FM transmission towers, and cell phone towers.

Optical fiber is the most significant resource for high speed data transmission; the City and its PA are served by two major optical fiber connections. Close to half of the fiber optic cable lines in the City and over half in the PA are expected to be affected by rising sea levels by 2100. Underground optical fiber and coaxial cable lines are not likely to be impacted by tidal inundation or rising ground water. However, associated junction boxes and service connection equipment will degrade in the presence of salt water. Access, emergency repairs, and maintenance may become much more complicated and expensive when tidal inundation occurs. The loss of service provided by underground optical fiber lines along U.S. Highway 101 could be catastrophic to the City and its PA. For the 38 above-ground communications facilities in the City and PA, eight are expected to be affected by rising sea levels by 2100. Stability of communication tower footings and rates of corrosion of structural attachment members can be expected to increase with tidal inundation. Electrical equipment and connections that are not rated for exposure to a marine environment may also be compromised. There is redundancy in the number of above ground communications towers if the eight towers at risk from tidal inundation by 2100 were impaired or removed.

The drinking water systems of the City and PA are complex and interconnected, with multiple sources, delivery systems, and interties between the two systems. In the City, municipal or potable water is supplied by Humboldt Bay Municipal Water District (HBMWD). In the PA, Humboldt Community Services District (HCSD) provides potable water to a substantial portion of the area, with interconnections and agreements that make HCSD water infrastructure relevant to the City's overall water system. Municipal water supply infrastructure includes main water transmission pipelines from Arcata to Eureka, ground water wells, booster pumping stations, storage reservoirs, treatment systems, and distribution system. In the City, storage and treatment components of the water system are well above the predicted inundation areas (high tank ground elevation ±150 feet and the underground reservoir on Hemlock Street at 195 feet NAVD 88) and are not expected to be susceptible to impacts from sea level rise or flooding. In the PA, none of the HCSD storage tanks are within the predicted tidal inundation zone for 2100. the City, portions of pipeline and components of the distribution system located in the industrial and commercial areas along the Eureka Waterfront are within the projected 2100 tidal inundation zone. In the PA, by as early as 2030 the municipal water distribution system operated by HCSD in King Salmon and Fields Landing, could be tidally inundated and by 2050 the system operated by HBMWD in Fairhaven could become tidally inundated. Any impairment in providing a safe supply of drinking water would be immediately unacceptable. There are no reliable backup sources of drinking water immediately available to the City if the transmission lines between Arcata and Eureka fail. Extreme water conservation measures and quick emergency repairs would be required. The loss or impairment of the HCSD's South Bay well could result in a significant impact on the water supply in the PA.

The City owns, operates, and maintains its waste water collection system and the Elk River Waste Water Treatment Plant (WWTP) located in the City. In the PA, the HCSD owns, operates, and maintains its waste water collection system and they have purchased approximately 30% of the WWTP's current capacity to serve some of unincorporated communities through an inter-governmental agreement with the City. The WWTP, located on the shore of Elk River Slough, is greater than 15.0 feet (NAVD 88) in elevation, and therefore is not expected to be directly exposed to tidal inundation by 2100. Treated waste water effluent is discharged to the west side of Elk River Spit via an outfall. To enable periodic discharge during the ebb tide, treated waste water is retained in the effluent holding pond (elevation 6 to 10 feet NAVD 88). The effluent holding pond relies on a tide gate to keep high tides from entering the pond. As the average low tide elevations rise, the tide gates may remain submerged longer each day, resulting in effluent being trapped behind the dike, thus reducing the capacity of the pond. Rising sea levels could also reduce the effectiveness of the gravity flow discharge system, and pumping requirements, maintenance, and power costs will likely increase. The waste water collection system consists of an underground network of sewer pipes, manholes, and lift and pump stations. The City's collection system includes 125 miles of underground pipe, 1,541 manholes and 22 lift/pump stations. In the PA, there are an additional 29 sewer lift stations and 78 miles of underground pipes. The City and HCSD's collection system during storm and high tide events already has problems with I/I. Many of the urban areas in the City and PA that will be affected by sea level rise of 13.1 feet (NAVD 88) by 2100 contain waste water collection infrastructure such as lift and pump stations, manholes, and a network of sewer pipes. Some of the lift stations and manholes are expected to experience regular tidal inundation. Ground water elevations in and adjacent to these tidal inundation areas may also rise. Both of these effects may increase inflow and infiltration (I/I) of ground water and brackish water into the waste water collection system. This can, in turn, overwhelm the hydraulic and mechanical capacities of the systems and upset the biological balance of the treatment plant digesters, causing mechanical failures that could result in the release of raw sewage into surface waters. The loss of functionality of the waste water treatment plant would be devastating to the entire City. Loss of the use of sections of the waste water collection system could significantly impact the residential, commercial, and industrial users in those areas and areas upstream that are tributary to those sections of the collection system. Untreated waste water discharges to the bay or sloughs could result in the closure of commercial oyster operations and recreational uses of the bay. Such closures could result in significant loss of revenue to the fishing and mariculture industries, depending on the timing of the spills.

U.S. Highway 101 is the primary north–south transportation corridor on the northern California coast; Caltrans is responsible for the maintenance of U.S. Highway 101. There are 6.2 miles of U.S. Highway 101 in the City, 1.1 miles of which traverse low-lying diked former tidelands. In the PA, there are an additional 5.5 miles of U.S. Highway 101, 3.4 miles of which traverse low-lying diked former tidelands. U.S.

Highway 101 is vulnerable and at risk from tidal inundation if segments of protective shoreline dikes on Eureka, Fay, and Elk River Sloughs are breached or overtopped. If these protective dikes fail, U.S. Highway 101 could become a causeway with open water potentially on one or both sides. Under these conditions, the road prism could be exposed to wind-induced wave erosion and slumping from over saturation. Over time and under repeated flooding, the road base may become saturated, causing the asphalt to buckle and require resurfacing. By 2050, nearly 2 miles of the highway on Arcata Bay are vulnerable and at risk of being tidally inundated, and by 2070, nearly 3 miles. On Elk River Slough, nearly 1 mile is vulnerable and at risk of tidal inundation. By 2100, when sea level is projected to reach 13.1 feet (NAVD 88), 2.4 miles of U.S. Highway 101 in the City and 3.4 miles in the PA could be tidally inundated. Any tidal inundation of the highway on a regular basis will be a significant disruption to the use of this important transportation corridor. U.S. Highway 101 is a critical asset for the City and the Humboldt Bay region. Any interruption of service on U.S. Highway 101 would be unacceptable. U.S. Highway 101 is one of the highest priority assets to the City.

Nearly all of the critical assets in the Coastal Zone are vulnerable and at risk in the long term (2050 to 2100), as 80% of the Coastal Zone could become tidally inundated. The City only owns and controls some of the critical assets (waste water treatment facilities, sewer lines and lift stations, municipal water lines and pump stations, storm water infrastructure, streets, some waterfront and adjacent properties with docks, marina, and coastal resources). Many of the critical assets are privately owned (bulk cargo docks, bulk fuel terminal, waterfront property, natural gas transmission lines and electric distribution infrastructure, and communications facilities) or controlled by other public entities, such as Caltrans, Humboldt Bay Harbor and Recreation Conservation District, Humboldt Waste Management Authority, Humboldt State University, California Department of Fish and Game, and Wiyot Tribe). As such, the City can only control some of the critical assets within its jurisdiction.

A full discussion of each major asset class and individual assets may be found in this Appendix.

2 Urban Land Uses

The low-lying areas of the City's waterfront, bottom land on Elk River Slough, and diked former tidelands on Eureka Slough, are less than 14 feet in elevation and are vulnerable and at risk from the high projections (MMMW of 13.1 feet and MAMW of 14.1 feet NAVD 88) of relative sea level rise for 2100. By 2100, nearly 80% of the coastal zone (CZ) in the City is vulnerable to tidal inundation. By 2100, tidal inundation may even extend beyond the current CZ boundary in both the City and PA (**Error! Reference source not found.**).

Figure 1. City of Eureka and the Coastal Zone boundary (red line) and the area that is vulnerable to tidal inundation (13.1 feet) by 2100 (blue).

As described earlier in Section 2.2, all of the potential tidal inundation maps assume that the protective shoreline structures (dikes/levees, railroad grade or roadways) are not there. Given the current range in shoreline elevations, the threshold for overtopping many of the dikes is 10.0 feet (NAVD 88). Therefore, potential tidal inundation areas for 2015, 2030, and 2050 are predicated on the assumption that the shoreline structures are compromised and no longer hold back MMMW. Table 1 summarizes the CZ areas that potentially could be inundated by planning horizon, not inundated, and total area.

Table 1. Summary of Coastal Zone areas in the City and Planning Area that potentially are vulnerable and at risk from tidal inundation by 2015, 2030, 2050 and 2100, areas not vulnerable to inundation and total acreage.

COASTAL ZONE above MSL	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total Acreage
City of Eureka	1116	1282	1394	1974	480	2454
Planning Area	3440	3851	4092	5347	4852	10199

In the City there are 2,454 acres within the CZ. In 2015, approximately 45% (1,116 acres) of the CZ in the City are potentially vulnerable to tidal inundation by the MMMW tide (7.7 feet NAVD 88) (**Error! Reference source not found.**). These vulnerable lands are primarily diked former tidelands on Eureka Slough that are at risk if dikes are breached, the City's waterfront in the PALCO marsh area, low-lying diked agricultural areas adjacent to Elk River Slough, and also salt marsh areas above MSL (3.7 feet NAVD 88), particularly on the three islands. By 2030, CZ areas in the City potentially vulnerable to tidal inundation by MMMW tide (8.6 feet NAVD 88), may increase by 7% (166 acres), primarily in the waterfront area west of Broadway and north of 4th Street. By 2050, the CZ area in the City that is potentially vulnerable to tidal inundation by the MMMW tide (9.6 feet NAVD 88), may increase by 5% (112 acres). By 2100, tidal inundation in the CZ could increase significantly by 24%, meaning fully 81% (1,974 acres) of the CZ below the projected MMMW tide (13.1 feet NAVD 88) could be tidally inundated. The CZ in the PA, occupies 10,199 acres above MHW elevation and the number of acres potentially vulnerable to tidal inundation by 2100 compared to the City is 5,347 acres versus 1,974 acres.

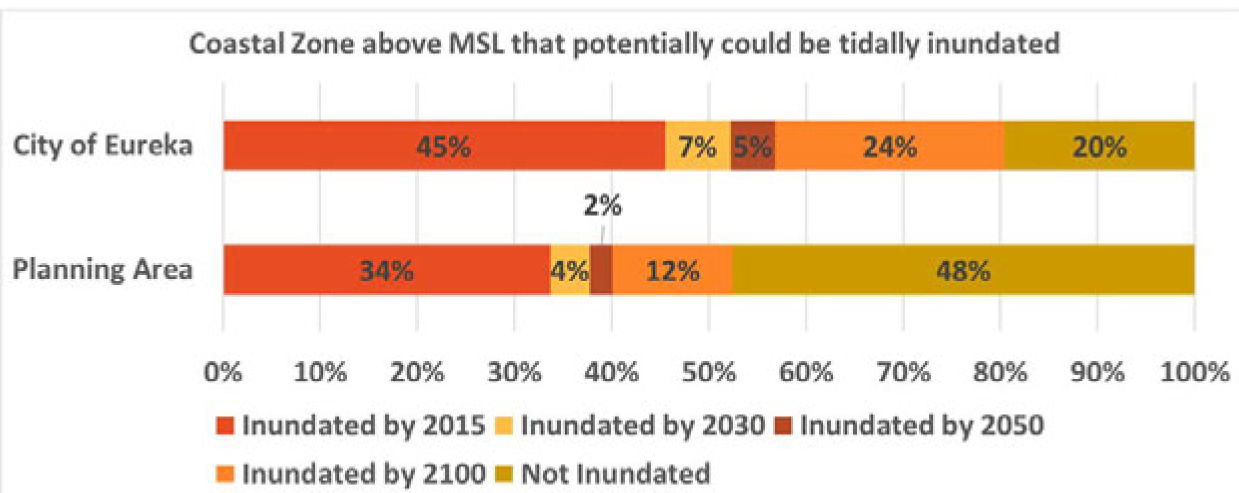

Figure 2. Extent of land above mean sea level (3.7 feet) that potentially could be tidally inundated in the coastal zone, the City of Eureka, and its Planning Area, and the area that is not likely to be inundated.

While there are more acres potentially vulnerable to tidal inundation in the PA, there is only 20% of the CZ in the City versus 48% in the PA that are not vulnerable to tidal inundation by MMMW in 2100. The percentage of the CZ in the City that is potentially vulnerable to tidal inundation beyond what is vulnerable today does not increase significantly until after 2050 when it increases 24% in area. While in the PA the area potentially vulnerable by 2100 does not increase significantly (18%) beyond what could be tidally inundated today.

There is an area that illustrates the potential vulnerability of diked lands and a variety of assets at risk now and from sea level rise that is bound by Eureka and Fay Sloughs, which are in both the City and PA (Figure 3). There are 3.3 miles of shoreline dikes on the bank of these two sloughs that prevents tidal inundation of this area, which protects U.S. Highway 101, Humboldt County’s Murray Field Airport, commercial properties west of 101, on Jacobs Avenue, Harper Motors, Indianola Road, State Fay Slough Wildlife Area, private agricultural lands and access to PG&E’s gas lines. Approximately 1.2 miles of the dikes protecting these developments and uses are rated highly vulnerable to being overtopped by 2.0 feet of sea level rise (Figure 4). The average surface elevation of the area behind these dikes is 4 to 5 feet; should the diked shoreline be breached or overtopped in 2015, this area could be subject to 3 to 4 feet of tidal inundation. By 2050, with a high projection of 1.9 feet of relative sea level rise, the MMMW would be 9.6 feet (NAVD 88) and the MAMW would be 10.7 feet (NAVD 88). Approximately 1.2 miles of dike, east of the airport, could potentially be overtopped if the dike has not been raised. Several thousand acres of diked agricultural land beyond the City on Eureka, Fay, Freshwater, and Ryan Sloughs are also potentially vulnerable to tidal inundation if the dikes are breached or overtopped and to sea level rise. In the PA, to the South of the City Elk River, Swain, and Martin Slough’s diked agricultural lands are also currently potentially vulnerable to tidal inundation if the protective earthen dikes are breached or overtopped by MAMW, 100-year extreme events, and sea level rise.

Figure 3. Eureka–Fay Slough unit (white), which is the most vulnerable area to tidal inundation at current mean monthly maximum tide elevations (7.7 feet), and City of Eureka boundary (black).

Figure 4. Eureka–Fay Slough unit shoreline vulnerability rating: red is high, yellow is moderate, and green is low.

2.1 Description

The City's waterfront, the area that abuts Humboldt Bay from Elk River Slough north to Eureka Slough, is approximately 5.9 miles in length. Based on the 1854 Township Plat maps, the area approximately west of Broadway Avenue/Summer Street from Vigo Street in the south to D Street in the north was historically salt marsh, and separated from the Eureka mainland by a tidal slough channel (Laird 2007; Figure 5).

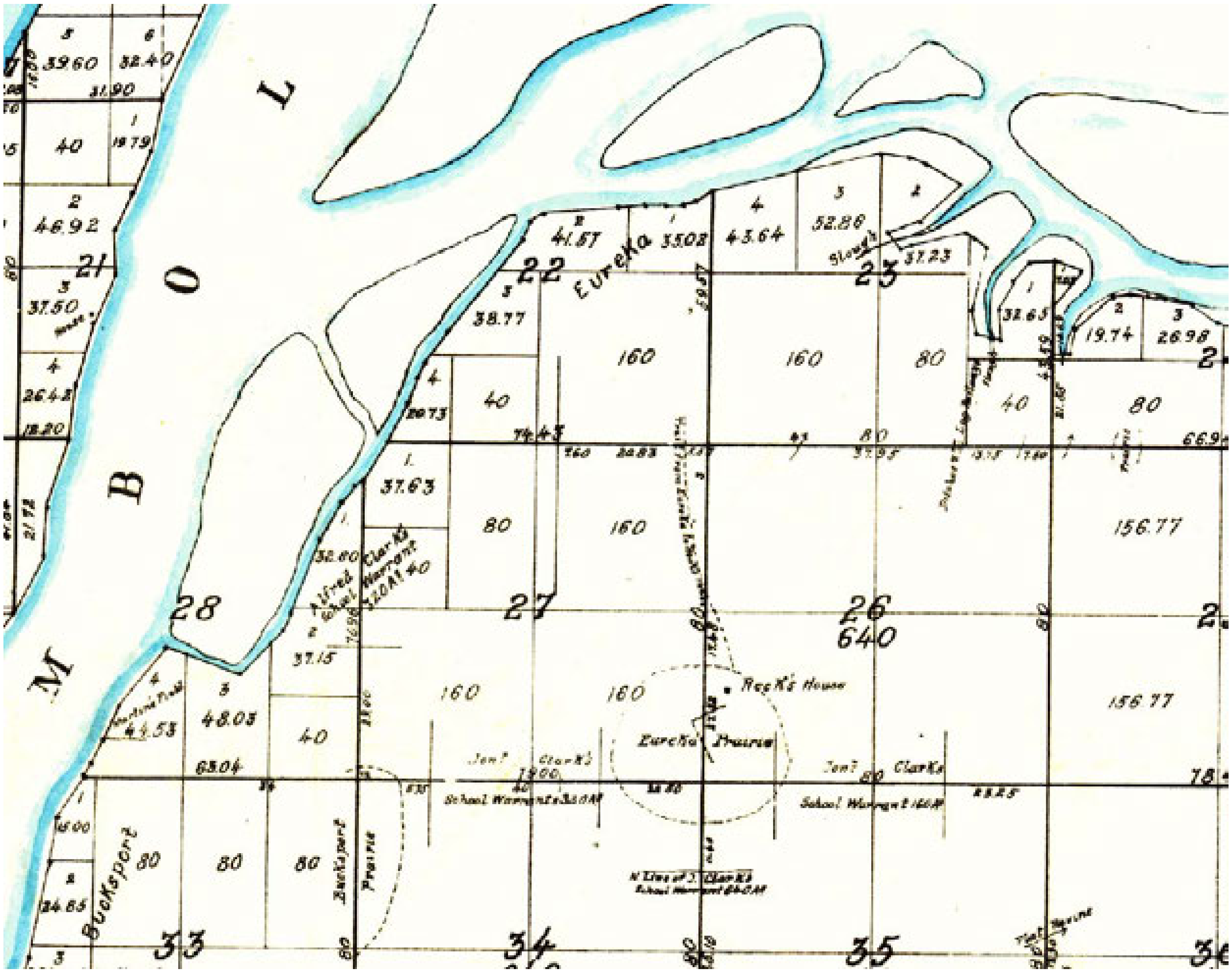

Figure 5. City of Eureka's waterfront from Bucksport to Eureka Slough based on original Township Plat (1854).

Historically, the waterfront south of Vigo Street (formerly the Bucksport area) and west of Broadway was low-lying windblown sand deposits overlaid on tidal mudflats or salt marsh (Laird 2007; Figure 5). As much as 2.6 miles of the waterfront, from Del Norte Street to T Street, was created by filling in the bay, creating an artificial shoreline. Most of the historic low-lying waterfront area surface elevation is now between 9.0 and 13.0 feet elevation.

Urban zoning classes potentially vulnerable and at risk from tidal inundation by 2100 in the City and PA are described in this section. To summarize, in the City, there are four urban zoning classes that are potentially vulnerable to sea level rise by 2100, and in the PA there are five. Figure 6 illustrates the percentage of the total area for each zoning class that is vulnerable and at risk from tidal inundation for 2050 compared to 2100, as well as the area that is not projected to be tidally inundated (Table 2). Each zoning class is described and assessed in further detail in this section.

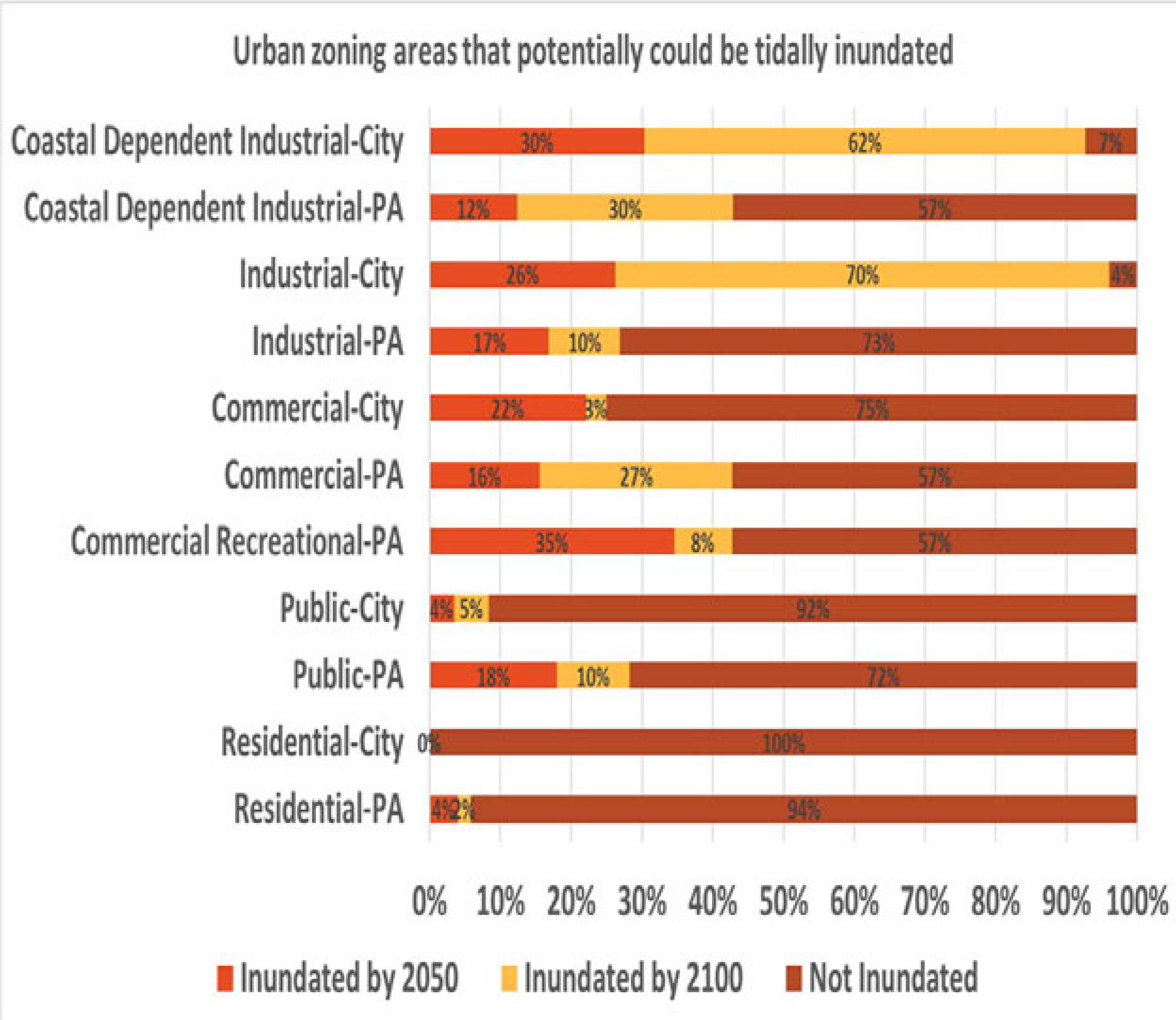

Figure 6. Urban zoning classes and percentage of total area in the City of Eureka and its Planning Area that potentially could be tidally inundated by 2050 compared to 2100 as well as the area that is not likely to be inundated.

The above bar graph shows the percentage of various zoning areas in the City and PA that are projected to be tidally inundated in the years 2050 and 2100, as well as the amount that would not be inundated. As the graph shows, a significant increase from 2050 to 2100 in the portion of both the Coastal Dependent Industrial (CDI) and Industrial zones in the City that are projected to become tidally inundated as well as cumulatively the total percentage of each zone that could be impacted. As the graph shows, sea level rise will impact these zones in the City much more significantly that in the PA. In the PA the Commercial zones by 2100 could be impacted much more than in the City. A more detailed description of urban zone tidal inundation impacts is listed in Table 2 and described below.

Table 2. Summary of Urban zoning classes and acres in the City of Eureka and its Planning Area that are potentially vulnerable to sea level rise by 2050 compared to 2100 as well as the acres that are not likely to be tidally inundated, and total acres for each zone.

Land Uses	Inundated by 2050	Inundated by 2100	Not Inundated	Total
Coastal Dependent Industrial-City	37	113	9	122
Coastal Dependent Industrial-PA	121	418	557	975
Industrial-City	47	172	7	179
Industrial-PA	99	158	429	587
Commercial-City	53	60	180	240
Commercial-PA	117	321	430	751
Commercial Recreational-PA	76	94	126	220
Public-City	13	31	339	370
Public-PA	132	208	527	735
Residential-City	0	0	2793	2,793
Residential-PA	262	378	6,144	6,522

In the City there could be a significant increase (62.3%) in the CDI zone potentially inundated from 2050 to 2100, resulting in possibly 92.6% (113 of 122 acres) of the CDI zone being tidally inundated and just 7.4% (9 acres) that may not be inundated. Similarly, in the City there could be a significant increase (69.8%) in the Industrial zone potentially inundated from 2050 to 2100, resulting in possibly 96.1% (172 of 179 acres) of the Industrial zone being tidally inundated and only 3.9% (7 acres) that may not be inundated. In the City, there is a minor (2.9%) increase in the Commercial zone that may be tidally inundated from 2050 to 2100, resulting in potentially 25% (60 of 240 acres) that could be tidally inundated but 75 % (180 acres) may not be inundated. For Public zoned areas in the City only 8.4% (31 of 370 acres) could be tidally inundated by 2100 and 91.6% (339 acres) may not be inundated. Residential zone areas are not likely to be tidally inundated by 2100.

In the PA there could be a significant increase (30.5%) in the CDI zone potentially inundated from 2050 to 2100, resulting in possibly 42.9% (418 of 975 acres) being tidally inundated but 57.1% (557 acres) may not be inundated. In the Industrial zoned areas that could be tidally inundated from 2050 to 2100 would increase just 10.1% to 27% (158 of 587 acres) and 73.1% (429 acres) may not be inundated. The area potentially inundated from 2050 to 2100 in the Commercial zone could increase 27.2% to 42.8% (321 of 751 acres) and 57.3% (430 acres) may not be inundated. Tidal inundation in the Commercial Recreational zone could increase from 2050 to 2100 by 8.2% to 42.7% (94 of 220 acres) and 57.3% (126 acres) may not be inundated. In the Public zone tidal inundation from 2050 to 2100 may increase 10.3% to 28.3% (208 of 735 acres) and 71.7% (339 acres) may not be inundated. The Residential zone from 2050 to 2100 could increase tidal inundation by just 1.8% to 5.8% (378 of 6,522 acres) but inundation of an additional 116 acres could be considered significant depending on the communities impacted even though 94.2% (6,144 acres) or the Residential zone may not be inundated.

2.1.1 Coastal Dependent Industrial

In the City, most of the CDI zoned property is located between the North Coast Railway Authority railroad and Waterfront Drive and the bay shoreline from the Elk River Wastewater Treatment Plant (WWTP) north to Marina Way. Of the 212 acres of CDI property, approximately 90 acres (42% of the CDI zoned properties) are below Mean High Water (5.8 feet) and are in fact in the bay, leaving 122 acres of upland CDI property. Approximately 1.4 miles (57%) of the CDI zoned waterfront is vacant and 1.1 miles are developed (33%). Approximately 60 acres (49%) of the CDI zoned properties above MHW are vacant. The 122 acres of CDI zoned properties above MHW elevation (i.e., the bay shoreline) range from 9.0 to 11.0 feet in elevation with just 9 acres predicted to not be inundated by 2100 (13.1 feet).

In the PA, there are 1,167 acres of CDI, but 192 acres are below MHW and are in the bay, leaving 975 acres of upland CDI property. In the PA, the CDI zoned waterfront property is approximately 4.2 miles located on the Samoa Peninsula from the Samoa Bridge south to the County's Samoa Boat Launch, of which 3.4 miles are vacant (81%). In King Salmon, there are 0.5 miles of CDI zoned waterfront where the PG&E Humboldt Bay Generating Station (HBGS) and Independent Spent Fuel Storage Installation (ISFSI; nuclear material storage) site are located. In Fields Landing, there are 1.3 miles of CDI zoned waterfront property and 1.0 miles (80%) are vacant.

2.1.2 Industrial

General and Light Industrial zoned properties are located inland and adjacent to the waterfront CDI zoned properties, west of Broadway and north of 4th Street. The industrial zoned property in the PA is located west of U.S. Highway 101 between Bracut and Eureka Slough (California Redwood Company property) and Fields Landing.

2.1.3 Commercial

In the City, the at risk waterfront commercial zoned area begins at the City's Wharfinger property, which ranges in elevation from 11.0 to 17.0 feet, and then from the C Street Dock east to Y Street, where the waterfront commercial properties range in elevation from 9.4 to 11.0 feet. Approximately, 1.0 miles (76%) of the waterfront commercial zoned properties are vacant. Other commercially zoned property at risk from tidal inundation includes Planned Shopping Commercial properties located at the Bayshore Mall and Service Commercial properties to the west and north of the U.S Highway 101 corridor (Broadway and north of the 4th/5th Streets couplet), and in the Jacobs Avenue area.

There is no waterfront Commercial zoned property in the PA, but there is Commercial zoned property in area east of U.S. Highway 101 on South Broadway and Fields Landing.

2.1.4 Commercial Recreational

The Commercial Recreational zoned property in the PA is located in King Salmon.

2.1.5 Public

In the City, the Public zoned properties abutting Humboldt Bay are the Woodley Island Marina, Humboldt County Murray Field Airport, North Coast Railroad Authority, Caltrans Highway 255, and the Elk River WWTP. Other Public zoned properties in the City are adjacent but inland of the waterfront, including North Coast Railroad Authority, Caltrans U.S. Highway 101, City Maintenance Yard, the vacant “Balloon Track,” and the Eureka Municipal Golf Course behind protective diked shoreline on Swain Slough. The WWTP is greater than 17.0 feet in elevation, but the surrounding ponds and treatment facility grounds range in elevation from 8.0 to 11.0 feet. The City’s Maintenance Yard is from 10.0 to 11.0 feet in elevation. The Balloon Track ranges in elevation from 9.0 to 13.0 feet. The Eureka Golf Course is located upstream of Fairway Drive and most of the property is less than 7.7 feet in elevation (mean maximum high tide). Woodley Island Marina is greater than 13.0 feet in elevation, with some areas close to the waterfront approximately less than 16.5 feet in elevation.

In the PA, Public zoned property abutting the bay is located on Samoa Peninsula at the County Samoa Boat Launch, in Fields Landing at the County Fields Landing Boat Launch, and on Arcata Bay on the North Coast Railroad Authority property.

2.1.6 Residential

In the City, there are no residential zoned properties vulnerable to tidal inundation by 2100. In the PA, the Residential zoned property located in areas vulnerable to tidal inundation by 2100 is located in the Indianola area east of Walker Point, Second and Third Sloughs, Martin Slough, King Salmon and east of U.S. Highway 101, Elk River east of Humboldt Hill, Fields Landing, and Fairhaven.

2.2 Exposure

Land uses on properties located on diked former tidelands are potentially vulnerable and at risk now from tidal inundation by MMMW (7.74 feet NAVD 88) if the protective shoreline structures are breached or overtopped, and from the high projections for sea level rise and extreme 100-year storm that reach or exceed 10.0 feet (NAVD 88).

Waterfront property located on fill depending on its surface elevation may be vulnerable and at risk from sea level rise and extreme 100-year storms that overtop the shoreline and tidally inundate or flood these areas.

In 2015, there are 613 acres, 190 acres in the City and in the PA 423 acres, that could be tidally inundated if shoreline structures are breached or overtopped. By 2030, there are 810 acres, 260 acres in the City and in the PA 550 acres, that could be tidally inundated if shoreline structures are breached, or by the high projection of MAMW (9.68 feet NAVD 88) or extreme 100-year storm of 10.8 feet (NAVD 88). By 2050, there could be 957 acres, 333 acres in the City and 624 acres in the PA that could be tidally inundated by the high projections for MMMW, MAMW, and the 100-year storm (9.64 feet, 10.68 feet, and 11.8 feet NAVD 88). By 2100, there are 1,953 acres 814 acres in the City and 1,139 acres in the PA, that could be tidally inundated by the high projections for MMMW, MAMW, and 100-year storm (13.1 feet, 14.14 feet, and 15.2 feet NAVD 88).

Exposure (percentage of the total area potentially tidally inundated by 2015, 2030, 2050, and 2100) for each urban land use class is described below.

2.2.1 Coastal Dependent Industrial

In the City, CDI lands that are vulnerable and at risk: now there are 12 acres, in 2030 there are 26 acres mostly west of the NCRA property and north of Truesdale Avenue, in 2050 there could be 37 acres inundated west of the NCRA property and north of Truesdale Avenue, and by 2100 113 acres west of the NCRA property and north of Truesdale Avenue that are projected to be tidally inundated (Table 3). Only 9 acres of CDI is not inundated by 2100.

Table 3. Coastal Dependent Industrial lands in the City of Eureka and its Planning Area that are potentially vulnerable now if shoreline structures fail and to sea level rise by 2030, 2050, and 2100 as well as the acres that are not likely to be tidally inundated by 2100, and total acres.

COASTAL DEPENDENT INDUSTRIAL	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total Acreage
City of Eureka	12	26	37	113	9	122
Planning Area	54	86	121	418	557	975

In the PA, CDI lands that are vulnerable and at risk: now there are 54 acres located on vacant lands south of Fairhaven and King Salmon and in Fields Landing, by 2030 86 acres could be inundated south of Fairhaven, at King Salmon and Fields Landing, by 2050 121 acres in the same communities, and by 2100 418 acres in King Salmon, Fields Landing, and on the Samoa Peninsula south of Fairhaven and east of Samoa. More than half of the CDI land in the PA will not be tidally inundated by 2100, located on the Samoa Peninsula.

Approximately 13% (121 acres) of the CDI land in the PA could be tidally inundated by 2050 compared to 62% (37 acres) of the CDI land in the City. There is a significant jump in the percentage of CDI land in the City that could be tidally inundated from 2050 to 2100, 62% (Figure 7). Just 7% of the CDI land in the City is projected to not be tidally inundated by 2100. Where as in the PA, the percentage of CDI land that could be tidally inundated from 2050 to 2100 would increase 30% but 57% (557 acres) of the CDI land is projected to not be tidally inundated by 2100, specifically located on the Samoa Peninsula.

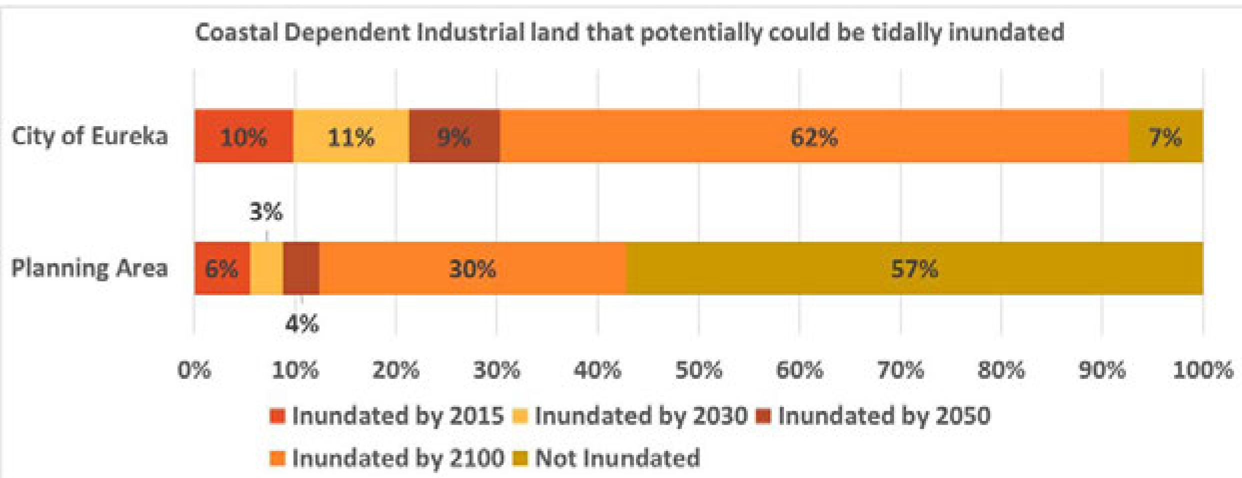

Figure 7. Coastal Dependent Industrial land and percentage of total area in the City of Eureka and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the area that is not likely to be inundated.

2.2.2 Industrial

In the City, Industrial lands are vulnerable and at risk: now there are 6 acres of Industrial zoned land, in 2030 22 acres of Industrial zoned property west of Broadway, in 2050 47 acres of Industrial zoned property west of Broadway, and by 2100 172 acres of Industrial zoned property west of Broadway (Table 4). Only 7 acres of Industrial land is not inundated by 2100.

Table 4. Industrial lands in the City of Eureka and its Planning Area that are potentially vulnerable now if shoreline structures fail and to sea level rise by 2030, 2050, and 2100 as well as the acres that are not likely to be tidally inundated by 2100, and total acres.

INDUSTRIAL	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total Acreage
City of Eureka	6	22	47	172	7	179
Planning Area	81	94	99	158	429	587

In the PA, Industrial lands that are vulnerable and at risk: now there are 81 acres of Industrial zoned land behind dikes west of U.S. Highway 101 (California Redwood Company), by 2030 94 acres of Industrial property in the same areas as now, by 2050 99 acres of Industrial property west of U.S. Highway 101 south of Bracut, and Fields Landing, and in 2100 158 acres. There are 429 acres of Industrial land in the PA that are projected to not be inundated by 2100.

In the City approximately 17% (47 acres) of Industrial land could be tidally inundated by 2050, while areas that are vulnerable and at risk increase 70% by 2100 to 83% (172 acres) (Figure 8). Just 4% of the Industrial land in the City is projected to not be tidally inundated by 2100. In the PA, 17% (99 acres) of the Industrial lands could be tidally inundated by 2050 increasing to 27% (158 acres) by 2100. But 73% (429 acres) of the PA's Industrial lands are projected to not be tidally inundated by 2100.

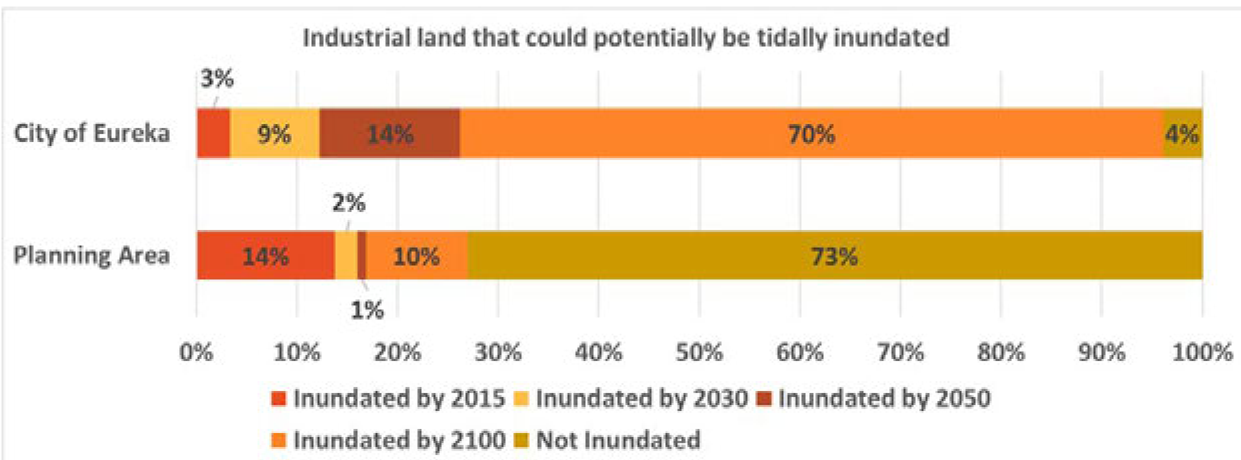

Figure 8. Industrial land and percentage of total area in the City of Eureka and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the area that is not likely to be inundated.

2.2.3 Commercial

In the City, Commercial lands are vulnerable and at risk: now there are 85 acres of behind dikes: Indianola, Harper Motors, and Jacobs Avenue, by 2030 101 acres and by 2050 117 acres could be tidally inundated, and by 2100 321 acres including 204 acres not previously inundated along the waterfront, from First Slough south to C Street and along Broadway Avenue to South Eureka (Table 5). Approximately 430 acres (57%) of Commercial land is projected to not be tidally inundated by 2100.

Table 5. Commercial lands in the City of Eureka and its Planning Area that are potentially vulnerable now if shoreline structures fail and to sea level rise by 2030, 2050, and 2100 as well as the acres that are not likely to be tidally inundated by 2100, and total acres.

COMMERCIAL	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total Acreage
City of Eureka	85	101	117	321	430	751
Planning Area	41	49	53	60	180	240

In the PA, Commercial lands that are vulnerable and at risk: now there are 41 acres of Commercial zoned property, south Broadway, by 2030 49 acres of Commercial zoned property, Fields Landing, in 2050 53 acres of Commercial zoned property east of U.S. Highway 101 on south Broadway near King Salmon, and Fields Landing, and by 2100 60 acres of Commercial zoned property. There are 180 acres that are projected to not be inundated by 2100.

In the City approximately 15% (117 acres) of Commercial land could be tidally inundated by 2050, while areas that are vulnerable and at risk increase 27% by 2100 to 43% (321 acres) (Figure 9). A significant 57% (430 acres) of the Commercial land in the City is projected to not be tidally inundated by 2100. In the PA, 22% (53 acres) of the Commercial lands could be tidally inundated by 2050 increasing to 27% (60 acres) by 2100. But 75% (180 acres) of the PA's Commercial lands are projected to not be tidally inundated by 2100.

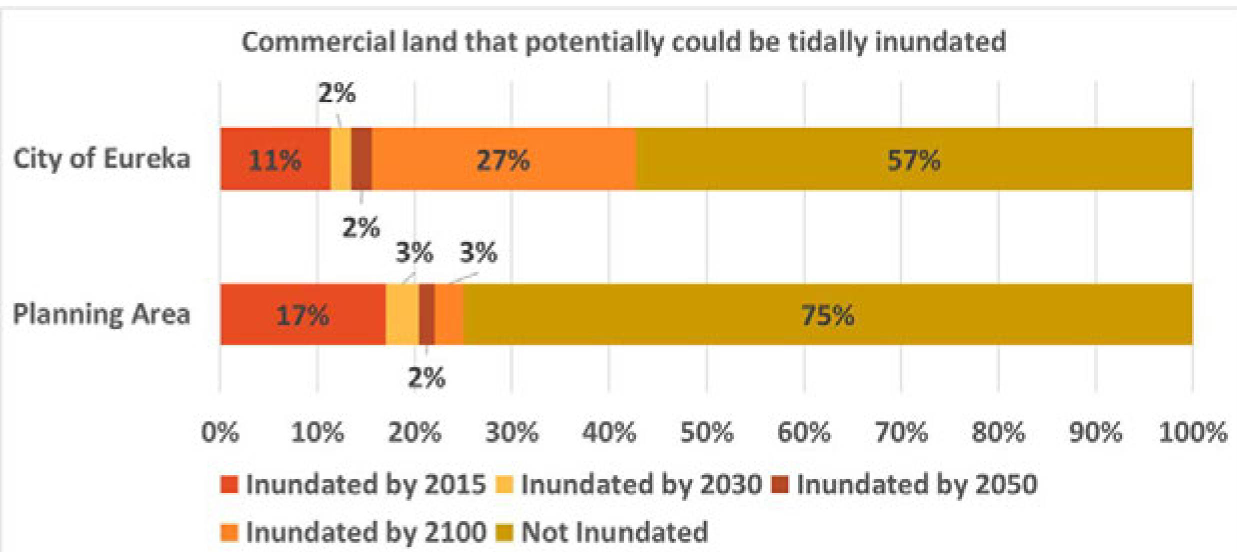

Figure 9. Commercial land and percentage of total area in the City of Eureka and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the area that is not likely to be inundated.

2.2.4 Commercial Recreational

There are 220 acres of Commercial Recreational zone that only exist in the PA, specifically in King Salmon area. There are 59 acres behind dikes located that are vulnerable and at risk now from tidal inundation if these dikes are breached or overtopped, by 2030 71 acres and by 2050 76 acres and in 2100 94 acres are projected to be tidally inundated. Approximately 126 acres (57%) of Commercial Recreational land is projected to not be tidally inundated by 2100.

2.2.5 Public

In the City, Public lands are vulnerable and at risk: now there are 87 acres located behind dikes in the Eureka–Fay Slough unit (Murray Field Airport), south of the WWTP low-lying areas on Elk River Slough, and behind dikes on Martin Slough on the Eureka Golf Course, by 2030 111 acres and by 2050 132 acres could be tidally inundated, and by 2100 208 acres of Public zoned land, including the Balloon Track and parts of the WWTP property (Table 6). Approximately 339 acres (72%) of Public land is projected to not be tidally inundated by 2100.

Table 6. Public lands in the City of Eureka and its Planning Area that are potentially vulnerable now if shoreline structures fail and to sea level rise by 2030, 2050, and 2100 as well as the acres that are not likely to be tidally inundated by 2100, and total acres.

PUBLIC	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total Acreage
City of Eureka	87	111	132	208	527	735
Planning Area	6	11	13	31	339	370

In the PA, Public lands that are vulnerable and at risk: now there are 6 acres behind dikes north of Park Avenue, by 2030 11 acres and in 2050 13 acres and by 2100 31 acres. There are 339 acres that are projected to not be inundated by 2100.

In the City approximately 18% (132 acres) of Public land could be tidally inundated by 2050, while areas that are vulnerable and at risk increase 10% by 2100 to 28% (208 acres) (Figure 10). A significant 72% (527 acres) of the Public land in the City is projected to not be tidally inundated by 2100. In the PA, 4% (13 acres) of the Public lands could be tidally inundated by 2050 increasing to 9% (31 acres) by 2100. But 92% (339 acres) of the PA's Commercial lands are projected to not be tidally inundated by 2100.

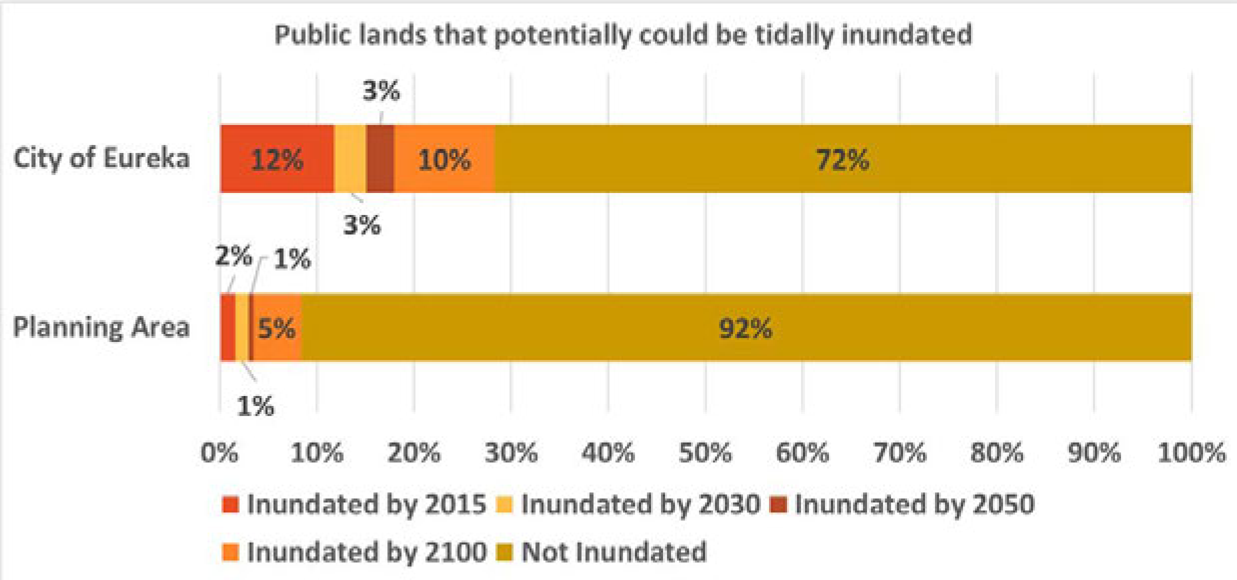

Figure 10. Public land and percentage of total area in the City of Eureka and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the area that is not likely to be inundated.

2.2.6 Residential

There are no Residential zoned lands in the City that are vulnerable or at risk from tidal inundation by 2100 based on the high projection for MMMW (13.1 feet NAVD 88). In the PA, Residential lands that are vulnerable and at risk: now there are 182 acres in: Indianola area east of Walker Point, Third Slough, Martin Slough, east of King Salmon and U.S. Highway 101, and Fields Landing, by 2030, 239 acres south of Myrtle Avenue near Pigeon Point, Martin Slough, King Salmon and Elk River east of Humboldt Hill and east of U.S. Highway 101, by 2050, 262 acres in Indianola east of Walker Point, Pigeon Point, Third Slough, Martin Slough, King Salmon and east of U.S. Highway 101, and Elk River east of Humboldt Hill, and by 2100, 378 acres in King Salmon and east of U.S. Highway 101, Elk River east of Humboldt Hill, Fields Landing, and Fairhaven (Table 7).

Table 7. Residential lands in the Planning Area that are potentially vulnerable now if shoreline structures fail and to sea level rise by 2030, 2050, and 2100 as well as the acres that are not likely to be tidally inundated by 2100, and total acres.

RESIDENTIAL	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total Acreage
Planning Area	182	239	262	378	6144	6522

In the City there are no areas that are vulnerable or at risk from tidal inundation by 2100 (Figure 11). In the PA, just 4% (262 acres) of the Residential lands could be tidally inundated by 2050 increasing to 6% (378 acres) by 2100. Most of these Residential lands reside in Fairhaven, King Salmon and Fields Landing. Projected sea level rise will likely be significant to these communities. But 94% (6,522 acres) of the PA's Residential lands are projected to not be tidally inundated by 2100 (Figure 11, Figure 12, Figure 13, Figure 14).

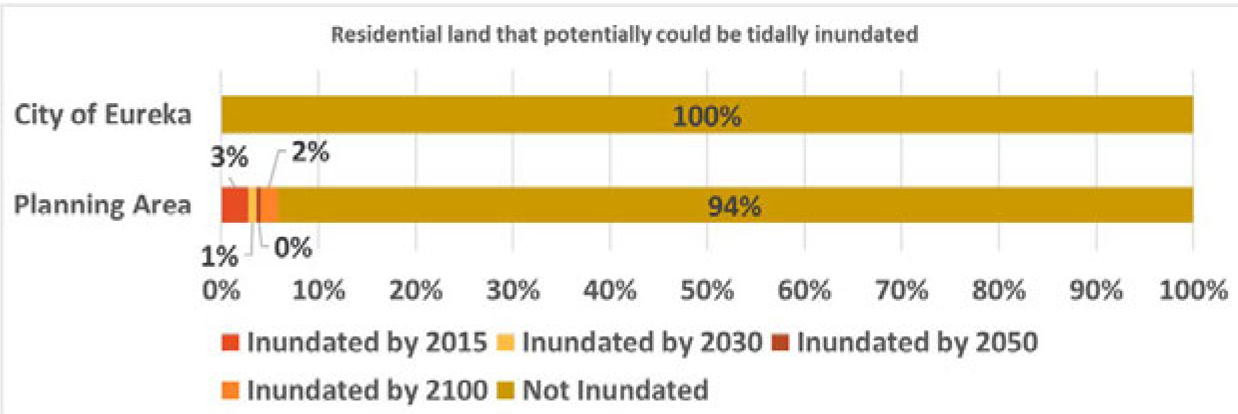

Figure 11. Residential land and percentage of total area in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the area that is not likely to be inundated.

2015

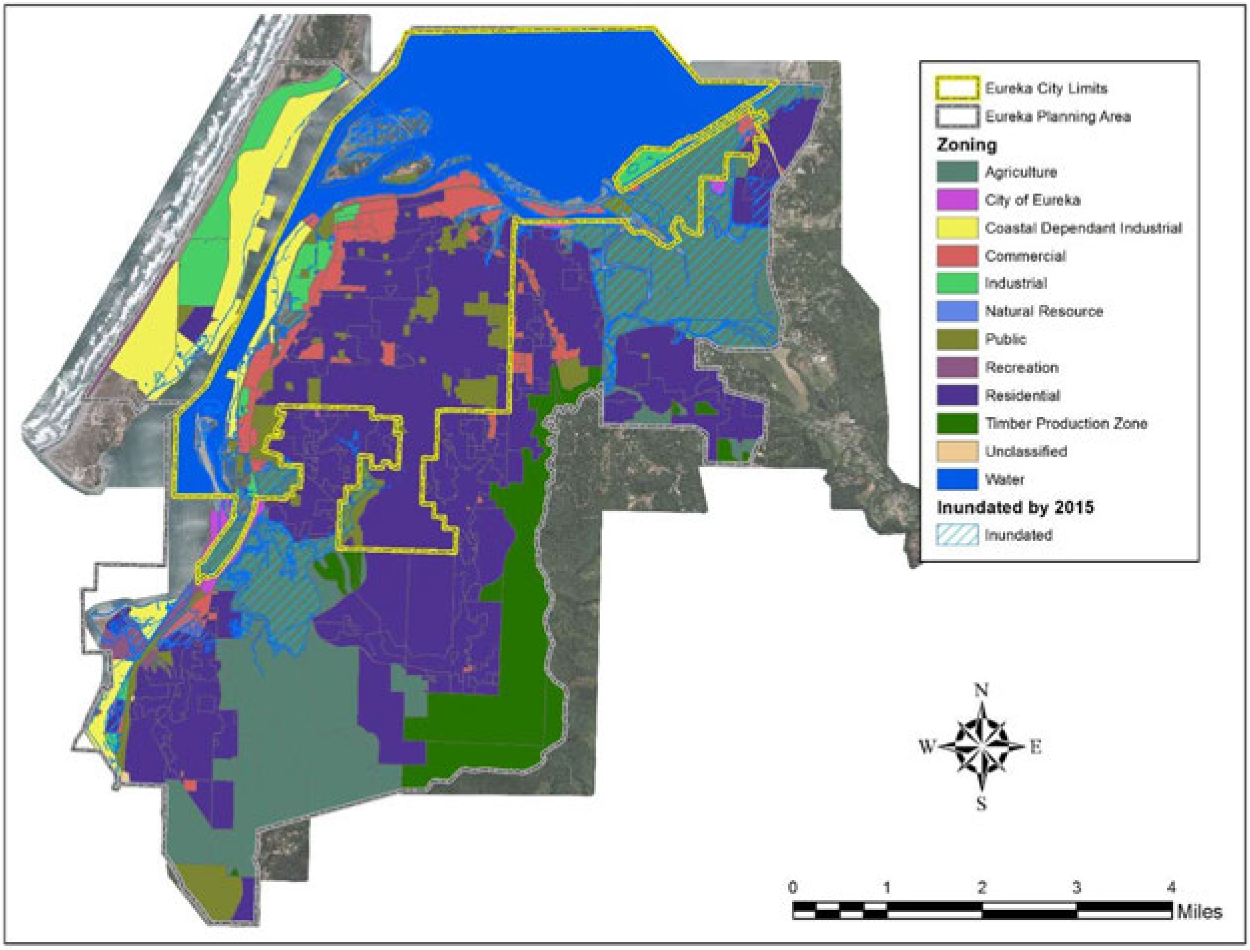

Figure 12. Areas in the City of Eureka and its Planning Area vulnerable to tidal inundation in 2015 (7.7 feet) by zoning classification.

2050

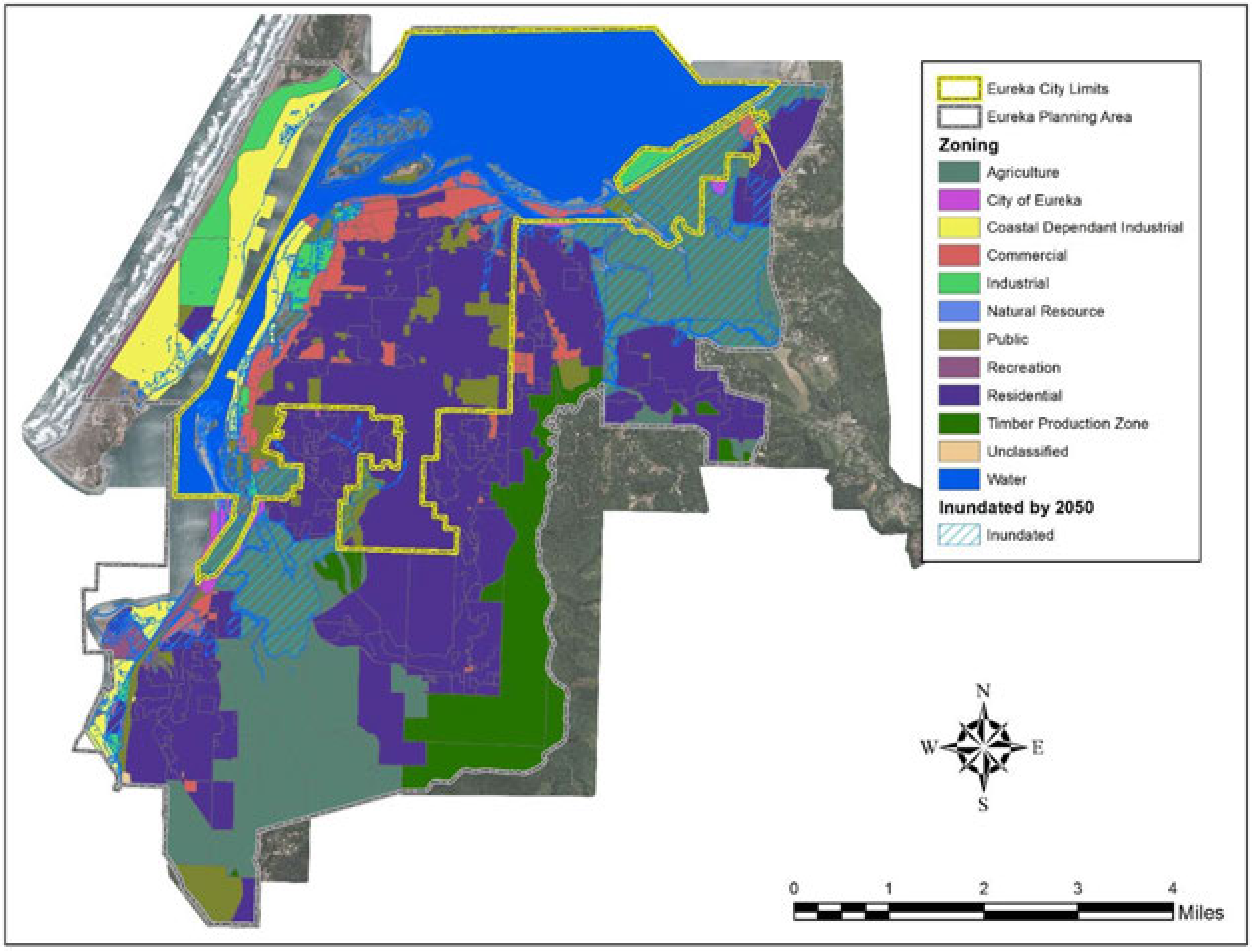

Figure 13. Areas in the City of Eureka and its Planning Area vulnerable to tidal inundation by 2050 (9.6 feet) by zoning classification.

2100

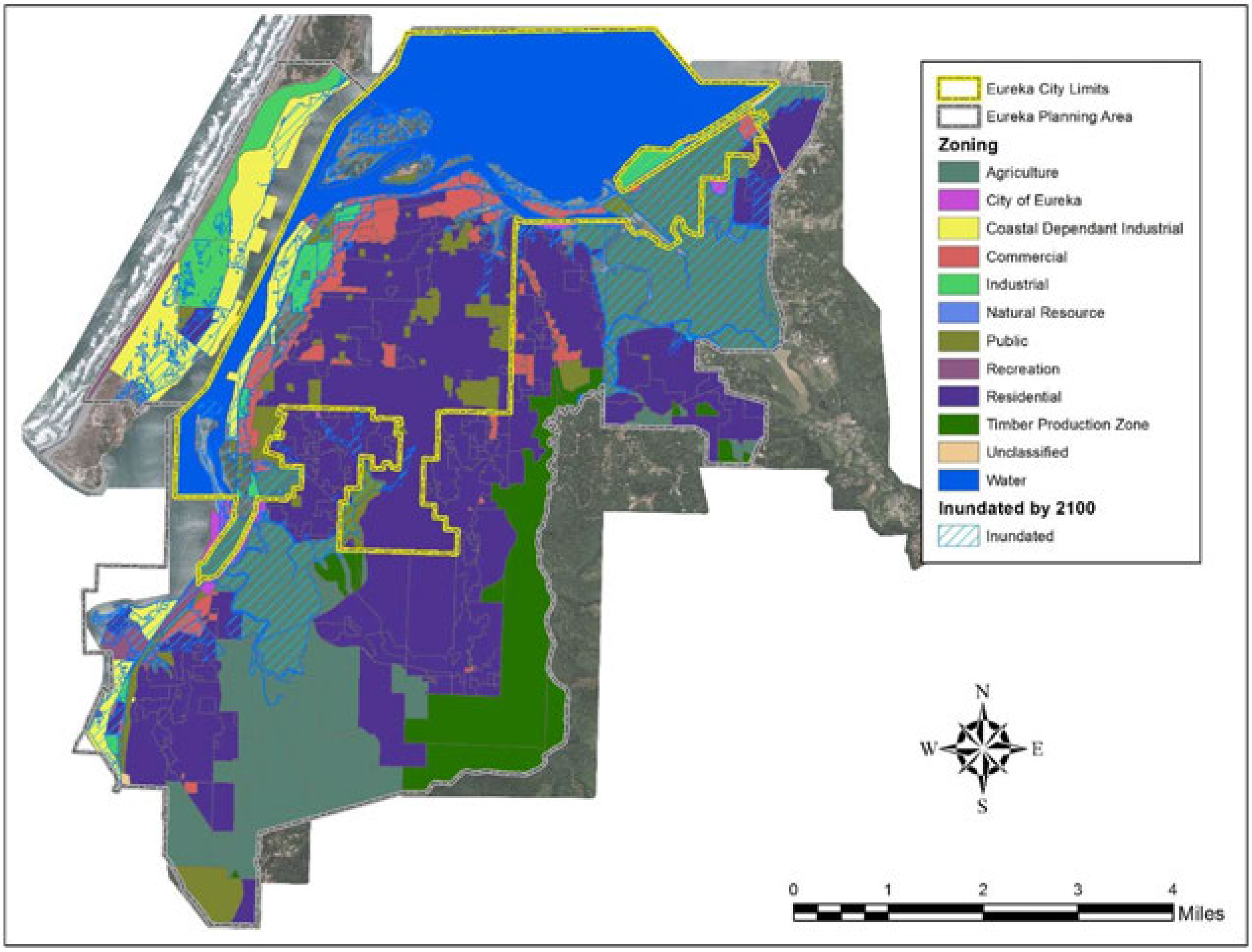

Figure 14. Areas in the City of Eureka and its Planning Area vulnerable to tidal inundation by 2100 (13.1 feet) by zoning classification.

2.3 Susceptibility

The Coastal Commission defines "susceptibility" as the degree to which a system (asset) is affected adversely either directly or indirectly by sea level rise (CCC 2015). An assets susceptibility is an element of its vulnerability to exposure and inability to cope with adverse effects of sea level rise.

Urban lands and developments, unprotected, are susceptible to a large degree to tidal inundation, salt water intrusion, and flooding. These sea level rise impacts are expected to occur to urban lands and their developments in the City and PA by 2050 and increasingly through 2100 based on projected increases in tidal elevations as result of relative sea level rise. Urban lands and their developments that are being protected now by shoreline structures like dikes could be adversely affected much sooner than 2050 by erosion and breaching that could result in the tidal inundation of urban lands and developments behind the dikes. Sea level rise is projected to overtop protective dikes and filled shorelines extensively from 2050 through 2100 that may cause tidal inundation, and saltwater intrusion. Sea level rise will also increase the elevations of extreme 100-year events (1% probability of occurring in any year), which could cause flooding of urban areas. The infrastructure (local streets) and utilities (wastewater, drinking water, electricity, natural gas, and communications) that support urban lands uses could also be adversely affected by 2050 and increasingly through 2100 by tidal inundation and flooding. If tidal inundation or flooding of urban lands and their developments is allowed to occur, they could cause these lands and developments to be abandoned.

While urban lands and developments are susceptible to sea level rise impacts they can in some locations adapt and be protected from, or accommodate, increasing tidal elevations. Adaptation measures and strategies will be explored by the City for priority assets that are vulnerable and at risk to sea level rise.

2.4 Consequence

Consequence is an element of risk combined with the likelihood of an event like sea level rise (CCC 2015). What is the likely consequence, result or effect, to the community of sea level rise impacts on an asset? The consequence to the community of the loss or impairment of an asset's functions or services is also a measure of how critical, important or significant or relevant, that asset is to the community.

What are the consequences to the community if its urban lands and developments are impaired by sea level rise? The City's urban zones and acreages that are potentially vulnerable and at risk by 2100 to sea level rise are: CDI (113 acres), Industrial (172 acres), Commercial (60 acres), and Public (31 acres) likely impacts are: tidal inundation, salt water intrusion, and flooding. In the PA urban zones and acreages that are potentially vulnerable and at risk to sea level rise by 2100 are: CDI (418 acres), Industrial (158 acres), Commercial (321 acres), Commercial Recreational (94 acres), Public (208 acres), and Residential lands (378 acres).

In the City, the potential loss of 93% of its CDI property, development, and all of its bulk cargo docks to sea level rise would be significant if its desires to continue to function as a sea port. In the PA, 557 acres of CDI zoned property with bulk cargo docks on the Samoa Peninsula would likely not be impacted by sea level rise projections for 2100. The loss of 43% of the PA's CDI zoned property would not be as consequential to the Humboldt Bay region as the City losing 93% of its CDI property would be to the City.

In the City nearly all, 96%, of Industrial zoned areas are projected to be tidally inundated by 2100. By 2050, only 17% (47 acres) of the City's Industrial zoned areas may be tidally inundated. There may be sufficient time to relocate Industrial developments, which are not coastally dependent uses before 2100. It is likely that the City would zone new areas for Industrial uses that would not be tidally inundated in 2100. The loss of the current 172 acres of Industrial zoned areas to tidal inundation by 2100 may not be significant to the City if it can find new areas to relocate its Industrial zone. In the PA, 17% (99 acres) of the Industrial lands could be tidally inundated by 2050 increasing to potentially 27% (158 acres) by 2100. However, 73% (429 acres) of the PA's Industrial lands are projected to not be tidally inundated by 2100. The loss of 27% of the Industrial zoned areas to sea level rise in the PA would not appear to be consequential to the Humboldt Bay region.

In the City, 43% (321 acres) of its Commercial zoned areas are potentially vulnerable and at risk from sea level rise by 2100. By 2100, 57% (430 acres) of the Commercially zoned areas are not projected to be tidally inundated. Similar to addressing the loss of Industrial zoned areas, if the City can find new areas to relocate its Commercially zone the projected loss to sea level rise may not be significant. In the PA, 27% (60 acres) of the Commercial zoned areas could be tidally inundated by 2100, leaving 75% (180 acres) not projected to be tidally inundated. This potential loss of Commercial areas in the PA does not seem consequential to the Humboldt Bay region.

In the City, 28% (208 acres) of Public land could be tidally inundated by 2100. All of these Public lands are located in the CZ and provide public access and recreational opportunities to Humboldt Bay. While not a significant percentage of the Public land zone is potentially vulnerable and at risk from sea level rise these lands and developments provide valuable and protected services to the general public. If the developments in these Public zoned areas cannot be relocated their loss could significant to the City and Humboldt Bay region. In the PA, only 9% (31 acres of Public zoned land may be tidally inundated by 2100, and 92% (339 acres) would still be able to provide services to the public. The loss of these 31 acres of Public zoned lands in the PA if not replaced at new locations would likely not be a consequential loss to the general public.

In the City there are no Residential zoned lands that may be tidally inundated by 2100. But in the PA, there are 6% (378 acres) that could be tidally inundated by 2100. Most of these Residential lands are located in disadvantaged communities of Fairhaven, King Salmon and Fields Landing. Projected sea level rise impacts such as tidal inundation of residential lands and salt water intrusion of underground utilities from 2050 through 2100 will likely be significant to the continued occupancy of these communities. If the housing units that are potentially vulnerable and at risk from projected sea level rise are not replaced elsewhere the quantity of affordable housing in the PA, may be reduced. The loss of these communities would be significant to their residents and to the Humboldt Bay region.

2.5 Priority

Each asset will be prioritized for the 2050 and 2100 planning horizon based on: its exposure to sea level rise impacts, susceptibility to expected impacts, and the consequence of the loss or impairment of the asset to the City, its criticality. Assets are given a priority ranking to facilitate the City in its selection of assets for development of adaptation measures and strategies.

The CDI urban zone in the City may begin to be exposed by 2050 (30%) and by 2100 92% could be tidally inundated. The CDI lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of CDI zoned areas in 2050 is not significant but by 2100 the extent of potential loss of CDI areas and developments would be consequential to the City. CDI zoned areas in the City were given a ranking of 4 by 2050 and 6 by 2100 (Figure 15).

The CDI urban zone in the PA may begin to be exposed by 2050 (12%) and by 2100 30% could be tidally inundated. The CDI lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of CDI zoned areas in 2050 is not consequential but by 2100 the extent of potential loss of CDI areas and developments would be of some consequence in the PA. CDI zoned areas in the PA were given a ranking of 3 by 2050 and 4 by 2100.

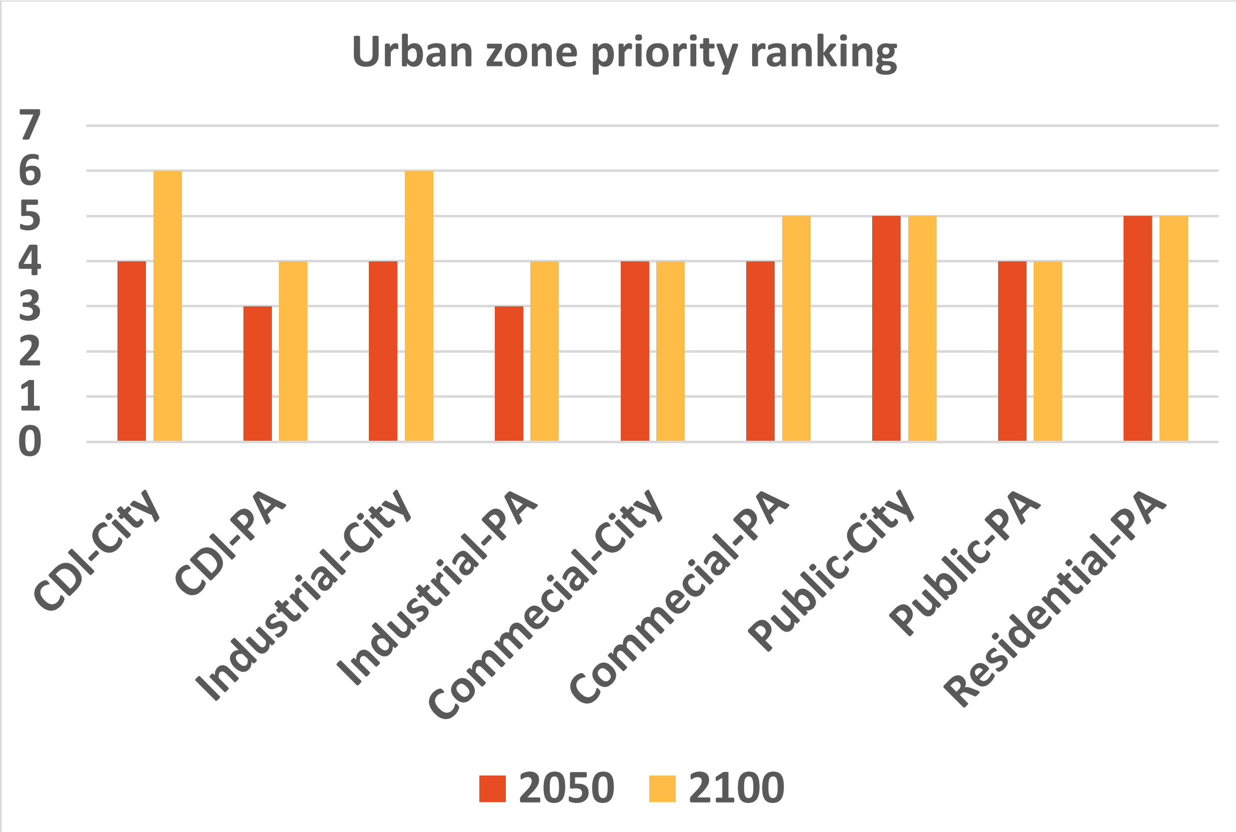

Figure 15. Priority ranking of urban zoned areas in the City and its Planning Area for 2050 and 2100 that can be used to determine priority for adaptation planning.

The Industrial urban zone in the City may be exposed by 2050 (26%) and by 2100 96% could be tidally inundated. The Industrial lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of Industrial zoned areas in 2050 is not significant but by 2100 the extent of potential loss of Industrial areas and developments would be consequential to the City. Industrial zoned areas in the City were given a ranking of 4 by 2050 and 6 by 2100.

The Industrial urban zone in the PA will begin to be exposed by 2050 (17%) and by 2100 27% could be tidally inundated. The Industrial lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of Industrial zoned areas in 2050 is likely not going to be important but by 2100 the extent of potential loss of Industrial areas and developments would be of some consequence in the PA. Industrial zoned areas in the PA were given a ranking of 3 by 2050 and 4 by 2100.

The Commercial urban zone in the City may be exposed by 2050 (22%) and by 2100 25% could be tidally inundated. The Commercial lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of Commercial zoned areas in 2050 and 2100 is not likely to be significant to the City. Commercial zoned areas in the City were given a ranking of 4 by 2050 and 4 by 2100.

The Commercial urban zone in the PA will begin to be exposed by 2050 (16%) and by 2100 43% could be tidally inundated. The Commercial lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of Commercial zoned areas in 2050 is likely not going to be important but by 2100 the extent of potential loss of Commercial areas and developments would be of some consequence in the PA. Commercial zoned areas in the PA were given a ranking of 4 by 2050 and 5 by 2100.

The Public urban zone in the City may be exposed by 2050 (4%) and by 2100 9% could be tidally inundated. The Public lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of Public zoned areas may significantly reduce coastal access by the general public in 2050 and 2100 which is likely to be significant to the City. Public zoned areas in the City were given a ranking of 5 by 2050 and 5 by 2100.

The Public urban zone in the PA will begin to be exposed by 2050 (18%) and by 2100 28% could be tidally inundated. The Public lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of Public zoned areas may significantly reduce coastal access by the general public in 2050 and 2100 which is likely to be significant in the PA. Public zoned areas in the PA were given a ranking of 5 by 2050 and 5 by 2100.

The Residential urban zone in the PA will begin to be exposed by 2050 (4%) and by 2100 6% could be tidally inundated. The Residential lands and developments are very susceptible to sea level rise impacts. The consequence of the loss or impairment of Residential zoned areas in 2050 is important and by 2100 the likelihood of potential loss of Residential areas and developments because the affected areas are disadvantaged communities would be of some consequence in the PA. Residential zoned areas in the PA were given a ranking of 5 by 2050 and 5 by 2100.

3 Coastal Resources

3.1 Description

Coastal resources are lands and resources protected from most development activities. They are located in the CZ and have been zoned by the City as Coastal Agricultural, Natural Resources, and Conservation or Development Waters. In the PA, coastal resources also include areas zoned Commercial Recreation. Coastal habitat areas that are particularly sensitive to disturbances are further considered environmentally sensitive habitat areas (ESHA). On Humboldt Bay, in the City and its PA, ESHA often contain tidal–brackish–freshwater aquatic species and wetlands, as well as easily disturbed dune and wildlife habitats. Humboldt Bay, or Wigi, is home to the Wiyot people and there are significant cultural resources around the perimeter of the bay and on its islands. While most of these cultural resources are not specifically designated Historic sites, they are nonetheless protected coastal areas. There are cultural Wiyot sites that are vulnerable and at risk from projected sea level rise. The results of the vulnerability and risk assessment of cultural sites to sea level rise will not be presented in this report. Information on these cultural sites is available from the City or Wiyot Tribe on request. Public access to Humboldt Bay along with its shoreline is another important and protected coastal resource.

In the City, a large portion of the coastal resources (agricultural lands 91% and freshwater wetlands 89%) are located in low-lying areas that are less than 14 feet (NAVD 88) in elevation and are potentially vulnerable and at risk to tidal inundation from projected relative sea level rise by 2100. Dune habitat areas are at risk from shoreline erosion as it is projected that sea levels may rise by 5.4 feet through 2100. In the PA, most coastal resources (agricultural lands 46% and freshwater wetlands 84%) are also located in low-lying areas that are less than 14 feet (NAVD 88) in elevation and are potentially vulnerable and at risk to projected relative sea level rise elevations for 2100.

3.1.1 Agricultural Lands

In the City, Agricultural zoned property is located primarily on Eureka Slough in an area bound by Eureka–Fay Sloughs, and an area off of Elk River Slough. The agricultural zoned properties along Eureka–Fay Sloughs are former tidelands that were diked off more than a century ago. There are approximately 3.3 miles of shoreline dikes protecting this area. Agricultural uses are principally permitted on lands zoned Agricultural Exclusive or Coastal Agricultural. Approximately 1.2 miles of the shoreline along Eureka-Fay Sloughs are rated highly vulnerable to erosion or overtopping and are susceptible to breaching (Figure 16). A significant portion of the diked agricultural lands along Eureka–Fay Sloughs also support seasonal freshwater emergent wetlands in the winter and spring, which are ESHA owned by California Department of Fish and Wildlife (DFW) who manages the area as a wildlife reserve where agricultural grazing practices are employed.

In the PA, Agricultural zoned properties are located on Eureka and Elk River Sloughs. The agricultural zoned areas in Eureka Slough area are also on diked former tidelands that are primarily privately owned. In the PA, there are 11 miles of diked shoreline on Eureka Slough protecting agricultural lands. These diked former tidelands also support seasonal freshwater emergent wetlands in the winter and spring. The low-lying Elk River bottom land is also zoned for Agricultural uses and DFW has a wildlife reserve unit on these agricultural lands as well. While much of Elk River bottom land is not former tidelands, it was formed by riverine alluvial deposits, it is nonetheless diked (2.9 miles) and potentially vulnerable and at risk today to tidal inundation, most likely as a result of the nearly 18 inches in relative sea level rise the area has experienced this last century. The diked floodplain and bottom land of Elk River also supports seasonal freshwater emergent wetlands.

3.1.2 Environmentally Sensitive Habitat Areas

In the City, there are three rural land use zones: Agricultural, Natural Resources, and Water areas to the west, south and north of the urban core. Within the City, there are also three islands in Humboldt Bay: Woodley, Duluwat (Indian), and Daby. The islands are predominately zoned Natural Resources with the exception of an area on Woodley Island, where dredged sediment was placed as fill. The filled area is now zoned Public Facility/Marina and is owned by the Humboldt Bay Harbor, Recreation and Conservation District.

As described earlier, diked former tidelands used for agriculture also support seasonal freshwater emergent wetlands, ESHA, in the winter and spring. In the City, most of the Agricultural zoned property and seasonal freshwater emergent wetlands are owned by DFW and the City. Most of the Natural Resource zoned lands in the City are also publicly owned (by the City and Humboldt Bay National Wildlife Refuge) and support environmentally sensitive habitat areas such as inter-tidal wetlands and salt marsh. The City also owns the unique landform known as Elk River Spit with its beach, dune, riparian, submergent freshwater wetland, and inter-tidal wetland habitats. In the PA, Natural Resource zoned lands are also predominately publicly owned and support dune habitats located on Samoa Peninsula (Bureau of Land Management), southern portion of Elk River Spit, and in King Salmon (HBHRCD), with one area of restored inter-tidal wetlands (salt marsh) on Freshwater Slough (HBHRCD). The City has zoned its state granted lands in Humboldt Bay Conservation Waters located roughly north of the Samoa Bridge and Development Waters south of Samoa Bridge. In the PA, Commercial Recreational lands with a wetlands overlay are located in King Salmon.

There are five types of wetland/aquatic environmentally sensitive habitat areas that occur in the City and its PA which are potentially vulnerable and at risk from tidal inundation (Table 8). The largest area that is potentially vulnerable and at risk from tidal inundation are freshwater emergent wetlands (3,265 acres), which are seasonal in nature. The U.S. Fish and Wildlife wetland delineation maps (2013) of the PA depict a 12.6-acre area at the end of Fay Slough as freshwater pond, when in fact it is diked former tidelands that was breached by king tides in 2010 and since has converted to inter-tidal wetlands.

Table 8. Environmentally sensitive habitat areas acreage potentially vulnerable and at risk from tidal inundation by 2100 in the City of Eureka and its Planning Area.

Environmentally sensitive habitat areas	CITY	PA	Total
Estuarine/marine wetlands	378	469	847
Freshwater emergent wetlands	513	2,752	3,265
Freshwater forest/shrub wetlands	122	289	411
Freshwater pond	11	32	43
Riverine	18	49	677
Coastal dune	47	58	105
Total	**1,089**	**3,649**	**4,738**

3.2 Exposure

3.2.1 Agricultural Lands

Agricultural lands in the City and PA protected by earthen dikes are not being tidally inundated. Agricultural lands in the City and PA are potentially vulnerable and at risk now to tidal inundation if the protective earthen dikes are breached or overtopped. Compounding the vulnerability and risk of these lands to tidal inundation is the nearly 1 foot of tectonic subsidence that has occurred on Humboldt Bay since these lands were originally diked in the 1890s. Many segments of dikes protecting agricultural lands in the City are not fortified and susceptible to erosion.

Agricultural lands in the City and PA are currently protected from tidal inundation by earthen dikes built on the shoreline of Eureka and Elk River Sloughs. The integrity of these dikes is currently threatened by bank erosion and overtopping during MAMW tides (8.78 feet NAVD 88) and 100-year storms (9.99 feet NAVD 88). Currently, there are 7.2 miles (50%) of dikes on Eureka Slough (Figure 16) and 2.7 miles (93%) on Elk River Slough (Figure 17) that are rated highly vulnerable to erosion and breaching or being overtopped by extreme tides and storms that exceed 9.7 feet (NAVD 88). If these dikes were to be breached, potentially all of the agricultural lands behind the compromised dikes could become tidally inundated. Rising tides and extreme storms may overtop existing dikes unless their elevations are increased. Rising tidal elevations and continual subsidence may also adversely affect drainage, resulting in the agricultural lands remaining saturated for longer periods of time. Rising ground water elevation in response to rising tidal elevations could cause vegetative conversions from pasture grasses to submergent and emergent wetland species. Productivity of these agricultural lands as measured in animal units per acre may decline with increased frequency and duration of soil saturation. Tidal inundation or salt water intrusion could make these agricultural lands unsuitable for grazing.

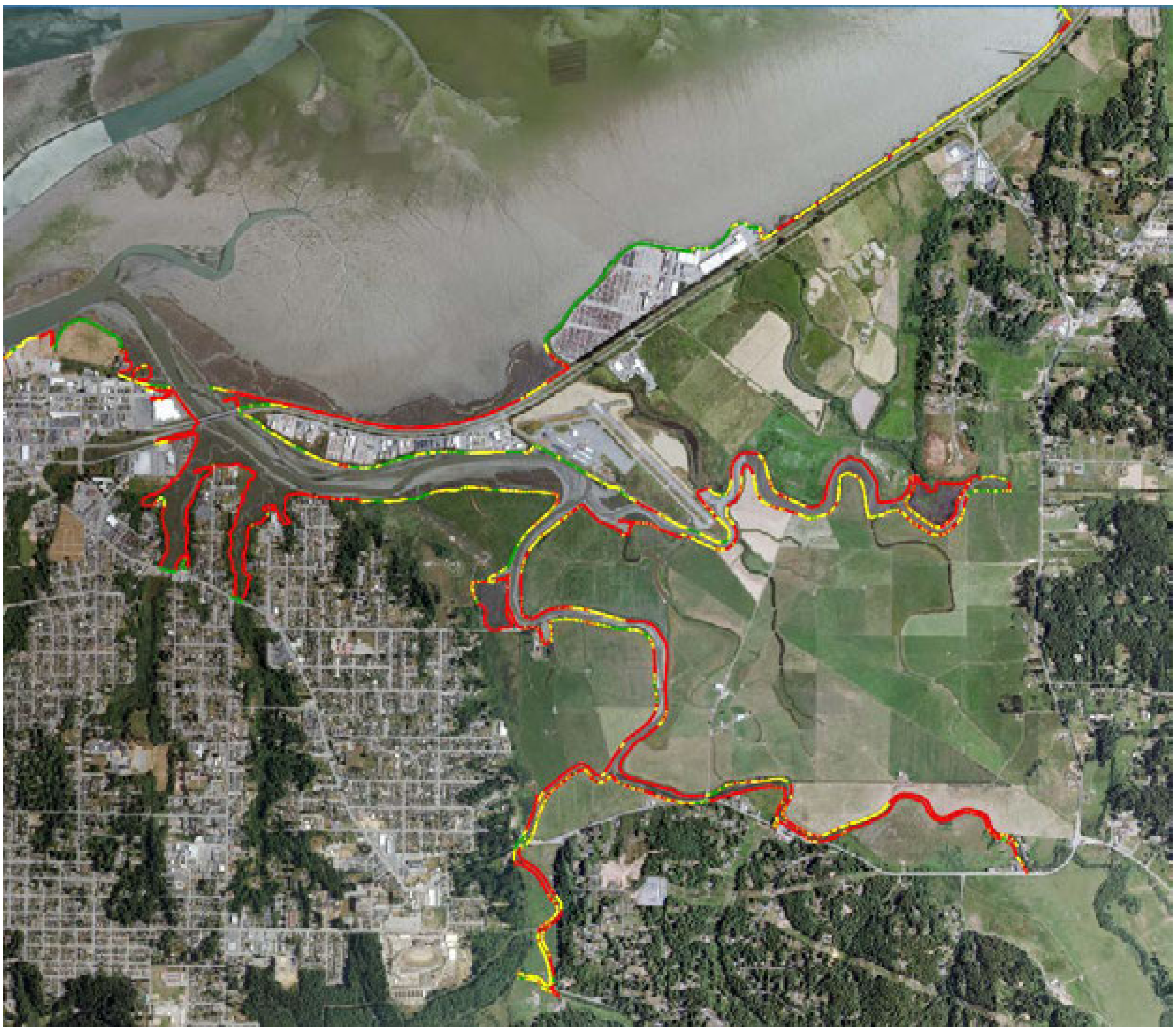

Figure 16. Eureka Slough (including Fay, Freshwater, and Ryan Sloughs) unit shoreline vulnerability rating: red is high, yellow is moderate, and green is low.

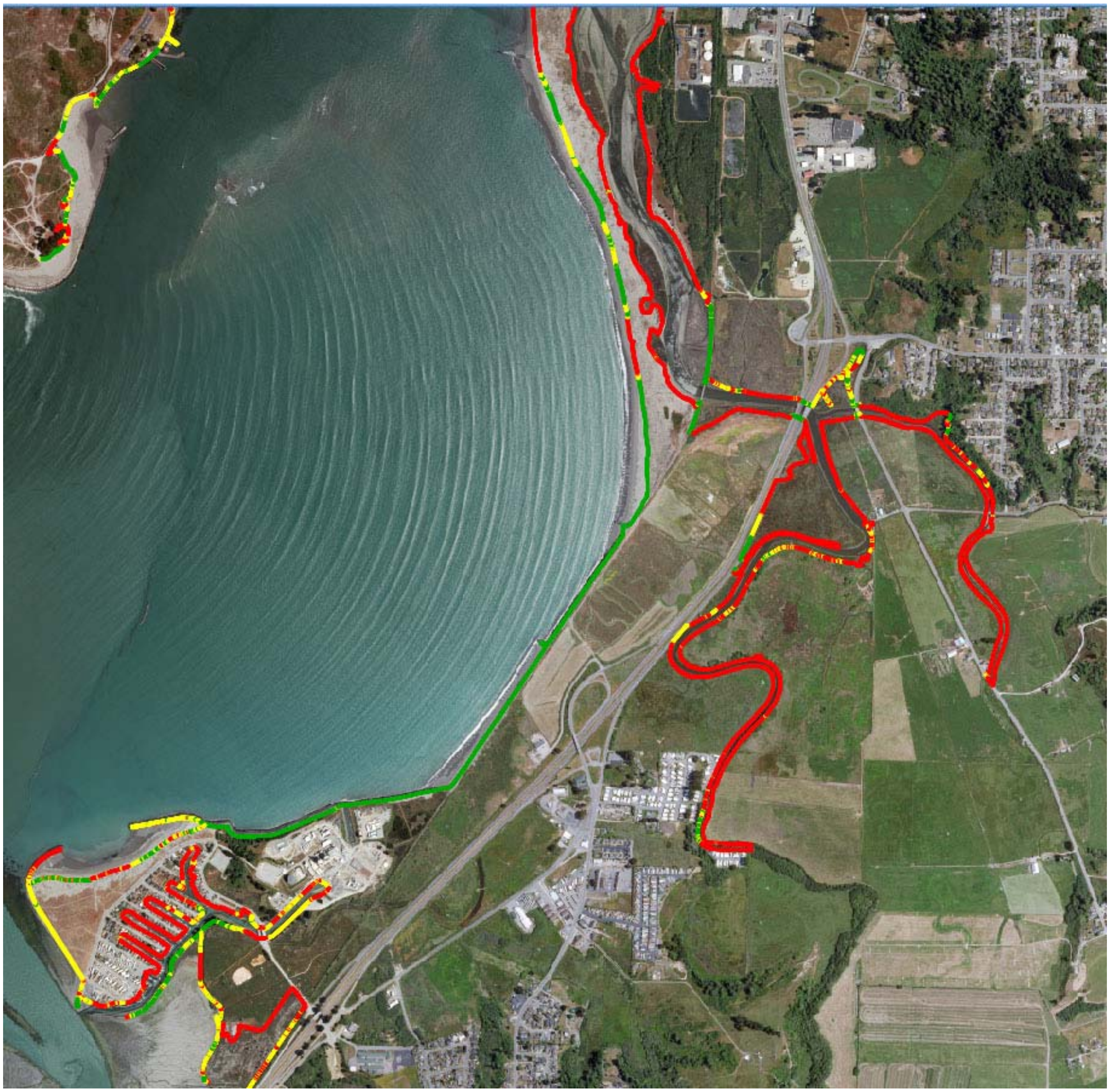

Figure 17. Elk River Slough unit (including Swain Slough) shoreline vulnerability rating: red is high, yellow is moderate, and green is low.

In the City, 88.2% (546 acre) of the agricultural lands potentially are vulnerable and at risk of being tidally inundated by the high projection for MMMW in 2050 (9.64 feet NAVD 88) and 91.9% (569 acres) by 2100, leaving 8.1% (50 acres) that are likely to not be inundated (Figure 18). In the PA, 43% (2,007 acres) of the agricultural lands potentially are vulnerable and at risk of being tidally inundated by the high projection for MMMW in 2050 and 46.4% (2,164 acres) by 2100, leaving 53.7% (2,511 acres) that are likely to not be inundated (Table 9).

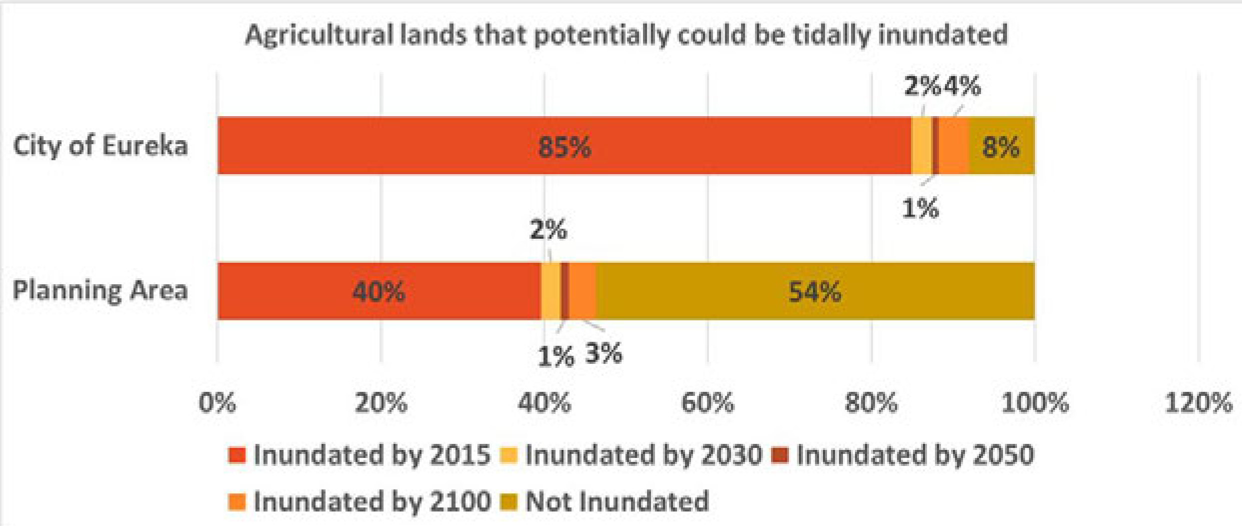

Figure 18. Agricultural lands and percentage of total area in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the area that is not likely to be inundated.

Table 9. Cumulative acreage of agricultural lands potentially vulnerable and at risk from tidal inundation in the City of Eureka and its Planning Area, total acreage and area likely not tidally inundated.

AGRICULTURAL LANDS	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total Acreage
City of Eureka	526	541	546	569	50	619
Planning Area	1849	1960	2007	2164	2511	4675

2015

In 2015, the diked shoreline protecting agricultural lands in the City is currently higher than MMMW of 7.7 feet (NAVD 88), but they are potentially vulnerable and at risk in a few locations from MAMW of 8.8 feet (NAVD 88). In the City, if dikes were breached or overtopped now, potentially most of the agricultural land (85%, 526 acres) could be vulnerable and at risk from tidal inundation (Figure 19). Currently in the City, there are 1.2 miles of dikes that are rated highly vulnerable either to breaching from shoreline erosion (0.8 miles) or being overtopped (0.4 miles) if extreme tides and storm surges exceed 9.7 feet (NAVD 88) and 100-year storms (9.99 feet NAVD 88), which is just 2 feet above the current MMMW elevation (Figures 19 and 20).

In the PA, all of Eureka, Freshwater, Fay, and Ryan Slough channels are diked and virtually all of the former tidelands in these areas are potentially vulnerable and at risk from tidal inundation if the shoreline is breached or overtopped (**Error! Reference source not found.**). Mean monthly maximum tides of 7.7 feet (NAVD 88) could overtop a few segments (689 feet) of diked shoreline on Eureka Slough, but MAMW of 8.8 feet (NAVD 88) could overtop 0.4 miles. On Elk River Slough, approximately 0.4 miles of dikes are potentially vulnerable and at risk from tidal inundation if the dikes are overtopped by MMMW of 7.7 feet (NAVD 88) and 1.5 miles by MAMW of 8.8 feet (NAVD 88) (Figures 19 and 20). In 2015, approximately 2,164 acres (46.4%) of the agricultural land in the PA is potentially vulnerable and at risk from tidal inundation (Figure 22).

Currently, in Eureka, Freshwater, Fay, and Ryan Sloughs, there are 6.0 miles of dikes that are rated highly vulnerable to either breaching due to shoreline erosion (4.0 miles) or being overtopped (2.0 miles) if extreme tides and storm surges exceed 9.7 feet (NAVD 88) (**Error! Reference source not found.**). In Elk River Slough, nearly all (93%) of the dikes on the lower reaches of Elk River and Swain Sloughs are rated highly vulnerable to either to breaching from shoreline erosion (0.5 miles), or being overtopped (2.2 miles) if tides or storm surges exceed 9.7 feet (**Error! Reference source not found.**).

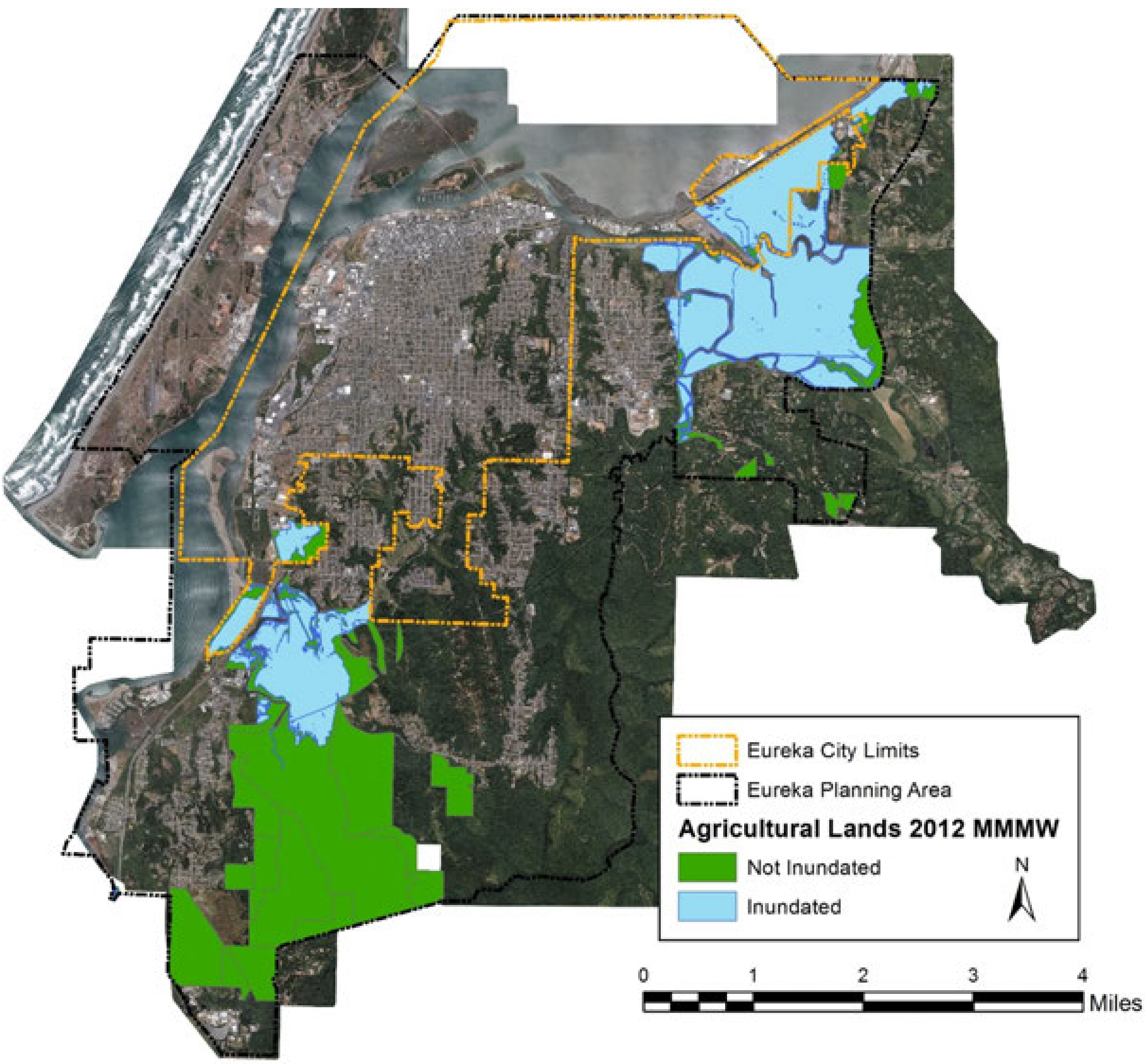

Figure 19. Agricultural lands in the City of Eureka and its Planning Area that could be tidally inundated if dikes are compromised in 2015 by mean monthly maximum tides of 7.7 feet (NAVD 88).

2030

In the City by 2030, MMMW elevations based on the high projection could increase to 8.6 feet (NAVD 88) and potentially overtop approximately 0.1 miles of dikes, if dike elevations are not raised. By 2030, MAMW elevations based on the high projection could rise to 9.7 feet (NAVD 88), and 0.4 miles of dikes could be vulnerable and at risk of being overtopped. Approximately 541 acres, which is 87.4% of the agricultural land in the City, could be tidally inundated if the dikes are compromised.

In the PA, MMMW could potentially overtop dikes on approximately 1.3 miles (0.2 miles on Eureka Slough and 1.1 miles on Elk River Slough), if dike elevations are not raised. By 2030 MAMW could rise to 9.7 feet (NAVD 88) and potentially overtop 2.0 miles of dikes on Eureka Slough and 2.2 miles on Elk River Slough. Approximately 1,960 acres, which is 42% of the agricultural land in the PA, could potentially be tidally inundated (Figure 20).

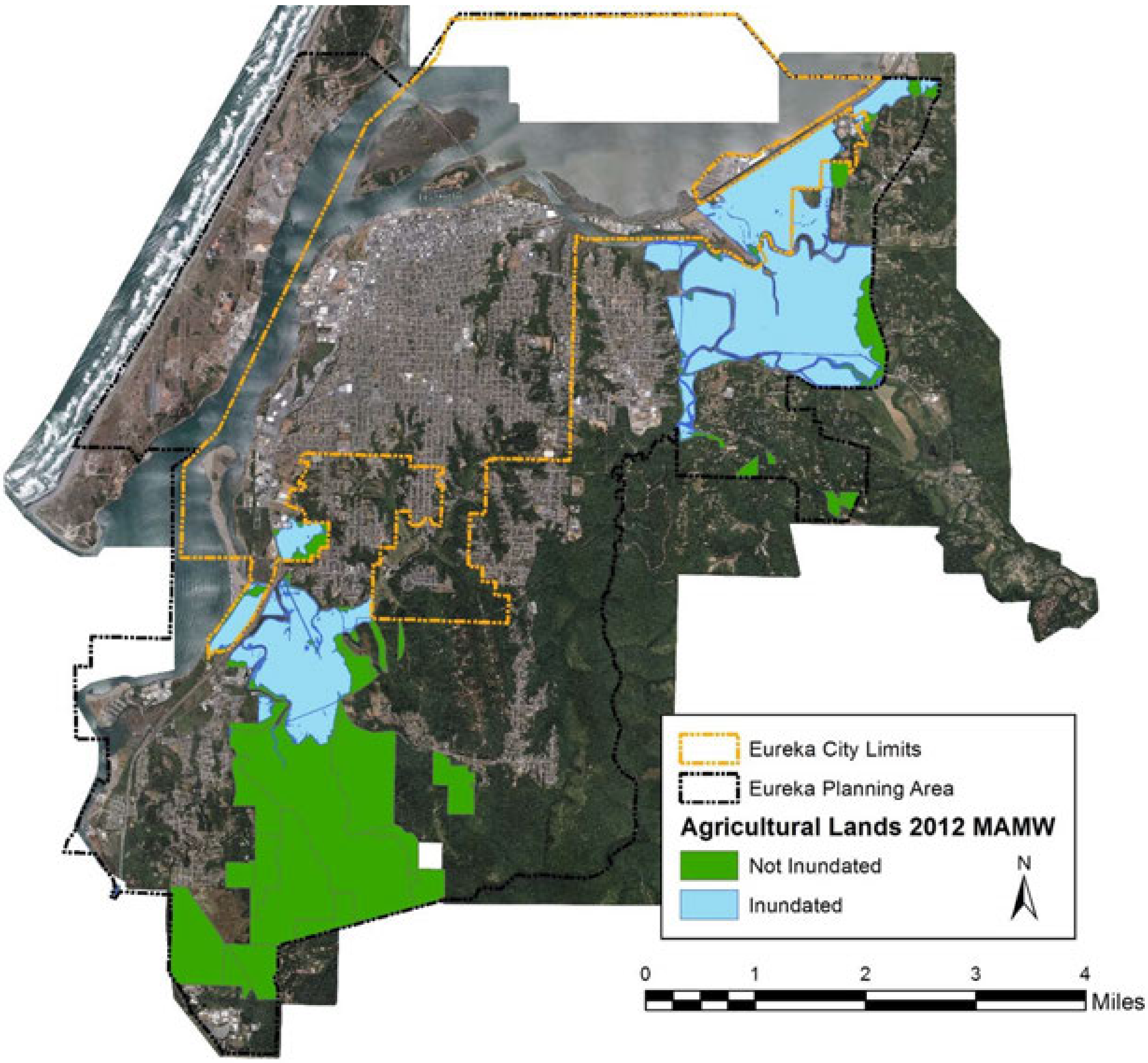

Figure 20. Agricultural lands in the City of Eureka and its Planning Area that could potentially be tidally inundated by 2030 by mean monthly maximum tides of 8.6 feet (NAVD 88).

2050

By 2050 in the City, MMMW could increase to 9.6 feet (NAVD 88) based on the high projection and 0.4 miles of dikes would be at risk of being overtopped. Mean annual maximum tides could rise to 10.7 feet 9NAVD 88), which could potentially overtop approximately 2.5 miles of dikes (76%) in the City, if dike elevations are not raised. Approximately 546 acres, which is 88.2% of the agricultural land in the City, could potentially be tidally inundated if the dikes are compromised. Mean low tides are also projected to increase by as much as 1.9 feet by 2050, which may reduce drainage capacity of these diked lands even if their shorelines remain intact.

In the PA, MMMW could make 2.0 miles of dikes potentially vulnerable and at risk of being overtopped. Mean annual maximum tides could rise to and potentially overtop 4.4 miles of dikes. The combined length of dikes overtopped in the City and PA could be 6.9 miles (48%) of dikes on Eureka Slough and 2.7 miles (92%) on Elk River Slough. By 2050, 2,007 acres (43%) of agricultural lands in the PA could be vulnerable and at risk from tidal inundation (Figure 21).

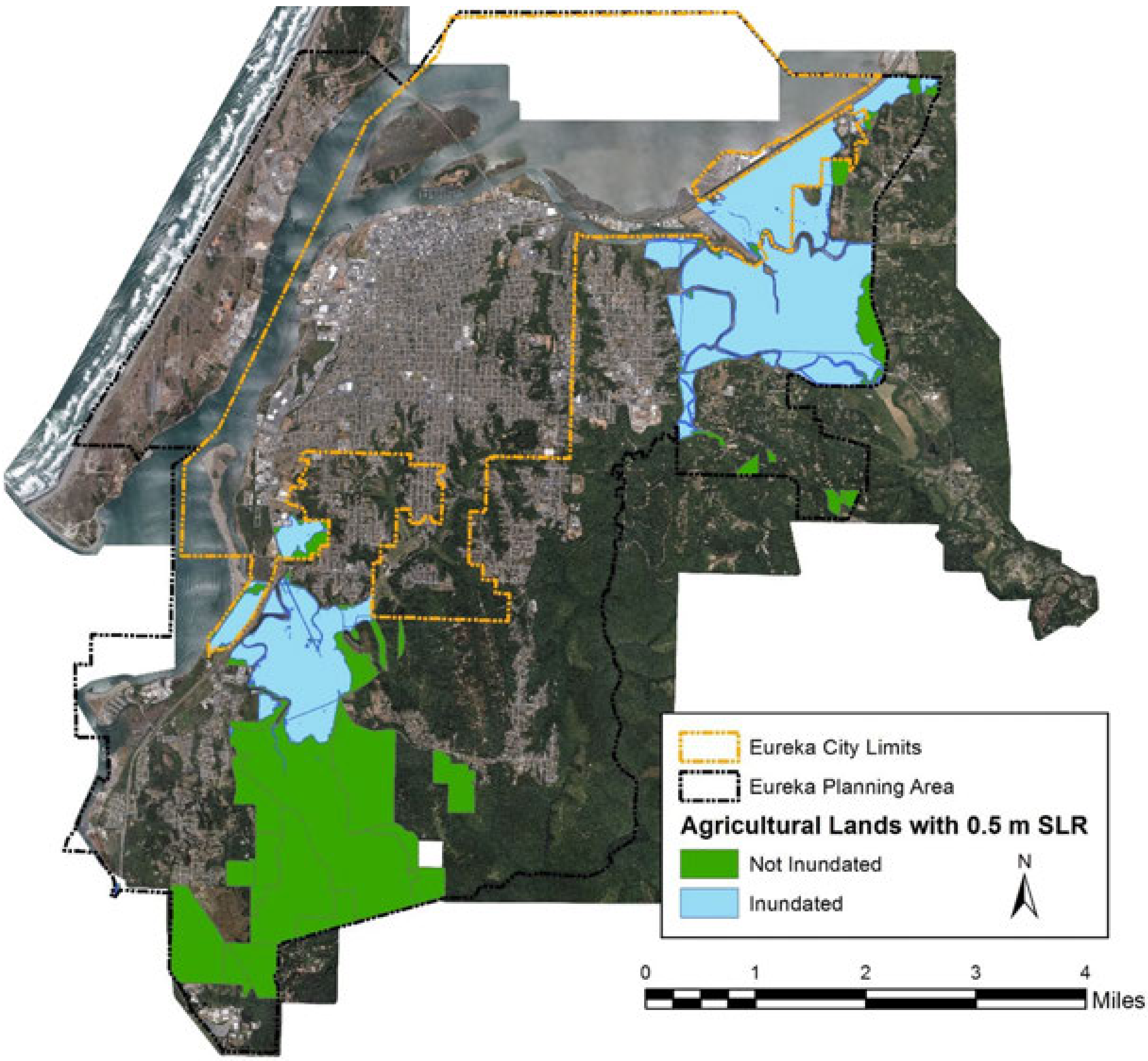

Figure 21. Agricultural lands in the City of Eureka and its Planning Area that could potentially be tidally inundated by 2050 by mean monthly maximum tides of 9.6 feet (NAVD 88).

2070–2100

By 2070 in the City, MMMW could increase to as high as 10.9 feet and to 13.1 feet (NAVD 88) by 2100. By 2070, 75% of the dikes could potentially be overtopped along Eureka–Fay Sloughs and all of the dikes there could be overtopped by 2100 (Figure 22). In the City, approximately 569 acres, 91.9% of its agricultural land could be vulnerable and at risk of being tidally inundated.

In the PA by 2070, 6.9 miles of Eureka Slough's dikes could be overtopped, and by 2100, 14.0 miles (97%), if dike elevations are not raised. On Elk River Slough by 2070, 2.9 miles of dikes could be overtopped and 100% by 2100. Low tides could increase 3.2 feet by 2070, which may greatly impair drainage of these diked lands. By 2100, 2,164 acres (46.4%) of Agricultural zoned property in the PA could be tidally inundated, and 5.4 feet of sea level rise may result in salt water intrusion of these diked agricultural lands, making them unfit for grazing (Figure 22).

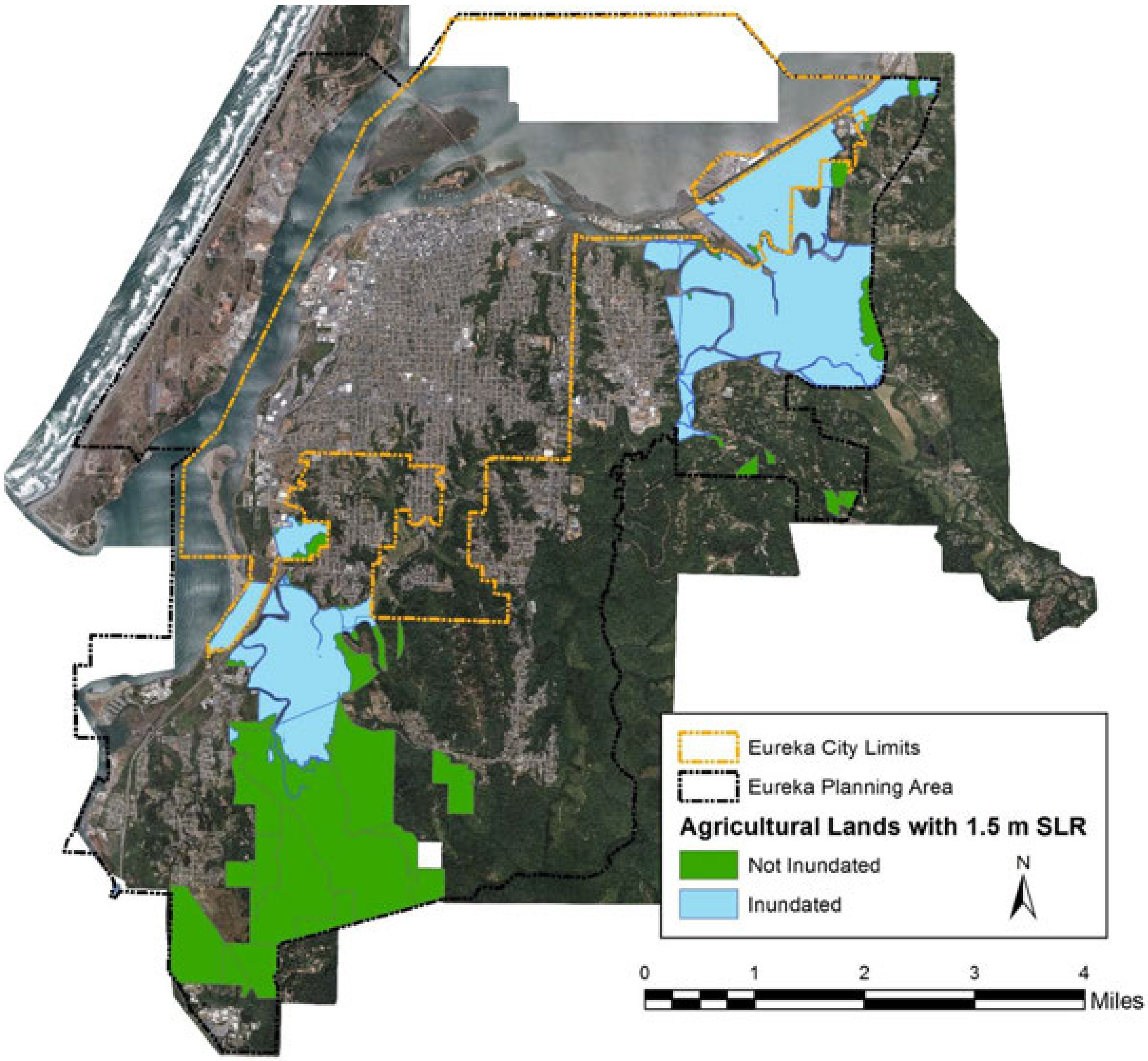

Figure 22. Agricultural lands in the City of Eureka and its Planning Area that could potentially be tidally inundated in 2100 by mean monthly maximum tides of 13.1 feet (NAVD 88).

3.2.2 Environmentally Sensitive Habitat Areas

The 847 acres of estuarine and marine wetlands on Arcata Bay and the three islands are vulnerable to wave induced erosion. But it is important to note that nearly all of the estuarine and marine wetlands (salt marsh), particularly the areas currently below MMMW of 7.7 feet (NAVD 88), are potentially vulnerable and at risk of "drowning" by rising tides projected to reach up to 5.3 feet by 2100. Salt marsh habitat on Duluwat and Daby Islands have nowhere to migrate. All of the other salt marsh areas in the City and PA are essentially surrounded by high ground or artificial structures such as railroad grades and U.S. Highway 101, and also have nowhere to migrate with rising tidal elevations. Salt marsh that is not able to migrate to higher elevations may start to drown and convert to mudflat after 2050, when the high projections for sea level rise rates are expected to accelerate faster than the rates of accretion necessary for salt marsh to stay in place.

By 2050, nearly all of the freshwater aquatic/wetland ESHA in the City, 96% (498 acres) and in the PA 85% (2,615 acres) are potentially vulnerable and at risk from being tidal inundated (Figure 23), which will cause a conversion of freshwater wetlands to salt water wetlands. These ESHA are predominantly located on diked former tidelands, which are currently potentially vulnerable and at risk from tidal inundation as a result of shoreline erosion or overtopping breaching the dikes. By 2100, in the City 98.8% and the PA 89.4% of the freshwater aquatic/wetland ESHA potentially could be tidally inundated. Only 6 acres in the City and 326 acres of freshwater aquatic/wetland ESHA could possibly avoid tidal inundation by 2100 (Table 10). Again, this exposure is a consequence of the fact that these wetlands are located behind earthen dikes that are potentially vulnerable and at risk from breaching and overtopping resulting tidal inundation of the lands currently being protected.

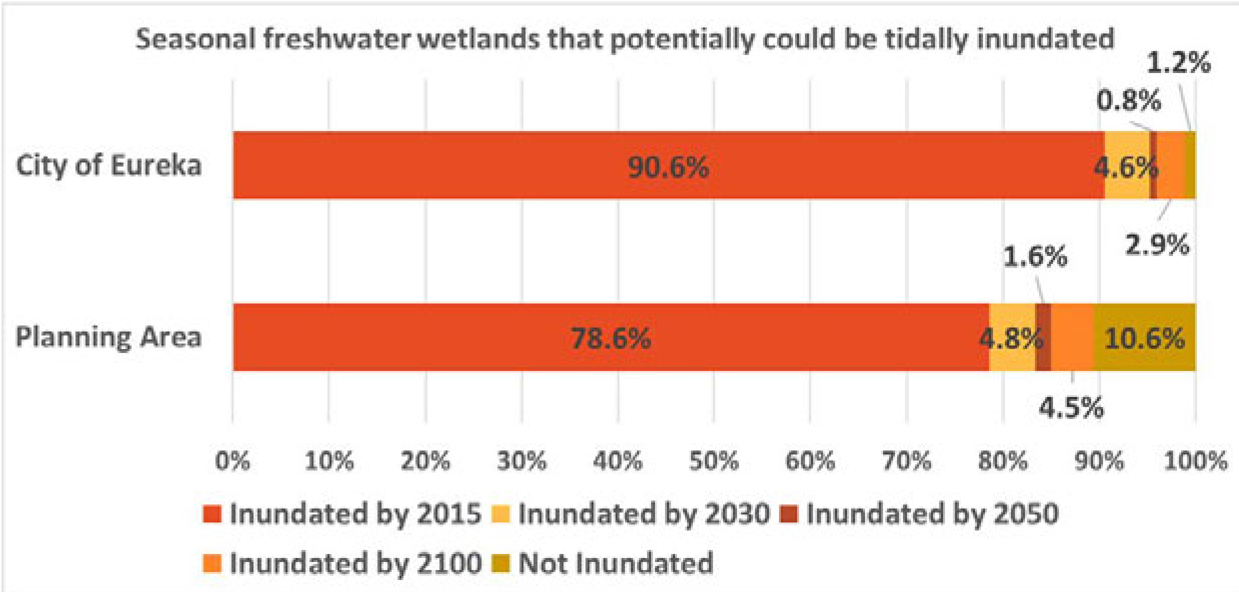

Figure 23. Seasonal freshwater wetlands (ESHA) percentage of total area in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the area that is not likely to be inundated.

Table 10. Cumulative acreage of freshwater wetlands potentially vulnerable and at risk from tidal inundation in the City of Eureka and its Planning Area, total acreage and area likely not tidally inundated.

FRESHWATER WETLANDS	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total Acreage
Planning Area	2,418	2,565	2,615	2,752	326	3,078
City of Eureka	470	494	498	513	6	519

The unique beach and dune ESHA on the west shore of Elk River Spit are at risk from shoreline erosion and retreat, as well as tidal inundation from 5.3 feet of projected sea level rise by 2100 and 100-year storms that could reach 15.2 feet (NAVD 88). These ESHA and the Elk River Spit itself may also be adversely impacted if the supply of sand or circulation of sediment in the bay is altered by sea level rise.

2015

In 2015, the City, the majority of the freshwater wetlands are on diked former tidelands along the banks Eureka and Fay Sloughs. These ESHA are currently potentially vulnerable and at risk of being tidally inundated if the dikes are breached by erosion or overtopped (Figure 24). There are 1.2 miles of dikes that are rated highly vulnerable either to breaching from shoreline erosion (0.8 miles) or being overtopped (0.4 miles) if water elevations exceed 9.7 feet (NAVD 88), just 2 feet above MMMW (7.74 feet NAVD 88). If the diked shoreline protecting these freshwater ESHA are not breached or overtopped, then these ESHA could persist until conditions change. There are 358 acres of estuarine/marine wetlands on the three islands, Second Slough, and along the NCRA railroad in Arcata Bay that are exposed to erosive wave energy from MAMW tides (8.78 feet NAVD 88) and extreme 100-year storms (9.99 feet NAVD 88).

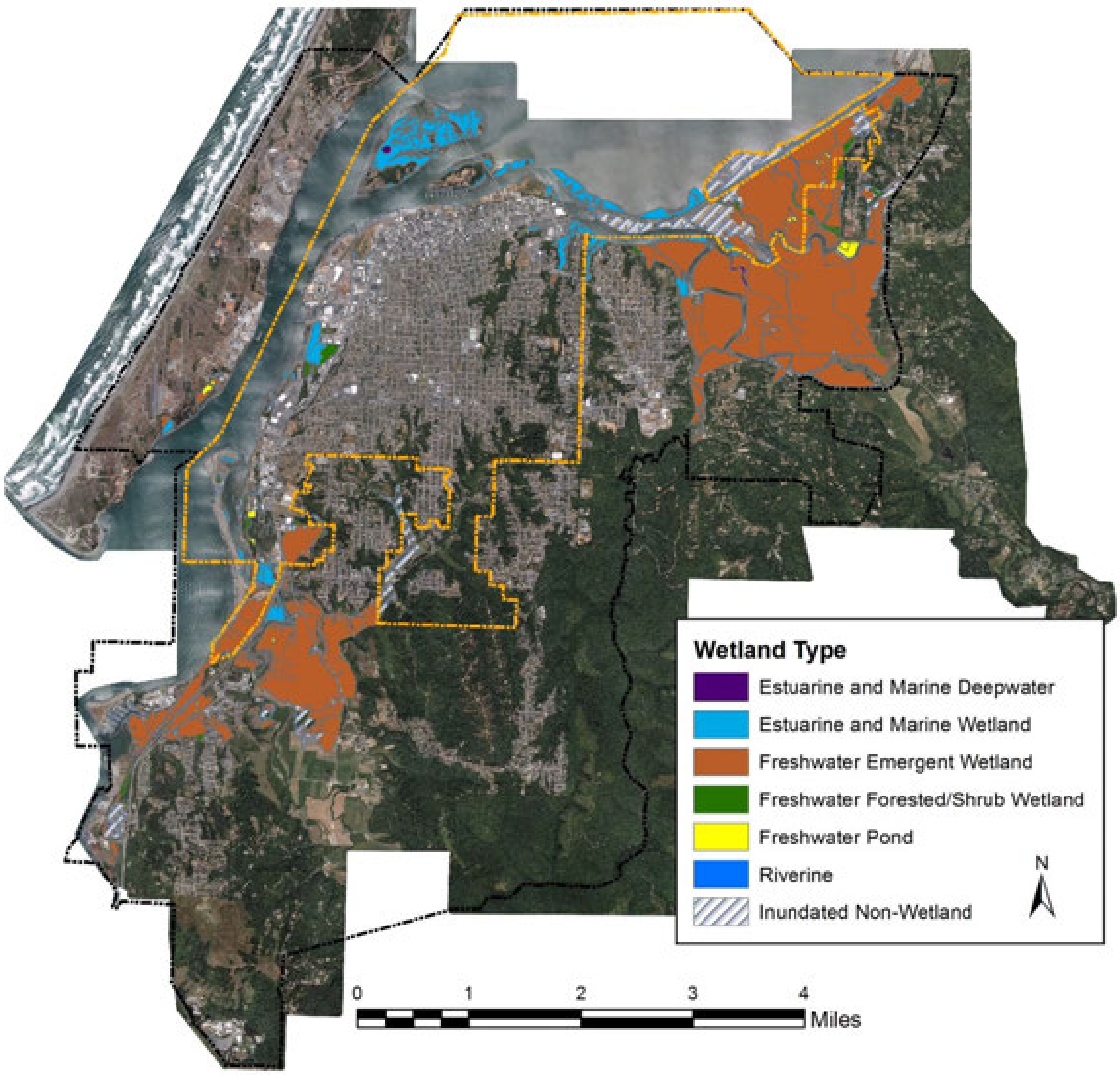

Figure 24. Environmentally sensitive habitat areas in the City of Eureka and its Planning Area that could potentially be tidally inundated if dikes are compromised in 2015 by the mean monthly maximum tide of 7.7 feet (NAVD 88).

In the PA, 2,418 acres of seasonal freshwater emergent wetlands (79%) located on diked former tidelands in Eureka Slough (Eureka, Fay, Freshwater and Ryan Sloughs) and Elk River Slough (Elk and Swain Sloughs). Similar to the City, these ESHA are vulnerable and at risk now from being tidally inundated if the dikes are breached by erosion or overtopped (Figure 24). On Eureka Slough, there are 0.4 miles of dike are vulnerable to being overtopped by MAMW (8.78 feet NAVD 88), and 2.4 miles by 2 feet of sea level rise. On Elk River Slough, there are 1.5 miles of dike vulnerable to being overtopped by MAMW, and 2.2 miles by 2 feet of sea level rise. In the Elk River, nearly 1 foot of valley tectonic subsidence over the last century has made the area more vulnerable to tidal inundation. There are 2.1 miles of natural shoreline (un-diked) that is at risk of being overtopped by a MAMW (8.78 feet NAVD 88), and 2.6 miles by 2 feet of sea level rise. The freshwater ESHA on Elk River Slough are potentially vulnerable and at risk now. There are also 437 acres of estuarine/marine wetlands at risk on Third Slough and Elk River Slough exposed to erosive wave energy during MMMW of 7.7 feet (NAVD 88).

2030

In the City by 2030, there are only an additional 24 acres of seasonal freshwater emergent wetlands and 32 additional acres of riparian areas potentially vulnerable and at risk from a high projection of 0.9 feet of sea level rise, MMMW could rise to 8.6 feet (NAVD 88). There are also 11 additional acres of estuarine/marine wetlands and 13 additional acres of coastal dunes potentially vulnerable and at risk from sea level rise (Figure 25, Table 10).

In the PA, there are an additional 147 acres of seasonal freshwater emergent wetlands and 53 additional acres of riparian areas potentially vulnerable and at risk from tidal inundation. There are also 17 additional acres of estuarine/marine wetlands and 15 additional acres of coastal dunes potentially vulnerable and at risk from sea level rise (Figure 25, Table 10).

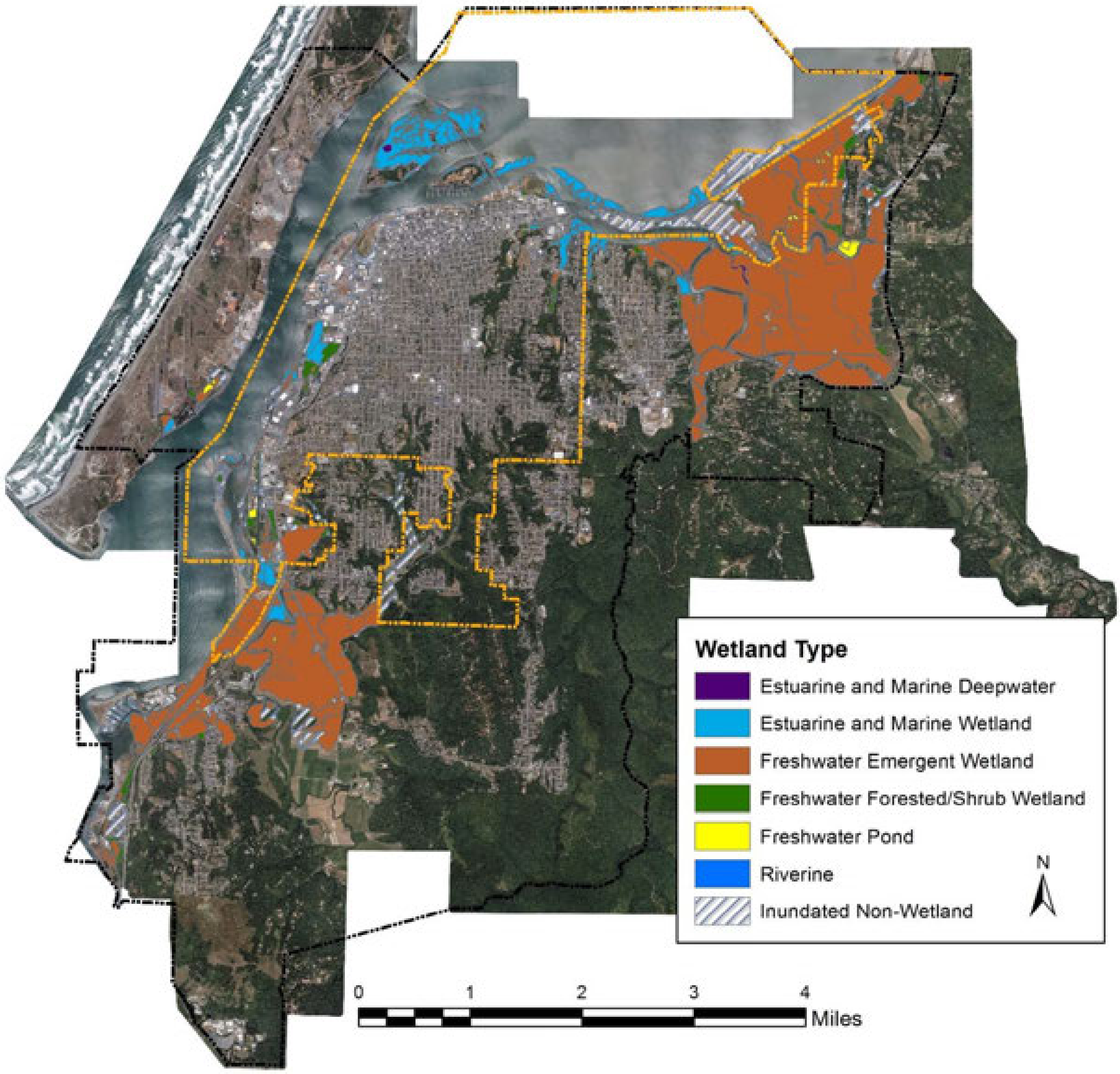

Figure 25. Environmentally sensitive habitat areas and non-wetland areas in the City of Eureka and its Planning Area that could potentially be tidally inundated by 2030 by the mean monthly maximum tide of 8.6 feet (NAVD 88).

2050

In the City, by 2050 compared to 2015, there are an additional 28 acres of seasonal freshwater emergent wetlands and 45 acres of riparian areas that are potentially vulnerable and at risk from tidal inundation if the high projection for sea level rise of 1.9 feet is reached MMMW could be 9.6 feet (NAVD 88). There are also 13 additional acres of estuarine/marine wetlands, and 20 additional acres of coastal dunes that are potentially vulnerable and at risk from tidal inundation (Figure 26, Table 10).

In the PA, by 2050 compared to 2015, there are an additional 197 acres of seasonal freshwater emergent wetlands and 78 additional acres of riparian areas potentially vulnerable and at risk from tidal inundation. There are also 21 additional acres of estuarine/marine wetlands and 23 additional acres of coastal dunes areas potentially vulnerable and at risk from tidal inundation (Figure 26, Table 10).

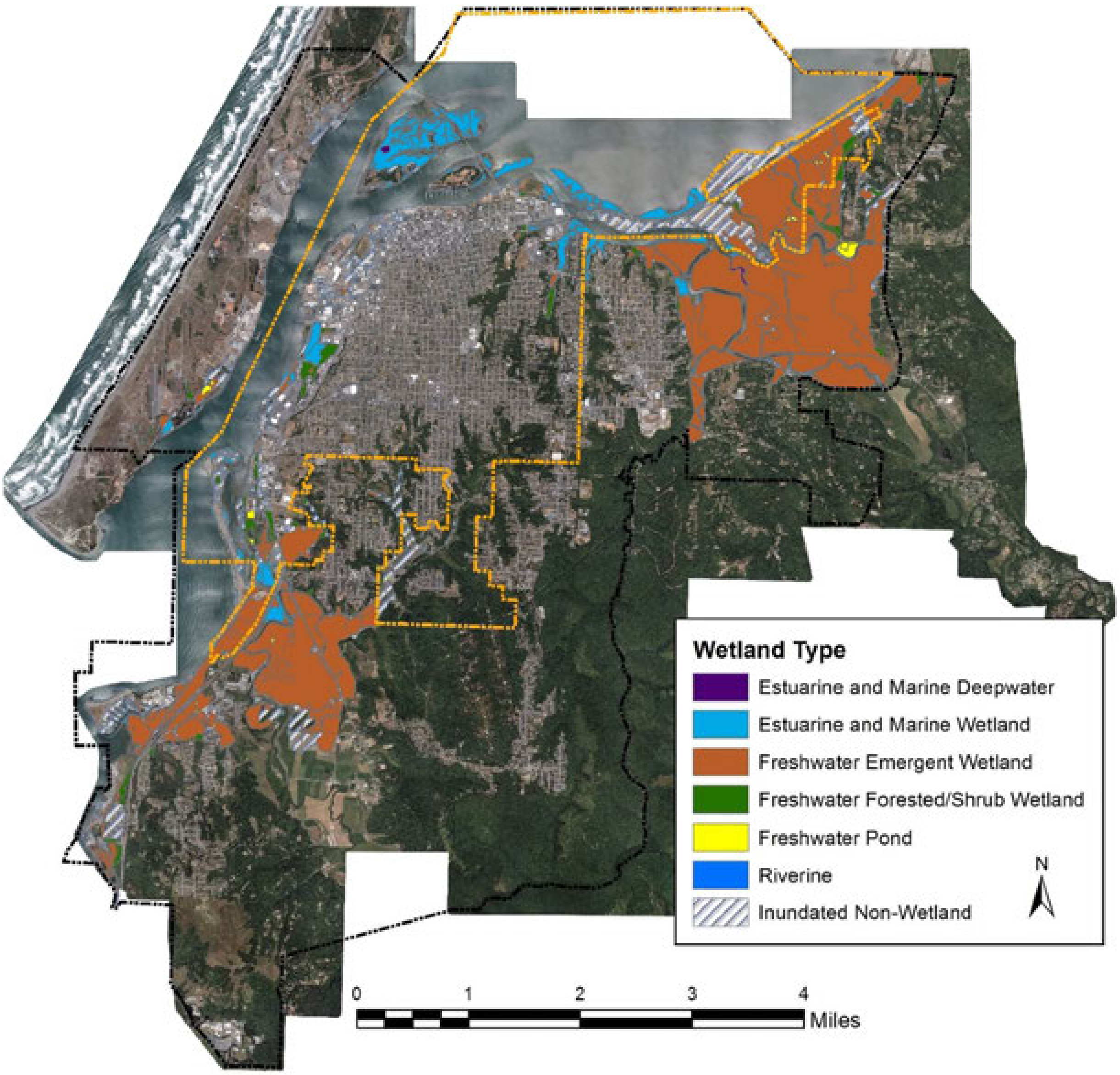

Figure 26. Environmentally sensitive habitat areas and non-wetland areas in the City of Eureka and its Planning Area that could potentially be tidally inundated by 2050 by the mean monthly maximum tide of 9.6 feet (NAVD 88).

2100

In City, by 2100 compared to 2015, there are an additional 43 acres of seasonal freshwater emergent wetlands and 74 additional acres of riparian areas potentially vulnerable and at risk from tidal inundation if the high projection for sea level rise of 5.4 feet is reached MMMW could reach of 13.1 feet (NAVD 88). There are also 20 additional acres of estuarine/marine wetlands and 41 acres of coastal dunes at risk (Figure 27, Table 10).

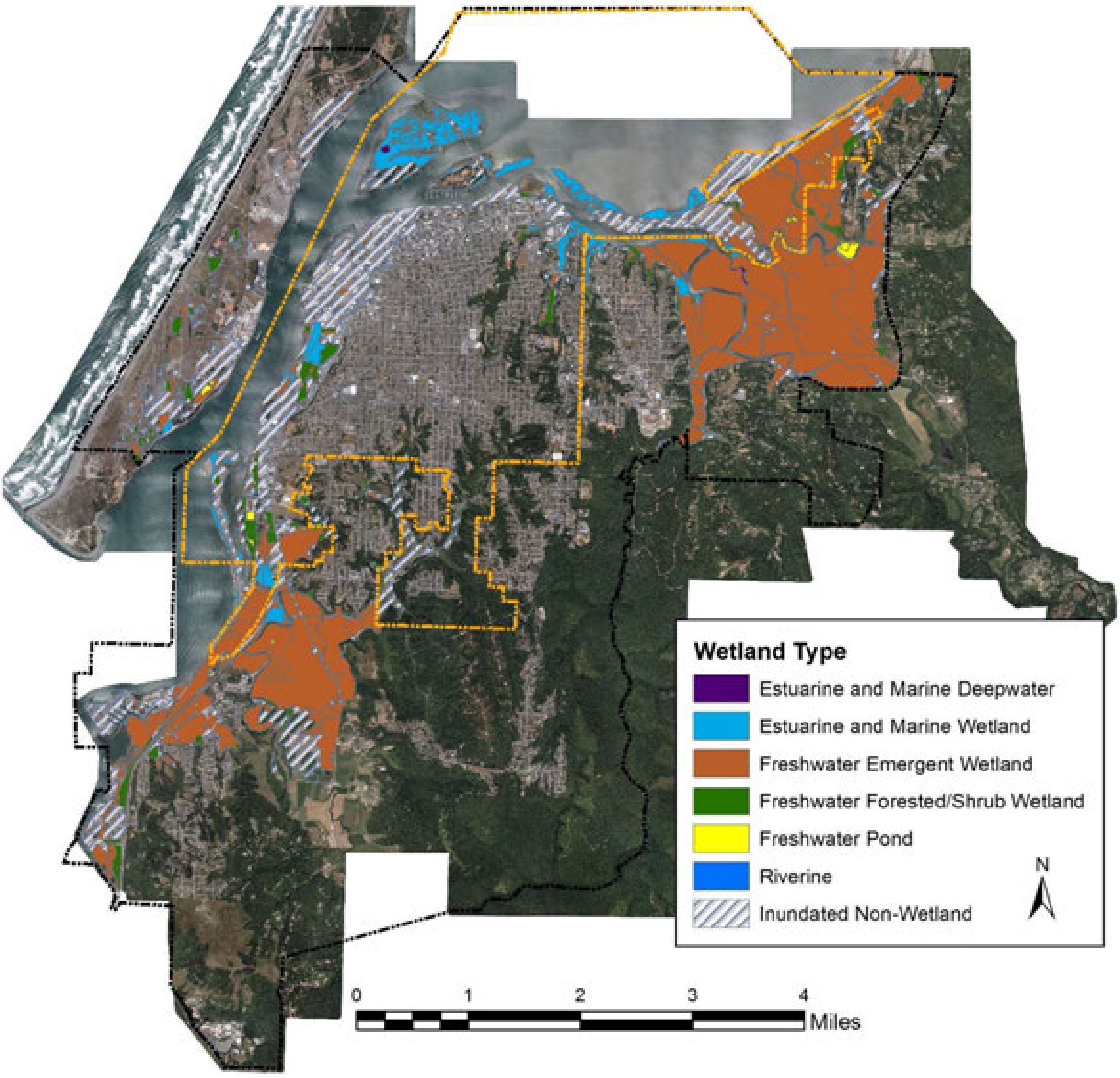

Figure 27. Environmentally sensitive habitat areas and non-wetland areas in the City of Eureka and its Planning Area that could potentially be tidally inundated by 2100 by the mean monthly maximum tide of 13.1 feet (NAVD 88).

In the PA, by 2100 compared to 2015, there are an additional 334 acres of seasonal freshwater emergent wetlands and 188 additional acres of riparian areas at risk from the mean monthly maximum tide of 13.1 feet (5.4 feet). There are also 32 additional acres of estuarine/marine wetlands and 51 additional acres of coastal dunes areas potentially vulnerable and at risk from tidal inundation (Figure 27, Table 10).

3.3 Susceptibility

Agricultural lands and freshwater wetland environments they support could be significantly and adversely affected, very susceptible, by salt water inundation. These agricultural lands and freshwater wetland environments may be less susceptible to flooding from a 100-year storm if the areas were able to drain. Salt water inundation would convert the freshwater vegetation to brackish and/or saltwater vegetation, or possibly mud flats depending on their surface elevation. If tidally inundation were to occur that would be a significant adverse impact to grazing, the primary agricultural and significant waterfowl use of these lands. These agricultural lands and freshwater wetlands are being protected now by shoreline structures, dikes, that could be adversely affected if they are breached or overtopped that could result in the tidal inundation of the lands and wetlands behind these dikes. Sea level rise is projected to potentially overtop protective dikes and filled shorelines extensively from 2050 through 2100 that may cause tidal inundation, and saltwater intrusion. Sea level rise will also increase the elevations of extreme 100-year events (1% probability of occurring in any year), which could cause flooding of these diked areas.

Drainage from these diked lands could be reduced by rising tides on the order of 2 to 5 feet, which are the approximate high projections for 2050 and 2100. Reduced drainage capabilities may increase flooding of the vegetation behind these dikes that provides grazing for livestock and waterfowl. Rising ground water in response to rising tides may also cause vegetative conversions from pasture grasses to submergent and emergent wetland species.

3.4 Consequence

The loss of 2,733 acres of diked agricultural lands and their uses from tidal inundation to the City and in the PA to the Humboldt Bay region would not be significant or consequential to the agricultural industry of Humboldt County. The loss of sales tax revenue to the City from 569 acres of agricultural land also would likely not be significant, the reduction in property tax revenues to the City may not be significant either as much of this area is State land. The loss of 3,265 acres of freshwater wetland ESHA located on these diked lands from tidal inundation, would impact migrating waterfowl and shore bird populations that utilize these areas. If the other diked lands on Humboldt Bay and Eel River Delta were similarly impacted by tidal inundation in the same time frame in response to sea level rise, then the loss of these wetland acres in the City and PA could be significant and cumulatively consequential to the wildlife and people in the Humboldt Bay region.

The significance of these agricultural lands to the City is not in their agricultural production per se but rather in their diked shorelines that not only protect these lands but also protect important urban uses and developments such as Humboldt County's Murray Field Airport and U.S. Highway 101, and essential underground infrastructure: City's municipal water transmission lines, sewer lines, and sewer lift stations; PG&E's natural gas lines. Dike failure and tidal inundation of these lands would significantly impair the City and others ability to access these underground utilities. The need to protect these dikes is significant to the City and Humboldt Bay region until which time the essential urban uses, developments, and underground utilities that are vulnerable and at risk from tidal inundation can be protected or relocated.

Also while the significance of these agricultural lands may not be in their tax revenues, these are nonetheless culturally significant historical landscapes in the Humboldt Bay region. The Eureka Slough bottom-land provides the community with important open space, wildlife habitats, and pastoral landscapes that help define the character of Humboldt Bay. The loss of these diked former tidelands would be a significant impact to this historical landscape, wildlife populations and the community.

These freshwater wetlands provide valuable grazing habitat for migratory waterfowl, especially formerly federally listed Aleutian geese. The DFW has a wildlife reserve in the City (Fay Slough) and in the PA (Elk River Slough) that serve these geese, as well as other waterfowl and shorebirds. Both of these wildlife reserves are vulnerable and at risk from tidal inundation now if the shoreline dikes are breached. Cumulatively, the diked agricultural lands in South and Arcata Bay are similarly vulnerable and at risk from tidal inundation if their dikes are breached. If this occurs, in response to extreme tides or a 100-year storm or projected sea level rise, a significant amount of the suitable Aleutian geese grazing habitat on Humboldt Bay may be lost, that would likely be consequential.

3.5 Priority

In the City agricultural areas are vulnerable and at risk from tidal inundation, by 2050 546 acres (88.2%) and by 2100 569 acres (91.9%) could be tidally inundated. Pasture vegetation on agricultural lands is very susceptible to tidal inundation. The consequence of the loss or impairment of agricultural areas by 2050 would be significant but by 2100 the additional acreage that could be tidally inundate would not be consequential to the City. Agricultural lands in the City were given a priority ranking of 6 by 2050 and 3 by 2100 (Figure 28).

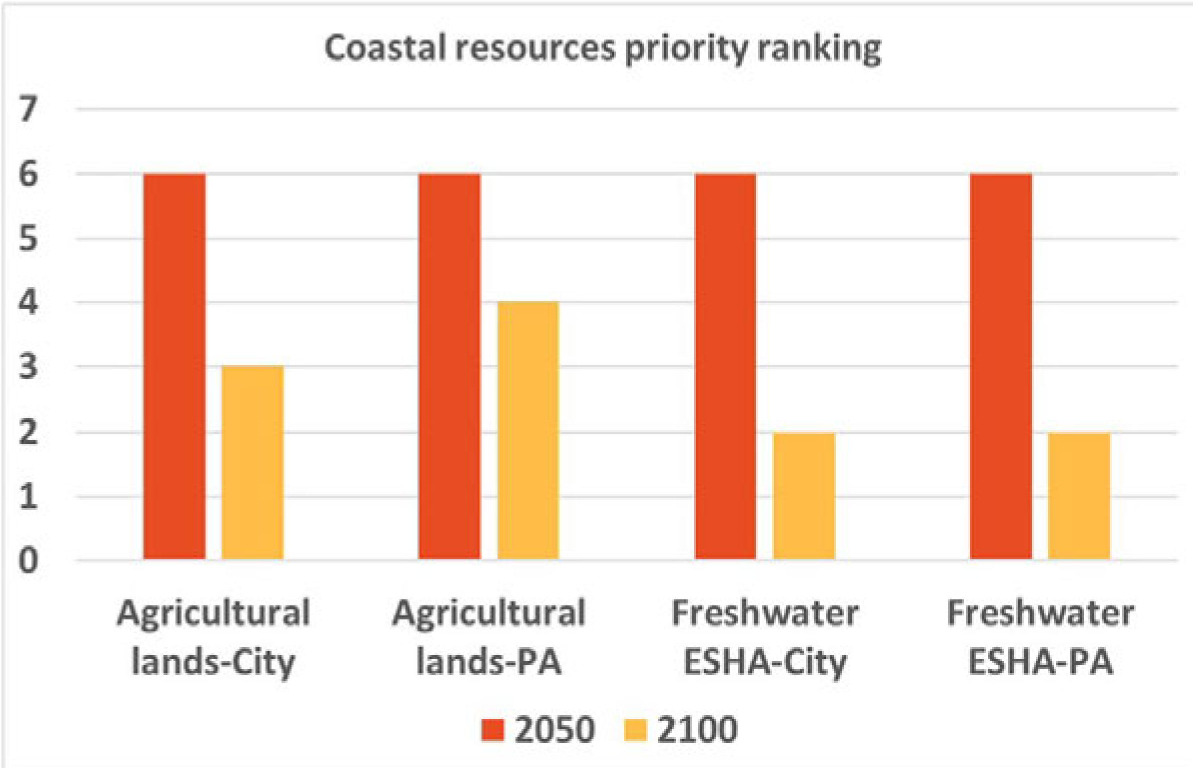

Figure 28. Priority ranking of coastal resource areas in the City and its Planning Area for 2050 and 2100 that can be used to determine priority for adaptation planning.

In the PA there could be 2,007 acres (43%) of agricultural areas exposed to tidal inundation by 2050 and by 2100 2,164 acres (46.6%). The consequence of the loss or impairment of agricultural areas by 2050 would be significant but by 2100 the additional acreage that could be tidally inundate would not be consequential in the PA. Agricultural lands in the PA were given a priority ranking of 6 by 2050 and 3 by 2100.

Freshwater wetland areas in the City are vulnerable and at risk from tidal inundation by 2050 498 acres (96%) and by 2100 513 acres (98.8%). Freshwater wetland vegetation is very susceptible to tidal inundation; prolonged exposure would cause the freshwater vegetation be replaced by brackish or salt water vegetation. The consequence of the loss or impairment of freshwater wetland areas by 2050 would be significant but by 2100 the additional acreage that could be tidally inundate would not be consequential to the City. Freshwater wetlands areas in the City were given a ranking of 6 by 2050 and 2 by 2100 (Figure 28).

There could be 2,615 acres (85%) of freshwater wetland areas in the PA exposed to tidal inundation by 2050 and by 2100 89.4%. The consequence of the loss or impairment of freshwater wetland areas in 2050 would be significant but by 2100 the additional acreage that could be tidally inundate would not be consequential to the PA. Freshwater wetland areas in the PA were given a ranking of 6 by 2050 and 2 by 2100.

4 Utilities

The City and its urban land uses are enabled by utilities that provide essential services. Impairment of utility infrastructure can affect all land uses and properties served by the affected utility. The utility infrastructure and services in the City and its PA are municipal water, waste water, storm water, energy, solid waste, and communications. A critical aspect of these utilities in relation to their exposure to sea level rise is their underground location. The City is responsible for the maintenance and operation of its municipal, waste, and storm water systems. The Humboldt Community Services District (HCSD) in the PA also utilizes the Elk River Waste Water Treatment Facility and provides an intertie to the City municipal water system. The infrastructure and operations for the energy, solid waste, and communications utility services are the responsibility of private companies or other public agencies.

4.1 Waste Water

4.1.1 Description

The City owns, operates, and maintains its waste water collection system and the Elk River Waste Water Treatment Plant (WWTP) located in the City. In the PA, the HCSD owns, operates, and maintains its waste water collection system and they have purchased approximately 30% of the WWTP's current capacity to serve some of unincorporated communities through an inter-governmental agreement with the City. The combined waste water collection and treatment system serves approximately 45,000 customers. There are no waste water collection or treatment systems in the remainder of the PA outside of the HCSD's jurisdiction.

The WWTP, constructed in 1982, is located on the shore of Elk River Slough. Its facilities are greater than 15.0 feet in elevation. It is a trickling filter type system, designed for peak dry weather flows of 9.5 million gallons per day (MGD) and a peak wet weather design flow of 32 MGD. When the flow exceeds 12.5 MGD, the primarily-treated effluent is blended with secondarily-treated effluent, chlorinated, dechlorinated, and discharged. When flows are approaching the design capacity of the plant, primarily-treated effluent is discharged to the "Overflow Marsh" with a perimeter dike that is less 11.0 feet in elevation (Figure 29), and held until it can be reintroduced back into the secondary treatment process.

Figure 29. City of Eureka's Elk River Waste Water Treatment Plant (WWTP), Elk River Slough, and Humboldt Bay.

The average dry weather flow through the treatment plant is 5 MGD. HCSD's average daily contribution is between 1 and 2 MGD. Flows are electronically measured throughout the City's SCADA interface. The plant often approaches the peak wet weather design flows (32 MGD) during storm and high tide events, indicating that the collection system already has problems with inflow and infiltration (I/I).

Treated, dechlorinated waste water effluent is discharged by gravity flow into Humboldt Bay on the outgoing tide through a 36-inch diameter outfall pipe that terminates in a diffuser near the bottom center of the navigation channel west of Elk River Spit. The siphon break (a tee in the pipe that is open to atmosphere) is located on the west side of the Elk River Spit.

Accumulated sludge from the primary treatment process is anaerobically digested, stored in two facultative sludge lagoons with perimeter dikes that are greater than 15.0 feet in elevation, dewatered with a centrifuge, and applied as a soil amendment to areas not in the tidal inundation zone for 2100.

Collection System

The collection system consists of an underground network of sewer pipes, manholes, and lift and pump stations. Sewage is collected from residential, commercial, and industrial customers in an underground pipe network that is slightly inclined to allow waste water to flow by gravity to the WWTP or a sewer lift station. A lift station is an underground tank that accumulates sewage from parts of the collection pipe network that do not have sufficient fall to reach the WWTP. As the basin fills, float switches activate pumps that lift the sewage and discharge it back into a gravity pipe at a higher elevation or into a force main that conveys the sewage under pressure back to another part of the system.

The City's collection system includes 125 miles of underground pipe, 150 manholes and 22 lift/pump stations. In the PA, HCSD owns and operates the collection system outside of the City limits, which consists of an additional 29 sewer lift stations and 78 miles of underground pipes (Figure 30, Figure 31, and Figure 32). HCSD serves the communities of Myrtletown to the east, Cutten to the southeast, Bayview, Ridgewood, Pine Hill, Rosewood, and South Eureka to the south, and Humboldt Hill, King Salmon and Field's Landing to the southwest. Their collection system interconnects with the 's collection system at several points.

The collection systems are currently experiencing deficiencies typical of their age, including: I/I of storm water and ground water, pipe deterioration, aging pumping systems, and capacity limitations.

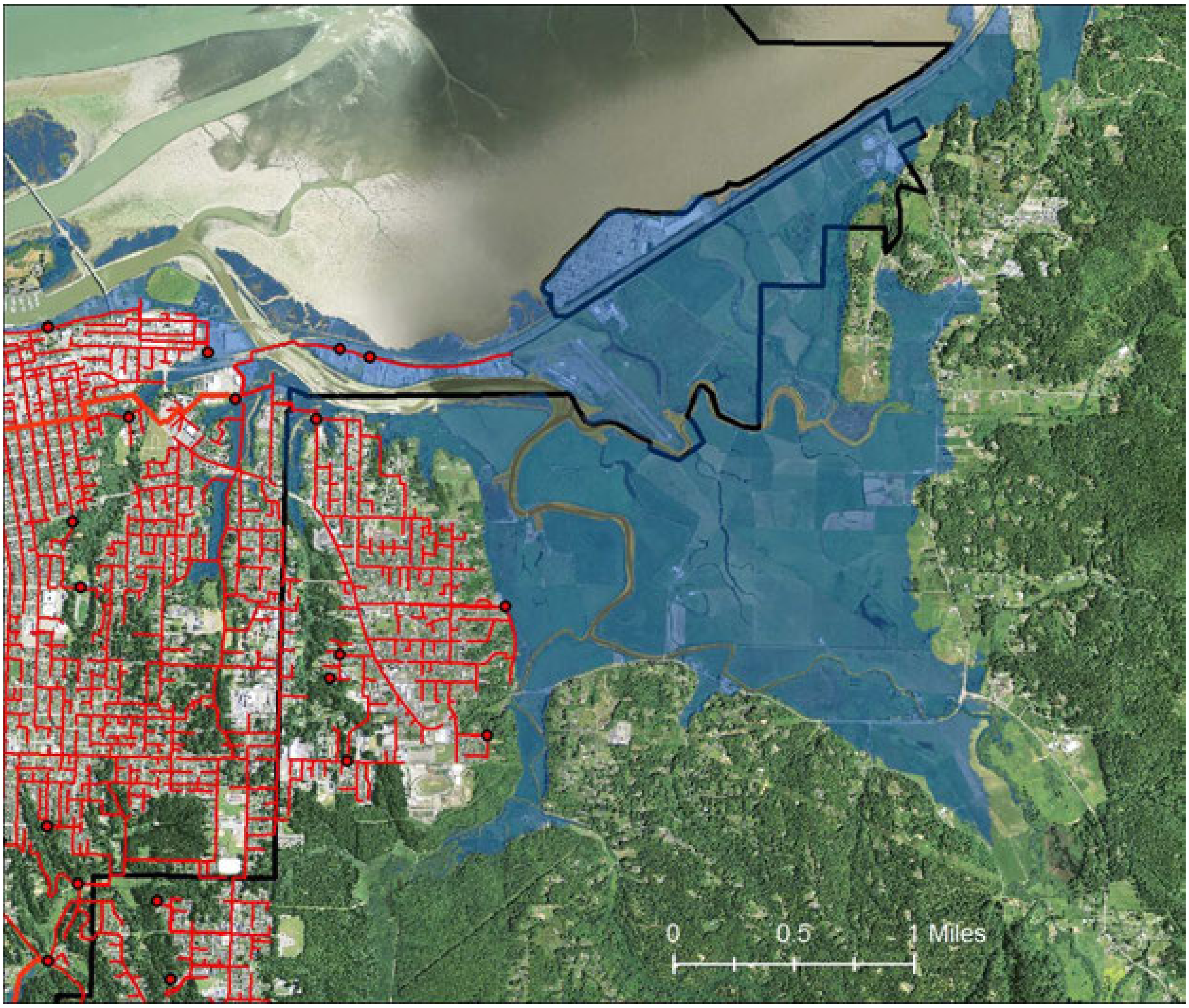

Figure 30. City of Eureka and Humboldt Community Services District's waste water collection system: collection pipes, force mains (bold red), lift stations (red dots), and potential tidal inundation area by 2100.

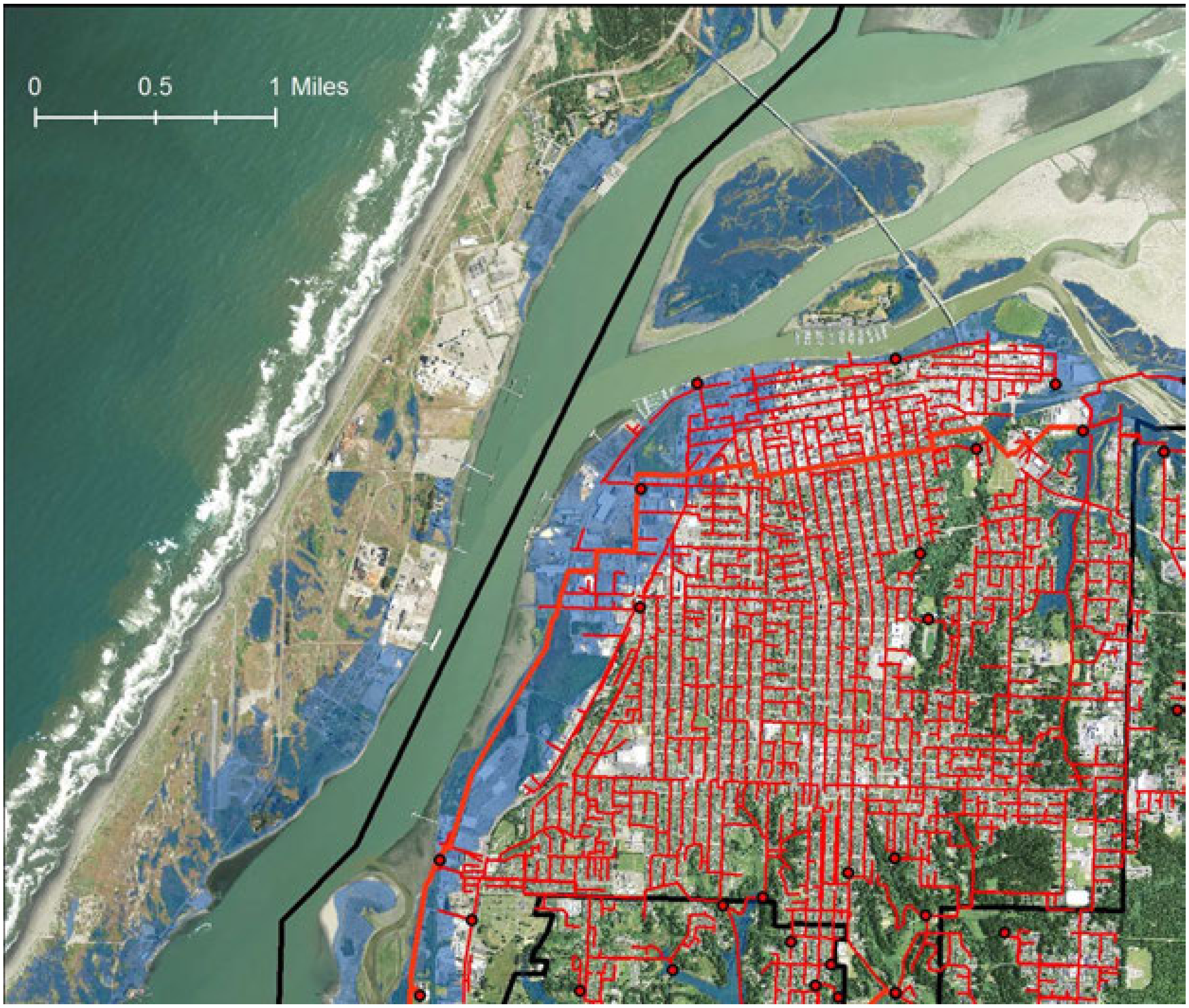

Figure 31. City of Eureka waste water collection system: collection pipes, force mains (bold red), lift stations (red dots), and potential tidal inundation area by 2100.

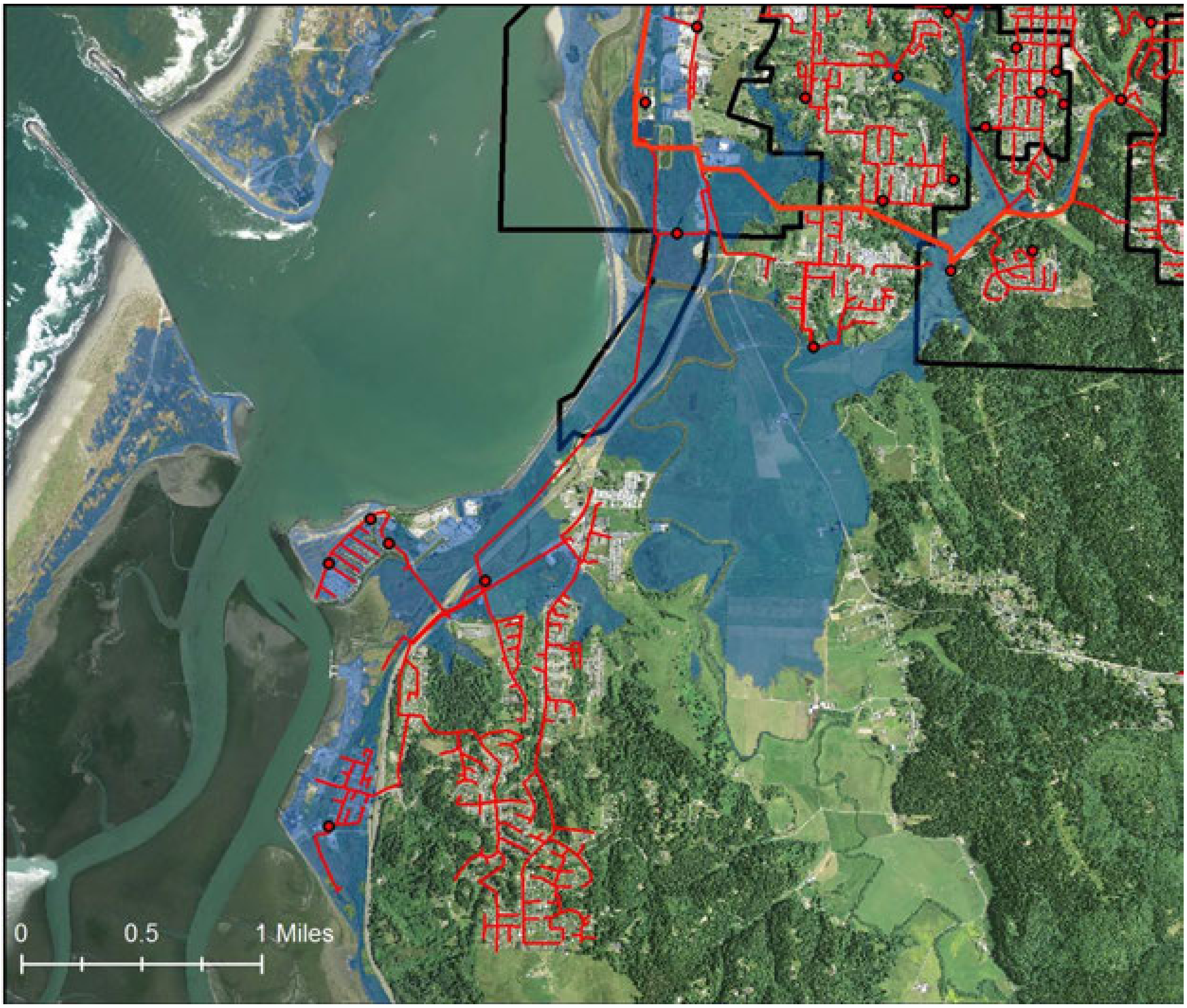

Figure 32. City of Eureka and Humboldt Community Services District's waste water collection system: collection pipes, force mains (bold red), lift stations (red dots), and potential tidal inundation area by 2100; and Elk River Waste Water Treatment Plant.

- Collection Pipe Network

The City's waste water collection system includes a wide variety of pipe sizes and materials types. The pipes range in diameter from 2 inches to 42 inches and are composed of ABS, PVC, AC, VC, and/or DIP. In the PA, the HCSD collection system is very similar in size and composition of the pipes and will be treated as part of the City's system for the purposes of this assets at risk analysis.

The collection pipes are buried in trenches at a depth ranging from 2 feet to over 10 feet deep. In most cases, the pipes are bedded in a gravel backfill. The pipes are sloped to drain by gravity to the nearest lift station, where the waste water is pumped up to the next leg of the system on its way to the treatment plant. Manholes are spaced approximately every 300 feet to allow access to the collection system.

- Lift/Pump Stations

An integral part of the collection system is the lift and pump stations. Pump stations are typically housed within a building. Lift stations are outside and typically flush with the surrounding ground. The City has 22 lift/pump stations, 11 of which are within the 2100 tidal inundation area (13.1 feet elevation NAVD 88; Table 11, Figure 30, Figure 31, Figure 32). In the PA, HCSD has 29 sewer lift/pump stations, and 9 are within the 2100 tidal inundation area (13.1 feet elevation NAVD 88; Table 11, Figure 30 and Figure 32).

Table 11. City of Eureka and Humboldt Community Services District's sewage lift and pump stations in the tidal inundation area for 2100 (13.1 feett elevation NAVD 88) and their surface elevation.

Lift/pump station	CITY	PA	Elevation (ft)
Jacob's Ave East	Lift		6.6
Jacob's Ave West	Lift		6.7
Hill Street	Pump		9.7
3rd and Y Streets	Lift		11.1
Waterfront Drive	Lift		10.7
Commercial Street	Lift		11.8
Washington Street	Pump		10.3
McCullens Street	Pump		10.4
Pound Road	Lift		9.2
Golf Course*	Lift		11.0
Martin Slough	Pump		11.0
Hoover Street		Pump	9.9
Field's Landing		Pump	7.9
S. Broadway Street		Pump	7.3
Pine Hill Road		Lift	9.2
Sea Ave		Lift	10.0
Edgewood Road		Lift	10.2
Buhne Drive		Lift	11.9
Perch Street		Lift	9.55
King Salmon Ave		Lift	8.2

* = Lift Station proposed to be deconstructed and removed.
Elevations are approximate and taken from DEM data at a single location per site.

Most parts of the collection systems rely on gravity to move the sewage and are not under pressure. Some parts of the systems include pressurized pipes. Sewage is pumped from the lift stations to other parts of the gravity system or from pump stations through a force main (interceptor system) all the way to the treatment plant. The 22 City lift/pump stations and 29 HCSD sewer lift/pump stations are located at strategic points throughout the regional collection system and convey waste water to the WWTP. The recently completed Martin Slough Interceptor and pump station will allow for the elimination of three major and three minor City -owned lift stations (one is in the tidal inundation area for 2100), and 13 minor HCSD-owned sewer lift stations. As of this writing, the stations are being converted to allow sewage to gravity flow into the collection system.

4.1.2 Exposure

The City and HCSD's collection system during storm and high tide events already has problems with I/I. Many of the urban areas in the City and PA that will be affected by sea level rise of 13.1 feet (NAVD 88) by 2100 contain waste water collection infrastructure such as lift and pump stations, manholes, and a network of sewer pipes. Some of the lift stations and manholes are expected to experience regular tidal inundation. Ground water elevations in and adjacent to these tidal inundation areas will also rise. Both of these effects will increase I/I of ground water and brackish water into the waste water collection system. This can, in turn, overwhelm the hydraulic and mechanical capacities of the systems and upset the biological balance of the treatment plant digesters, causing mechanical failures that could result in the release of raw sewage into surface waters. Other sea level rise impacts include limited access to collection pipes, lift and pump stations, and WWTP for maintenance and operations. Infiltration will occur even outside the inundation areas due to elevated ground water levels.

The following sections evaluate the impacts to specific components of the waste water system.

- **Collection Pipe Network**

In the City, the oldest parts of the collection system are located in the waterfront area, north of 4th Street. These pipes are old and some are cracked and separated at the joints. Much of the waterfront area was built on unconsolidated, porous fill materials that allow tidal waters to seep well inland from the edge of the bay. Surface water and ground water also percolate into and through the fill and flow downhill, toward the bay. Ground water saturates the fill and backs up against the seawater. The ground water elevation occurs at the approximate elevation of the average high/low tide. Rising sea levels can cause a rise in ground water elevations both seasonally and in sync with the daily tidal cycle. In the PA, the HCSD collection system in King Salmon and Fields Landing are subject to the same considerations.

In the City, 6% (7.4 miles) of sewer line potentially are vulnerable and at risk of being tidally inundated by the high projection for MMMW in 2050 (9.64 feet NAVD 88) and 15%(17.8 miles) by 2100, leaving 85% (103.1 miles) that are likely to not be inundated (Figure 33). In the PA, 6% (3.8 miles) of sewer line potentially are vulnerable and at risk of being tidally inundated by the high projection for MMMW in 2050 and 11% (7.5 miles) by 2100, leaving 89% (58.1 miles) that are likely to not be inundated (Table 12).

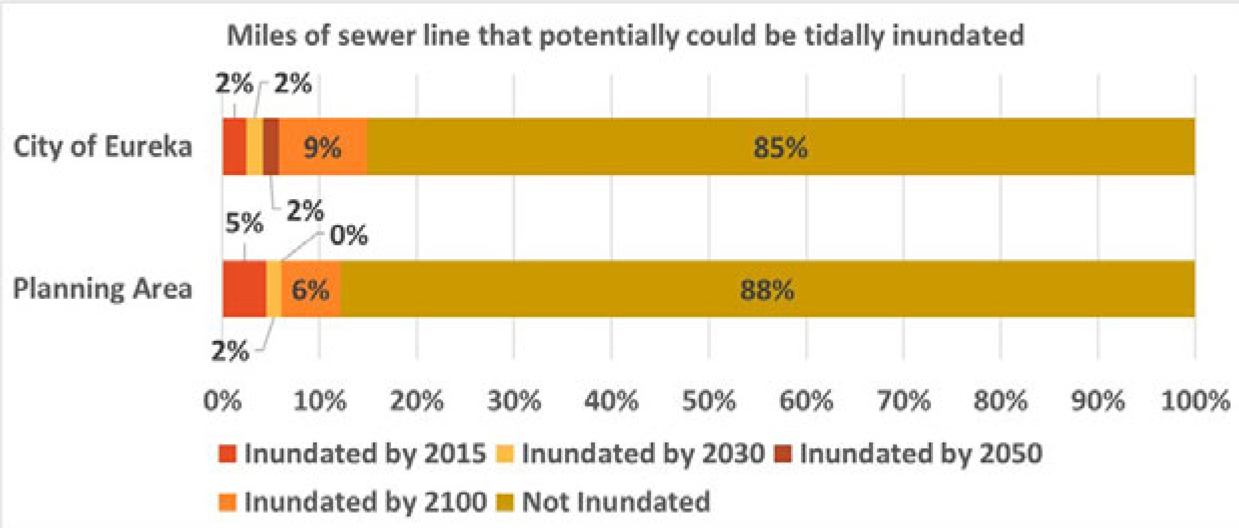

Figure 33. Sewer lines and percentage of total miles in the City of Eureka and its PA that potentially could be tidally inundation in 2015, 2030, 2050, and 2100 as well as the miles of sewer line that will likely not be inundated.

Table 12. Cumulative miles of sewer lines potentially vulnerable and at risk from tidal inundation in the City of Eureka and its Planning Area, miles of sewer line likely not tidally inundated, and total miles of sewer line.

SEWER LINE (miles)	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	2.5	4.7	7.4	17.8	103.1	120.9
Planning Area	3.1	3.6	3.8	7.5	58.1	65.6

The collection pipe networks in low-lying areas (King Salmon and Fields Landing) and on diked former tidelands (Jacobs Avenue) or current tidelands (Second and Third Sloughs) are likely below the water table. Between 2050 and 2100, the number of miles of sewer lines that could be tidally inundated more than doubles: 7.4 to 17.8 miles in the City, and 3.8 to 7.5 miles in the PA. The collection system throughout all of the tidal inundation areas is vulnerable and at risk from being flooded by rising ground water levels. When ground water is high, it can infiltrate into the gravel bedding and then into the pipes through cracks and leaking joints. Depending on the depth of the pipe and the porosity of the pipe bedding, trench fill materials and the surrounding ground; the infiltration can occur well outside of the tidal inundation area as ground water is backed up by the rising tides or tidal waters infiltrate through the porous ground. This infiltration can be fresh and/or brackish water.

- **Lift/Pump Stations and Manholes**

The lift/pump stations and manholes in the tidal inundation areas are vulnerable and at risk from storm water (freshwater) and/or inflow flowing into the collection system through the non-sealed lids and vent pipes. This can occur when storm water backs up because it cannot discharge to the bay due to high tides or, when tide gates are stuck open allowing seawater to back up into the inundation area, or if the dikes breach. Other sources of inflow include roof drains and storm drains illegally connected to the sewer collection network.

When the lift/pump stations are exposed to tidal inundation, they have the potential to fill with sea water through non-sealed hatches and covers (inflow). This will not necessarily hurt the lift station, but it will pump water that does not need to be treated into the collection and treatment systems. This excess water could hydraulically overload the system, potentially resulting in discharge of untreated sewage into the surface water. More important is that the dilution of the sewage with brackish water will also hinder the biological processes that treat the sewage, resulting in a breakdown in the entire treatment process.

Additionally, the tidal inundation of the areas surrounding the lift station will limit access to the station for routine maintenance and/or emergency repairs. Tidal inundation may also damage exposed electrical components and controls and impact auxiliary emergency power (portable generator) functionality.

In the City, 19% (4 lift stations) of the sewer lift stations potentially are vulnerable and at risk of being tidally inundated by the high projection for MMMW in 2050 (9.64 feet NAVD 88) and 46%(10 lift stations) by 2100, leaving 54% (12 lift stations) that are likely to not be inundated (Figure 34). In the PA, 23% (7 lift stations) of sewer lift stations potentially are vulnerable and at risk of being tidally inundated by the high projection for MMMW in 2050 and 28% (8 lift stations) by 2100, leaving 72% (21 lift stations) that are likely to not be inundated (Table 13).

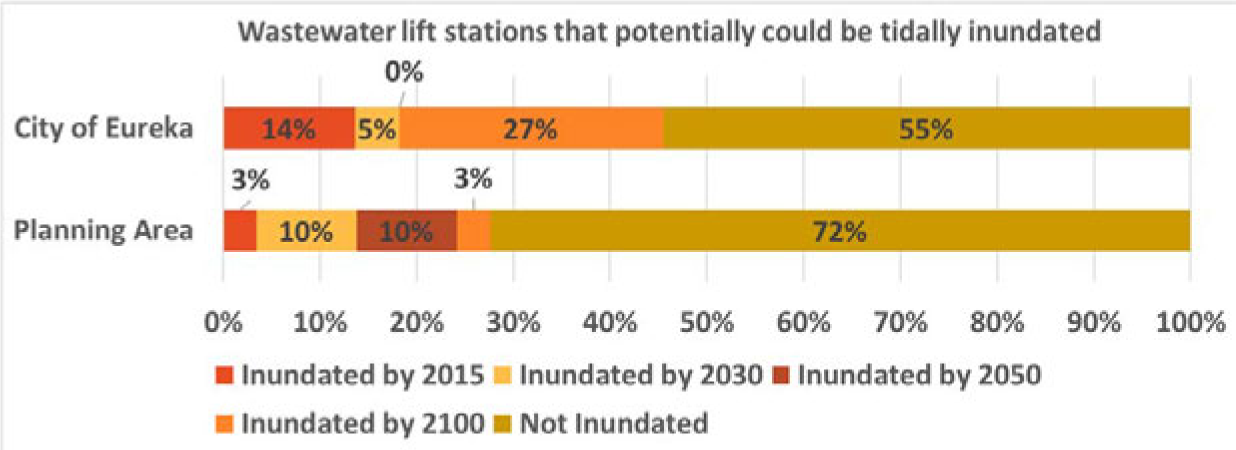

Figure 34. Sewer lines and percentage of total miles in the City of Eureka and its PA that potentially could be tidally inundation in 2015, 2030, 2050, and 2100 as well as the miles of sewer line that will likely not be inundated.

Table 13. Summary of waste water collection system components in the City of Eureka and its Planning Area impacted by current conditions and relative sea level rise projections for 2030, 2050, and 2100.

WASTEWATER LIFT STATIONS	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	3	4	4	10	12	22
Planning Area	1	4	7	8	21	29

In the City, the Jacob's Avenue lift stations #1 (west) and #2 (east) pump sewage to the Hill Street pump station (Figure 35). They are located in diked former tidal lands in a hydrologic unit that is protected from tidal inundation by dikes along Eureka and Fay Sloughs, and the NW Pacific Railroad grade. The surface elevations at the Jacob's Avenue stations are approximately 6.6 to 6.7 feet (NAVD 88) and are below the current MMMW elevation of 7.7 feet (NAVD 88).

Figure 35. Sewer lift and pump stations: Jacob's Avenue #1 and 2, Hill Street, Hoover Street, Edgewood Road, Y Street, and sewer mains and sewer interceptor that potentially could be tidally inundated in 2015 by the mean monthly maximum tidal inundation area of 7.7 feet (NAVD 88).

These stations are currently vulnerable and at risk from tidal inundation if the dikes on Eureka or Fay Slough or associated tide gates fail. As sea level rises, these dikes will be more likely to fail due to erosion and saturation. If the dikes do not fail but the tide gates malfunction, attenuated flooding will occur. Even if the tide gates do not fail accumulated storm water will not be able to flow out of the diked bay lands until they are higher than the tides, resulting in flooded and saturated conditions.

These two stations are at the lowest elevation of all other lift stations in the collection system, below current MMMW tide levels, and are the most susceptible to tidal inundation. It is likely that significant I/I is already occurring on a periodic basis based on the observed flows at the Hill Street pump station. The Jacobs Avenue commercial and residential private property and Humboldt County's Murray Field Airport would be adversely affected if these two lift stations fail.

Based on the Waste Water System Facilities Plan developed by Brown & Caldwell (2008), the Hill Street pump station (9.7 feet NAVD 88) experiences greater I/I flows than any other monitored station in the collection system. During storm events, the station has been observed to pump more than 11 MGD. That is more than the peak dry weather design capacity of the WWTP. The Hill Street pump station is located alongside Second Slough, a tributary of Eureka Slough, and is the starting point of connection for the Eureka Cross Town Interceptor. The Cross Town Interceptor main begins at the Hill Street pump/lift station, in the northwest section of the City, runs parallel to U.S. Highway 101 through town along 7th/8th Streets, then turns south on Koster, west on 14th/15th Streets, and south along the old railroad track corridor to Hilfiker Lane, ending at the WWTP. The Hill Street pump station is potentially vulnerable and at risk from tidal inundation by 2050 when MMMW tides may rise to 9.6 feet (NAVD 88) and MAMW tides could average 10.7 feet (NAVD 88).

In the PA, to the east of the Hill Street pump station are the Hoover Street pump station and Edgewood Road lift station. The Hoover Street pump station is located adjacent to inter-tidal wetland on Third Slough, a tributary to Eureka Slough, at 9.9 feet (NAVD 88). This pump station is potentially vulnerable and at risk from tidal inundation by 2050 during MAMW that may reach 10.7 feet (NAVD 88) and by 2070 when MMMW is projected to rise to 10.9 feet (NAVD 88). The Edgewood Road lift station, elevation at 10.2 feet (NAVD 88), is located at the current edge of the tidal inundation boundary should the dikes on Freshwater or Ryan Slough fail in 2015. This lift station is potentially vulnerable and at risk from tidal inundation by MAMW with a high projection of 10.7 feet (NAVD 88) in 2050 and MMMW tides of 10.9 feet (NAVD 88) in 2070. The Edgewood Road lift station pumps to the Hoover Street station. A loss of service at either station would impact the Myrtletown area.

The Third and Y Street lift station is located near the Target store on the northeast side of Eureka at an elevation of 11.1 feet (NAVD 88), and is within the projected 2100 tidal inundation area below 13.1 feet (NAVD 88), along with the parking lot area of Target, and a low-lying section of the adjacent U.S. Highway 101 (Figure 35). The areas impacted by loss of service at this station are commercial and residential clients between O and Y Streets and between 6th Street and Waterfront Drive in the northeast corner of Eureka.

The Waterfront lift station at 10.7 feet (NAVD 88) serves the residential area north of 2nd Street and east of J Street in Old Town Eureka, as well as receiving sewage flows from the 3rd and Y Street lift station. This station could be tidally inundated by MAMW (10.7 feet (NAVD 88) in 2050 and potentially be tidally inundated by MMMW tides between 2070 (10.9 feet (NAVD 88) and 2100 (13.1 feet (NAVD 88); Figure 36).

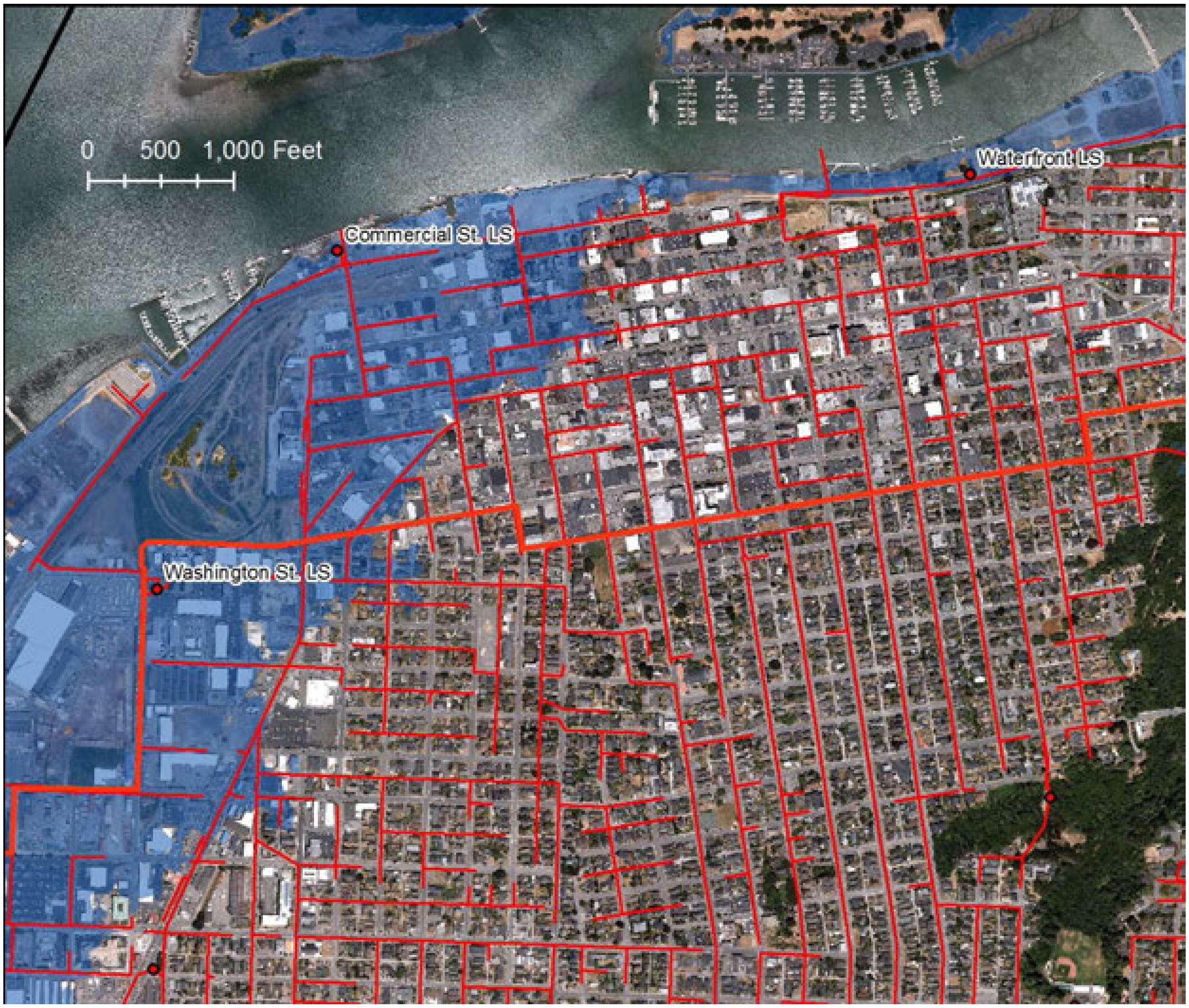

Figure 36. Sewer lift stations: Waterfront Street, Commercial Street, Washington Street, and sewer mains and sewer interceptor that potentially could be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

The Commercial Street lift station is located at 11.8 feet (NAVD 88) and could potentially be tidally inundated by 2070, when MAMW is projected reach 12.0 feet (NAVD 88). Tidal inundation of the station and surrounding area of nearly one half mile radius could occur during the projected 2100 tidal conditions of 13.1 feet (NAVD 88) (Figure 36). The approximate waste water collection basin served by this station extends along the waterfront from Koster Ave to A Street, and from 2nd Street to Humboldt Bay, and includes coastal dependent industrial, waterfront commercial, and public facility properties. Sewage from the Commercial Street lift station flows to the Washington Street pump station.

The Washington Street pump station at 10.3 feet (NAVD 88) is expected to lose vehicular access via Washington Street and Koster Street by 2050 when MMMW tides are projected to rise to 9.6 feet (NAVD 88) and MAMW to 10.7 feet (NAVD 88). This station and surrounding area of approximately a quarter mile radius could potentially be tidally inundated between 2070 (10.9 feet (NAVD 88) and 2100 (13.1 feet (NAVD 88) under MMMW tidal conditions (Figure 36).

The McCullens/Truesdale Street pump station at 10.4 feet (NAVD 88) is the final point of conveyance for the City's waste water collection system before reaching the WWTP. The station may be tidally inundated by MAMW of 10.7 feet (NAVD 88) projected for 2050, and by MMMW tides between 2070 (10.9 feet (NAVD 88) and 2100 (13.1 feet (NAVD 88); Figure 37). Disruption of the operations at this station could impact a very large service area.

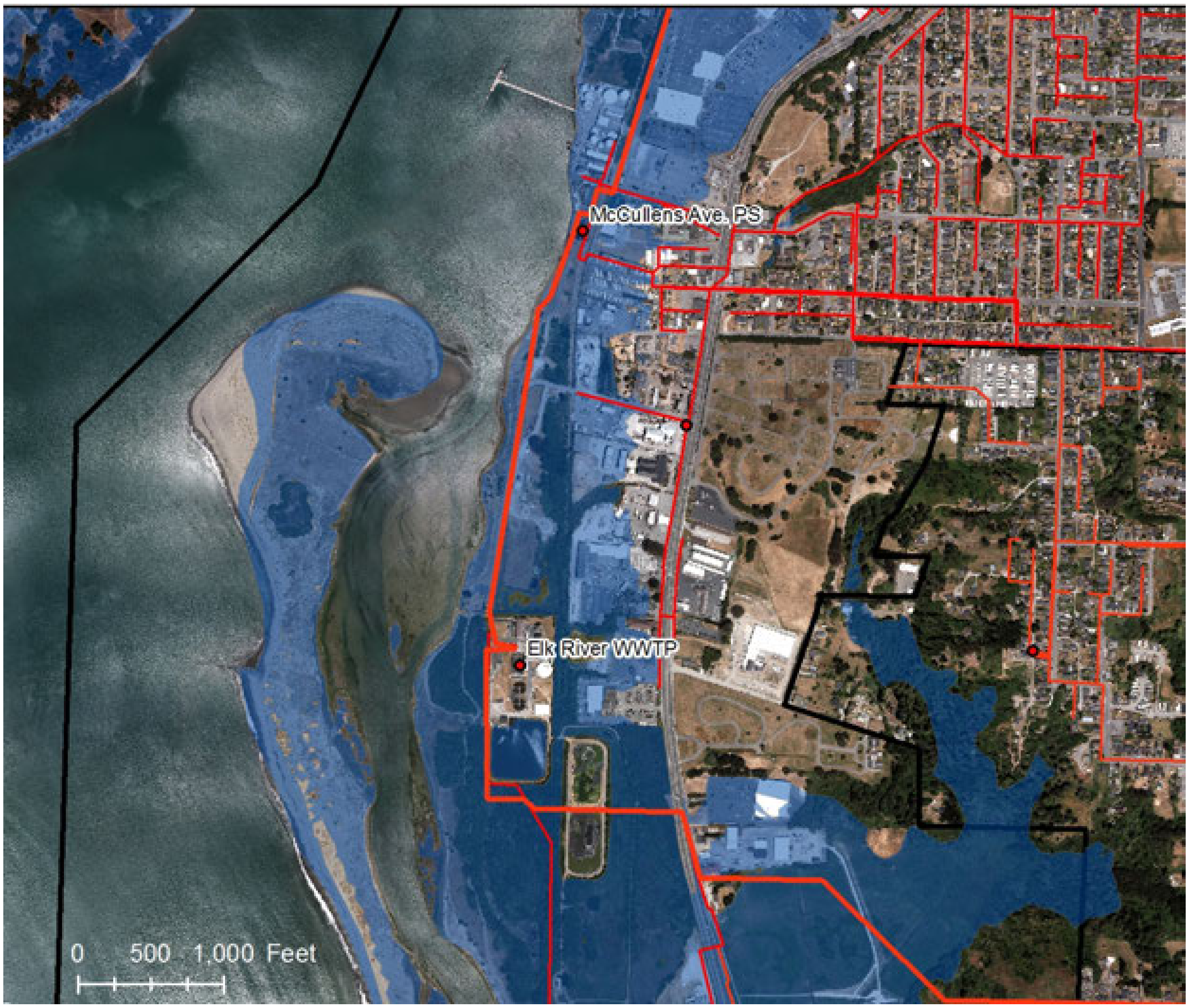

Figure 37. McCullens Avenue pump station, Elk River Waste Water Treatment Plant, and sewer mains and sewer interceptor that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide (13.1 feet NAVD 88).

The Pound Road lift station (Figure 38) is located at an elevation of 9.2 feet (NAVD 88) by the mouth of the Elk River, just south of the WWTP. It is within the high projection for 2030 MAMW inundation area of 9.7 feet (NAVD 88), and is expected to be tidally inundated by MMMW tides of 9.6 feet (NAVD 88) by 2050.

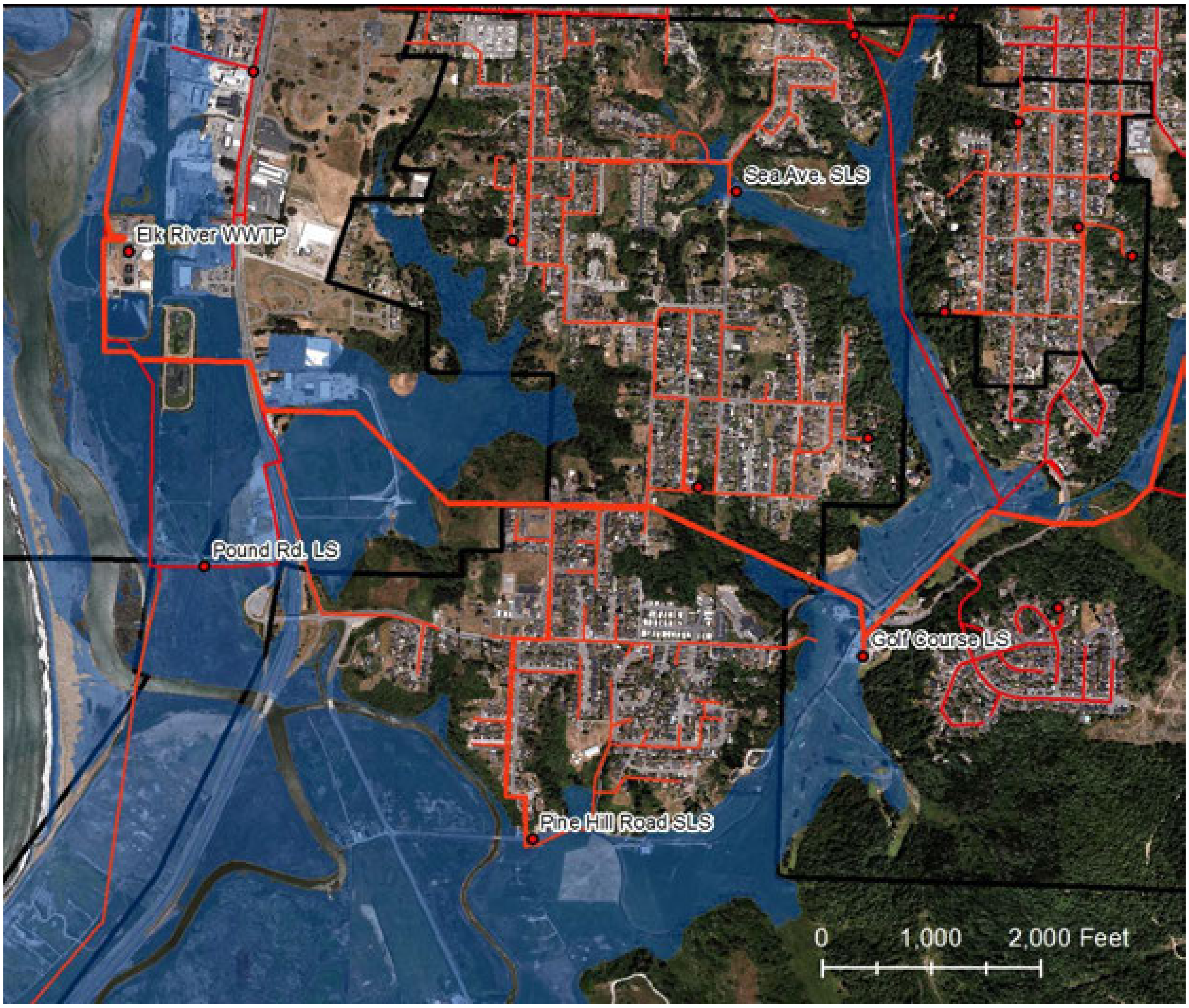

Figure 38. Pound Road, Sea Avenue, Golf Course, and Pine Hill Road sewer lift stations, Elk River Waste Water Treatment Plant, and sewer mains and sewer interceptor that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

In the PA, the recently completed Martin Slough Interceptor (MSI) will improve the waste water collection system efficiency and capacity. The MSI is a collaborative project between the City and HCSD. The Golf Course lift station (Figure 38) at an elevation of 11.0 feet (NAVD 88), is currently planned to be decommissioned with the completion of the Martin Slough Interceptor Project. The new Martin Slough pump station is located in the vicinity of the existing Golf Course lift station and will serve as the starting point for the MSI force main. If the north bank dike on Swain Slough is breached, it is likely that the Martin Slough pump station could be tidally inundated by the high projection for MAMW (12.0 feet NAVD 88) in 2070 and MMMW (13.1 feet NAVD 88) by 2100 if not properly fortified. The Pine Hill Road lift station (Figure 38) is also vulnerable and at risk from tidal inundation by MAMW of 9.7 feet (NAVD 88) in 2030 or MMMW tides of 9.6 feet in 2050 if the dikes on the north bank of Swain Slough are breached. Similarly, the Sea Avenue lift station (Figure 38) at 10.0 feet (NAVD 88) is vulnerable and at risk from tidal inundation by MAMW of 10.7 feet (NAVD 88) projected for 2050 and MMMW tides of 10.9 feet (NAVD 88) in 2070.

Based on the waste water infrastructure mapping provided by the HCSD, the South Broadway Street pump station (7.3 feet NAVD 88) and Fields Landing lift station (7.9 feet NAVD 88) are currently vulnerable and at risk from tidal inundation by MMMW of 7.7 feet (NAVD 88) and MAMW of 8.8 feet (NAVD 88) (Figure 39). In King Salmon, the King Salmon Avenue lift station (8.2 feet NAVD 88) is currently vulnerable and at risk from MAMW of 8.8 feet (NAVD 88). The Perch Street (9.5 feet NAVD 88) lift station could potentially be at risk from MAMW of 9.7 feet (NAVD 88) in 2030 and MMMW tides of 9.6 feet (NAVD 88) by 2050, while the Buhne Street lift station (11.9 feet NAVD 88) is vulnerable and at risk from MAMW of 12.0 feet in 2070 and MMMW of 13.1 feet (NAVD 88) in 2100.

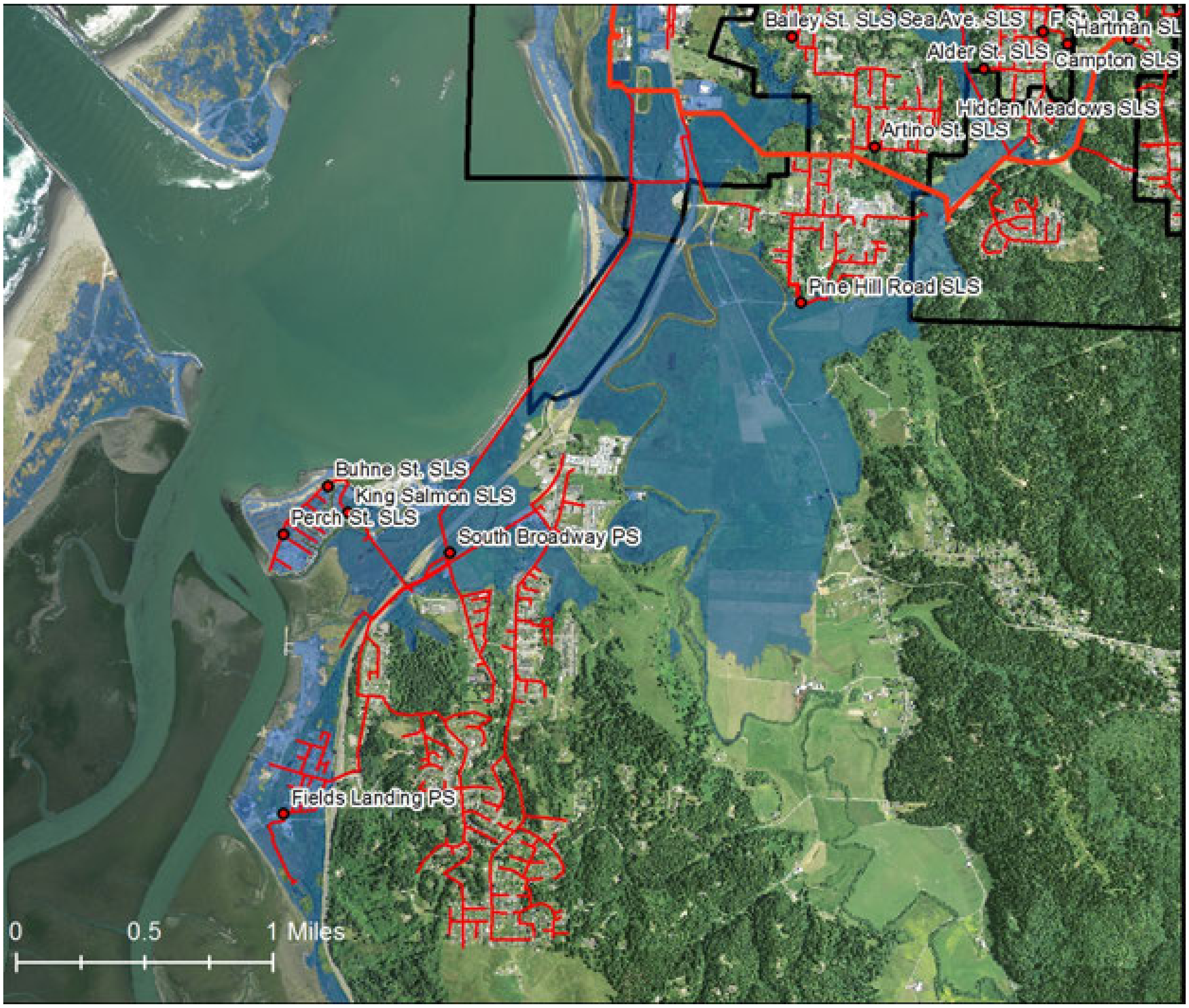

Figure 39. South Broadway pump station, and Fields Landing, King Salmon, Perch Street, and Buhne Street lift stations, and sewer mains that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

- **Waste Water Treatment System**

The WWTP elevation 15.0 feet (NAVD 88) is located in the southwest portion of the City on the shore of Elk River Slough with Eureka (Entrance) Bay directly across the Elk River Spit from the WWTP (Figure 40). The WWTP is located on fill that varies in elevation between 14.0 and 15.0 feet (NAVD 88) and was placed on tide lands lying west of the Northern Pacific Railroad grade. The grounds and most of the crucial equipment and systems are above the projected sea levels through 2100 (13.1 feet MMMW and 14.1 feet MAMW, NAVD 88). The elevation of the containment dike around the treated waste water effluent holding pond is approximately 15.0 feet (NAVD 88). The elevation of the containment dike around the facultative sludge lagoons, which store bio solids for up to two years, is between 22.0 and 23.0 feet (NAVD 88). The elevation of the containment dike around the Overflow Marsh (emergency discharge holding pond) is between 9.0 and 10.0 feet (NAVD 88). A sealable tide gate isolates the Overflow Marsh from an inter-tidal wetland area to the south, which in turn is separated from Elk River Slough by a dike and tide gates. The elevation of the access road to the WWTP (Hilfiker Lane) varies between 11.0 and 15.0 feet (NAVD 88). The WWTP and Hilfiker Lane are shielded from wave energy originating in the Entrance Bay by the Elk River Spit and tidal marshes.

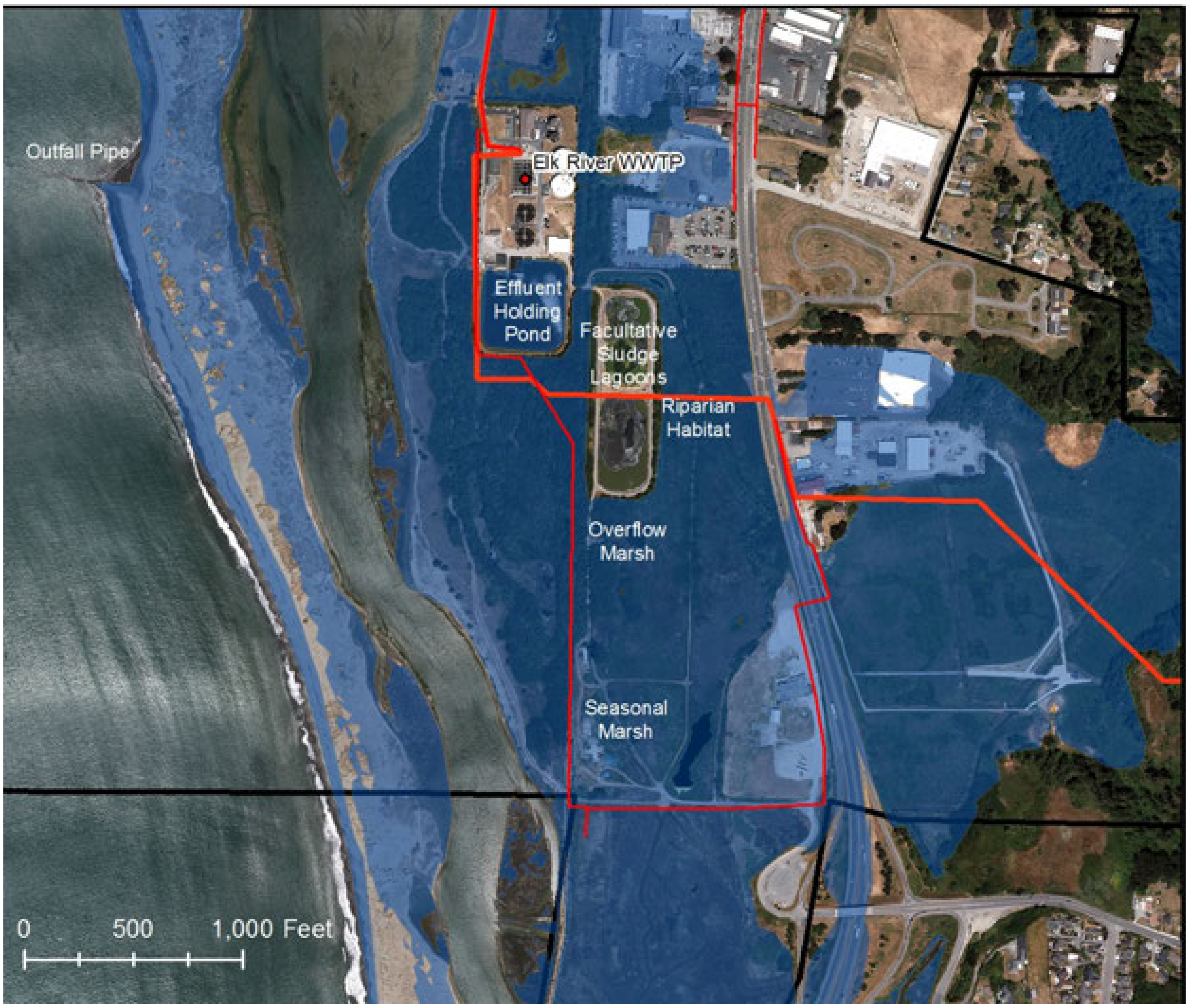

Figure 40. Entrance (Eureka) Bay, Elk River Spit and Slough, and City of Eureka's Elk River Waste Water Treatment Plant infrastructure, sewer mains, and interceptors that would be tidally inundated by 2100 by the potential mean monthly maximum tides of 13.1 feet.

The WWTP's discharge system or outfall is designed to discharge only during the outgoing tide cycle. To enable periodic discharge, treated waste water is retained in the effluent holding pond until an ebb tide occurs. The effluent holding pond relies on a tide gate to keep high tides from entering the pond. The water surface elevation of the treated effluent holding pond varies between 6 feet and 10 feet (NAVD 88) depending on operations at the WWTP. Depending on tidal cycle and holding capacity considerations, the effluent in the holding pond is dechlorinated and either has to be pumped out, using two large pumps within the effluent pumping station or flows out of the pond through a tide gate by gravity during the low tide. The outfall pipe is located on the west side of the Elk River Spit. The outgoing tide carries the treated waste water past the mouth of Humboldt Bay and into the ocean. This ebb tide discharge provides the functional equivalent of an ocean outfall and virtually eliminates the possibility of the discharge impacting the shellfish harvesting areas located in Arcata Bay. As the average low tide elevations rise, the tide gates will remain submerged longer each day, resulting in effluent being trapped behind the dike, thus reducing the capacity of the pond. Rising sea levels could reduce the effectiveness of the gravity flow discharge system, and pumping requirements, maintenance, and power costs will likely increase. The tide gates that control tidal action must be maintained in the face of rising sea levels for the discharge system to properly operate. Tide gates that control the movement of water out of the Overflow Marsh must also be maintained in the face of rising sea levels to preserve the capacity of that marsh.

As sea levels rise, access via Hilfiker Lane to the WWTP is expected to become impaired likely between 2050 and 2070 unless the lane is elevated. PG&E overhead transmission poles and underground gas lines that serve the plant located just to the north will also be subject to tidal inundation, and consequently may need to be protected or relocated.

The WWTP will not be directly exposed to tidal inundation due to its elevation. The tidal marshes and the Elk River Spit could change position, elevation, and composition in response to changing tidal cycles and currents, reducing their ability to shield the WWTP site from erosion and inundation. If this were to occur, the earthen dikes surrounding the WWTP would be subject to erosion and breaching from wave action and tidal currents.

The exposure mechanism that will have the biggest impact on the WWTP is from increased I/I through pump/lift stations and leaky pipes. This will lead to hydraulic overloading of the system and upsetting the biological activities within the treatment system. I/I is already a problem for the City and the HCSD's collection system. Rising sea levels will exacerbate this problem. The collection pipe networks in the Old Town area (Waterfront Drive through 5th Street between Broadway and I Street) and in the Westside Industrial area (west of Broadway from 2nd Street to Hawthorne Street), King Salmon, and Fields Landing are most at risk from sea level rise.

While the WWTP, effluent pond, and sludge lagoons are not at risk of inundation by 2100, the waste water collection system will impact the operation and function of the WWTP as described previously. The marshes surrounding the WWTP are integral to the operations of the plant and that their capacities and discharges will be reduced by rising sea level high projections for 2050 (9.6 feet NAVD 88) to 2100 (13.1 feet).

2015

In the City, there are two lift stations, 2.5 miles of sewer lines, and 23 manhole covers at risk from tidal inundation. The two lift stations at Jacobs Avenue (6.6 and 6.7 feet, NAVD 88) are vulnerable and at risk from tidal inundation if the dikes on Eureka or Fay Slough are breached, as they are lower in elevation than the MMMW of 7.7 feet (NAVD 88). The sewer lines feeding the Hill Street pump station next to Second Slough experience I/I during high tides and storm events. This pump station has been observed to pump more than a third of the wet season capacity of the WWTP during storm events.

In the PA, there is one pump station at South Broadway Street (7.3 feet NAVD 88) and 3.1 miles of sewer lines potentially vulnerable and at risk from tidal inundation by MMMW of 7.7 feet (NAVD 88). The Fields Landing pump station (7.9 feet NAVD 88) and King Salmon Avenue lift station (8.2 feet) may also be at risk by MAMW of 8.8 feet (NAVD 88).

2030

In the City, there are no more stations at risk from MMMW of 8.6 feet (NAVD 88), but there are now 4.7 miles of sewer lines, and 28 manhole covers vulnerable and at risk from tidal inundation. There are two more stations: Hill Street pump station at 9.7 feet (NAVD 88) and Pound Road lift station at 9.2 feet (NAVD 88) potentially vulnerable and at risk from tidal inundation during MAMW of 9.7 feet (NAVD 88).

In the PA, there are two more pump and lift stations (Fields Landing at 7.9 feet and King Salmon Avenue at 8.2 feet, NAVD 88) potentially vulnerable and at risk from MMMW of 8.6 feet (NAVD 88), and now 3.6 miles of sewer lines vulnerable and at risk from tidal inundation. The Pine Hill Road lift station (9.2 feet) on Martin Slough and the Perch Street lift station (9.5 feet NAVD 88) in King Salmon may also be vulnerable and at risk by MAMW of 9.7 feet (NAVD 88).

2050

In the City, the Pound Road lift station (9.2 feet NAVD 88) could potentially be vulnerable and at risk from MMMW of 9.6 feet (NAVD 88), and 7.4 miles of sewer lines, as well as 54 manhole covers are potentially vulnerable and at risk from tidal inundation. The Hill Street pump station (9.7 feet NAVD 88), Waterfront Drive lift station (10.7 feet

NAVD 88), Washington Street pump station (10.3 feet NAVD 88), and McCullens Street pump station (10.4 feet NAVD 88) could potentially be vulnerable and at risk from MAMW of 10.7 feet (NAVD 88).

In the PA, the Pine Hill Road (9.2 feet NAVD 88) lift station on Martin Slough and Perch Street (9.5 feet NAVD 88) lift station in King Salmon could potentially be vulnerable and at risk from MMMW of 9.6 feet (NAVD 88), and 3.8 miles of sewer lines are potentially vulnerable and at risk from tidal inundation. The Hoover Road pump station (9.9 feet NAVD 88) and Edgewood Road lift station (10.2 feet NAVD 88) near Third Slough and Freshwater/Ryan Sloughs, and Sea Avenue lift station (10.0 feet) near Martin Slough may also be vulnerable and at risk from MAMW of 10.7 feet (NAVD 88).

In total, there are 10 stations, 11.2 miles of sewer line, and a minimum of 54 manhole covers (data on manhole covers from HCSD was not available) potentially vulnerable and at risk from tidal inundation by 2050.

2070

In the City, there are four more lift stations: Hill Street pump station (9.7 feet NAVD 88), Waterfront Drive lift station (10.7 feet NAVD 88), Washington Street pump station (10.3 feet NAVD 88), and McCullens Street pump station (10.4 feet NAVD 88) potentially vulnerable and at risk from MMMW of 10.9 feet (NAVD 88). The Y Street lift station (11.1 feet NAVD 88), Commercial Street lift station (11.8 feet NAVD 88), Golf Course lift station (11.0 feet NAVD 88), and Martin Slough pump station (11.0 feet NAVD 88) may also be vulnerable and at risk from MAMW of 12.0 feet (NAVD 88).

In the PA, there are three more stations: Hoover Road pump station (9.9 feet), Sea Avenue lift station (10.0 feet), and Edgewood Road lift station (10.2 feet) potentially vulnerable and at risk from MMMW of 10.9 feet. The Buhne Drive lift station (11.9 feet) may also be vulnerable and at risk from MAMW of 12.0 feet (NAVD 88).

All total there are seven more stations potentially vulnerable and at risk from tidal inundation by 2070.

2100

In the City, there are four more stations: Y Street lift station (11.1 feet NAVD 88), Commercial Street lift station (11.8 feet NAVD 88), Golf Course lift station (11.0 feet NAVD 88), and Martin Slough pump station (11.0 feet NAVD 88) may also be vulnerable and at risk from MMMW of 13.1 feet (NAVD 88), and now 17.8 miles of sewer lines, and 76 manhole covers potentially vulnerable and at risk from tidal inundation.

In the PA, there is one more lift station, Buhne Drive (11.9 feet NAVD 88), potentially vulnerable and at risk from MMMW of 13.1 feet (NAVD 88), and now 7.5 miles of sewer lines vulnerable and at risk from tidal inundation.

In total, there are five more stations, 17.8 miles of sewer line, and a minimum of 76 manhole covers potentially vulnerable and at risk from tidal inundation by 2100.

4.1.3 Susceptibility

The waste water treatment system at the WWTP is very susceptible to the adverse effects of sea level rise, especially tidal inundation. The biological treatment process and electrical systems are sensitive, whereas the collection system is not.

It is possible that increasingly long periods of ground saturation could result in settlement or movement of the pipes but, in general, the collection system (including the lift stations) are fairly insensitive to flooding and inundation. The lift stations and collection pipe networks exposed to tidal inundation will allow salt water into the collection and treatment system. This will hydraulically overload the collection and treatment system and cause a breakdown in the treatment process. If too much salt water is introduced into the treatment process, the biological system within the treatment plant will cease to function, resulting in a failure of the treatment process. The biological system is not able to cope with this sea level rise impact.

By 2050, 18% of the lift stations and 6% of the sewer lines in the City and 24% of the lift stations and 6% of the sewer lines in the PA could be tidally inundated based on the high projection for MMMW of 9.64 feet (NAVD 88). The percentage of lift stations that could be tidally inundated by 2100 increases to 45% and 15% for sewer lines in the City but just 28% for lift stations and 11% for sewer lines in the PA based on the high projection for MMMW of 13.1 feet (NAVD 88). In the City over 40% of the lift stations and sewer lines that could be tidally inundated by 2100 could be impacted by 2050, and in the nearly 90% of the lift stations and 50% of the sewer lines.

Electrical components of the lift stations are also very susceptible to being tidally inundated or flooded. If the electric supply and control systems are exposed to salt water, they are likely to malfunction. Protective adaptation measures could reduce adverse impacts to electrical systems.

The wastewater system was designed to withstand and adapt to the standard amount of stress from extreme weather events, and growing population demand. As extreme weather events occur more frequently than historically experienced, and sea level rise continues, the existing wastewater system infrastructure will not be easily able to continue operation without major system modifications based on newly developed design standards specific to our local conditions.

4.1.4 Consequence

The loss of functionality of the waste water treatment plant would be devastating to the entire City. If the I/I become too big of an issue, the City may opt to restrict the use of the collection system in the affected areas. This would seriously impact the residential, commercial and industrial uses of those areas and areas upstream that are tributary to those sections of the collection system. Future growth could also be impacted by loss of treatment capacity if the system has excessive I/I. If the treatment plant ceases to function, the impacts will be felt by all of the 45,000 users in the City and HCSD's service areas.

The Elk River WWTP is large and located to accept wastewater from the surrounding area. The collection system throughout the City and surrounding unincorporated area is designed to convey flows to the WWTP, making relocation of the plant likely infeasible by 2050. The expense associated with relocation of the plant, and complete redesign and installation of the collection system, is cost prohibitive for the City. In order to be protected in its current location, new structures will need to be built at the plant, and the collection system may need to be selectively fortified. It is likely that lift and pump stations at risk will need to be moved, elevated, or diked, to avoid tidal inundation.

Malfunctions at the waste water treatment plant potentially could result in untreated waste water discharges to the bay or sloughs that could result in the closure of commercial oyster operations and recreational uses of the bay. Such closures could result in significant loss of revenue to the fishing and mariculture industries, depending on the timing of the spills. The potential adverse impact will be to the surface water from raw sewage overflows and/or inadequate treatment at the plant. Sewage spills into the bay will have a large impact on public health, aquatic resources and recreational uses.

The consequences of the loss or impairment of the waste water collection or treatment system would be very significant, and unacceptable to the City and its PA. The consequences of degrading water quality as a result of untreated sewage discharges would be significant to commercial and recreational uses of Humboldt Bay.

4.1.5 Priority

While there is waste water infrastructure in both the City and its PA, there is just one WWTF serving the City and HCSD in the PA. The waste water system serving the City and HCSD in the PA is vulnerable and at risk from tidal inundation, by 2050. The loss or impairment of this critical system would a significant adverse impact to the City and Humboldt Bay region.

The priority ranking for lift stations by 2050 is 5 in the City and 6 in the PA, but by 2100 the ranking increases in the City to 6 and decreases in the PA to 3 (Figure 41). The priority ranking for sewer lines by 2050 and 2100 is 5 in the City and PA. By combining priority ranking for waste water lift stations and sewer lines for the City and PA for 2050 and 2100 generates a similar high ranking for both areas and planning periods.

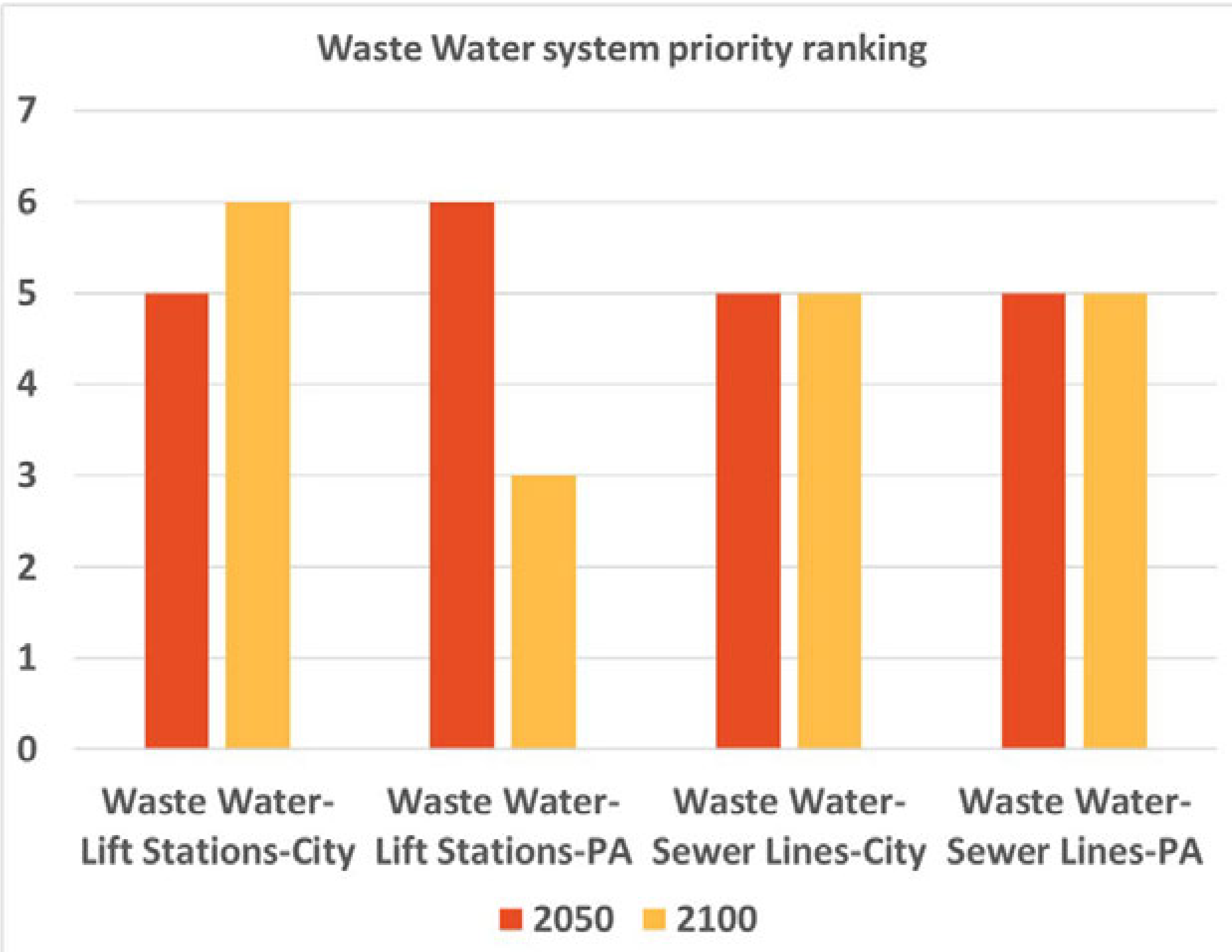

Figure 41.   Priority ranking of waste water lift stations and sewer lines in the City and its Planning Area for 2050 and 2100 that can be used to determine priority for adaptation planning.

4.2 Drinking (Municipal) Water

4.2.1 Description

In the City, municipal or potable water is supplied by Humboldt Bay Municipal Water District (HBMWD). The City provides potable water to customers within its jurisdictional boundaries, and in a few rare instances, to customers outside of the City boundary. The City's average annual daily system demand is approximately 4 MGD. The average peak month daily demand is just above 5 MGD.

In the PA, HCSD provides potable water to a substantial portion of the PA, with interconnections and agreements that make HCSD water infrastructure relevant to the City's overall water system. HCSD receives water from the HBMWD via its Truesdale pump station and from wells near the base of Humboldt Hill. HCSD customers' average water consumption is 2.6 MGD. The HCSD's average peak month daily demand is 3.2 MGD.

The City's municipal water supply infrastructure includes two main water transmission pipelines from Arcata to Eureka, storage and treatment systems, and distribution system. The City's distribution system is interconnected with the HCSD distribution system at various locations, including the Truesdale Street pump station. The City does not own any wells.

Water Supply

Potable water is conveyed from the HBMWD system to the City via the City-owned Mad River Pipelines (MRP). The MRP conveys water from the "Eureka Turnout" located at 7th and A Streets in Arcata (elevation 60 feet) to the City-owned Ryan Slough booster pump station, near the intersection of Myrtle Avenue and Mitchell Road (elevation 8.9 feet NAVD 88), in the PA (Figure 42). Water will flow from Arcata to the City's raw water reservoir (at Dolbeer and W Streets) without additional pumping, but the capacity of the MRP can be increased, as needed, by operating the Ryan Slough booster pump station. The two pipes that comprise the MRP (concrete-cased steel and HDPE) feed into a single 24-inch diameter ductile iron (DI) pipe at the pump station. That DI pipe also carries water to the Hubbard Street pump station owned by HCSD, which pumps the water into the rest of their system.

The City also has an intertie connection to the HCSD system at the "HCSD Turnout," in the City at the Truesdale Street booster pump station (elevation 9.7 to 10.1 feet NAVD 88). The HCSD pump station receives water via a HBMWD pipeline beneath Humboldt Bay. The station and system on the landward side is the HCSD's system. The HCSD's

27-inch pipeline is isolated from the City's distribution system by valves. The intertie allows backup and emergency water supplies of up to 2 MGD to flow either direction. It is rarely used and the valves are not exercised on a regular basis.

The entire length of the MRP are located outside of the City limits, traversing lands that the City does not own. The pipelines, valves, and access roads traverse 6 miles of low-lying areas, former tidelands protected by shoreline dikes, used for agriculture and wildlife lying east of U.S. Highway 101. The ground surface elevation along the route varies from 5 to 20 feet NAVD 88.

The original 24-inch diameter concrete-encased steel pipe was installed in the 1930's. A new 28-inch diameter, high density polyethylene (HDPE) pipe was installed parallel to the old pipeline in 2005 for redundancy and to increase the capacity of the delivery system. Both pipes are currently in service. The two pipes are joined through piping and valves at various locations along the route, allowing the City to isolate sections of the transmission line for maintenance and repair while still continuously supplying water to the City. HDPE pipeline has increased the capacity of the MRP from approximately 6.5 MGD to about 8.0 MGD and significantly increases the resiliency of the MRP.

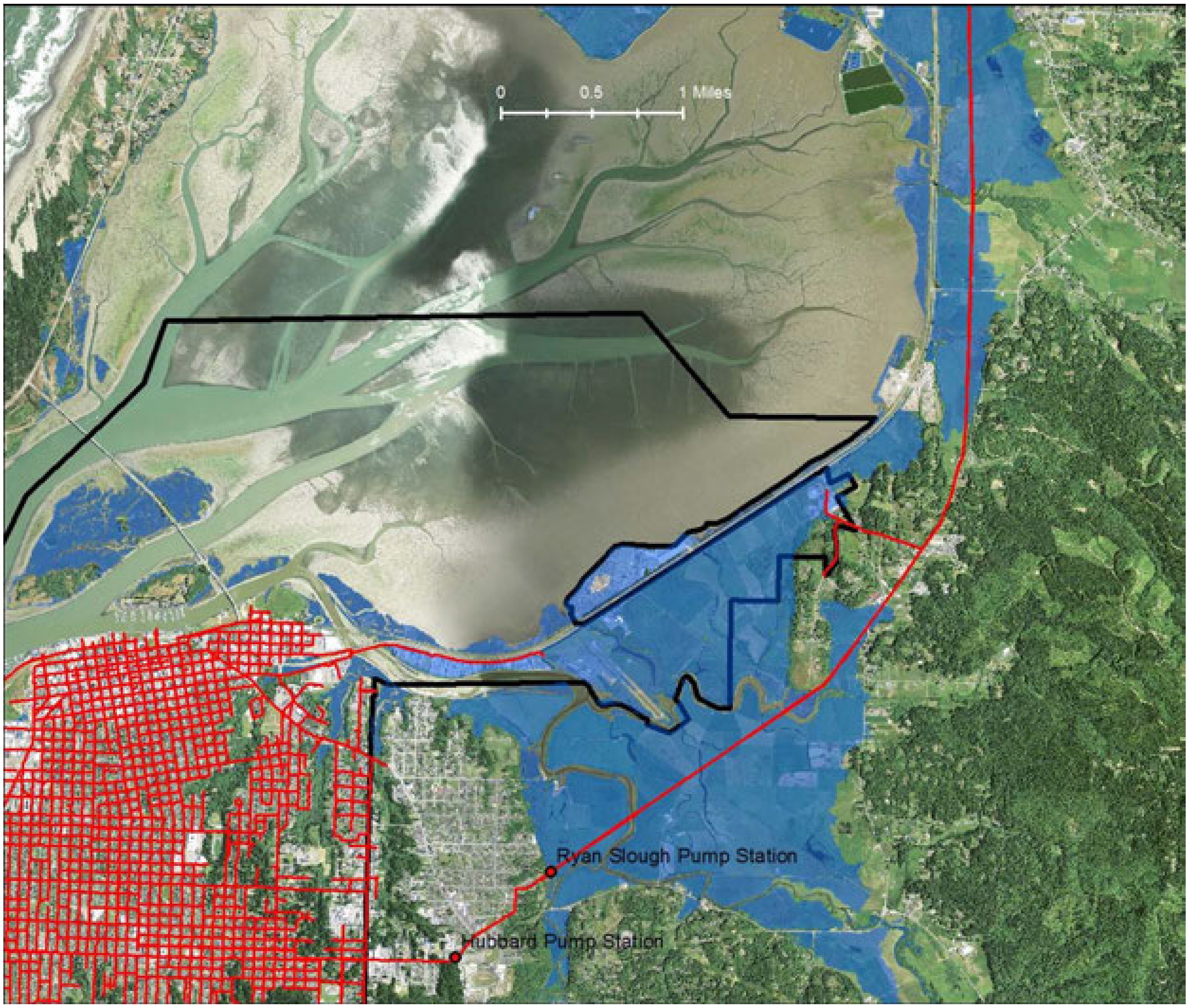

Figure 42. City of Eureka Mad River municipal water transmission lines, Ryan Slough and Hubbard pump stations, and City boundary with potential tidal inundation area for 2015 if dikes fail.

In the PA, the HCSD obtains water for its customers from three sources. The HCSD purchases one-third of its water from HBMWD via a water pipeline that runs down the Samoa Peninsula and crosses under the bay to the Truesdale water booster pumping station. This pipeline is the primary means that the HCSD receives water from HBMWD and has the capacity to supply 2.0 MGD. The HCSD recently purchased the remaining 1.0 MGD capacity of the pipeline in order to fulfill future needs. HBMWD water via HCSD supplies the central areas of Cutten and Ridgewood. The HCSD purchases another one-third of its water from the City through the Hubbard and Harris booster station. The City contract allows for 0.5 MGD delivery, up to 1.0 MGD if excess water is available, and supplies the northern areas of Myrtletown and Freshwater. The final one-third of HCSD potable water traditionally came from three HCSD-owned wells located at the base of Humboldt Hill. They are known as the Spruce Point, the South Bay, and the Princeton wells. These ground water wells supply potable water to the southern areas of Humboldt Hill, Pine Hill, King Salmon, Field's Landing, and College of the Redwoods. The ground water wells are approximately 400 feet deep. The Princeton well is no longer active. Its elevation is approximately 14 feet NAVD 88. The South Bay well has also been taken off-line temporarily to address an issue with coarse sand discharging with the water. The South Bay well is at approximately 10 feet elevation. Investigation and repair of the South Bay well is significant because it is the highest producing well (at approximately 700 gallons per minute, GPM) of the three District-owned wells. The Spruce Point well is active and has a capacity of approximately 470 GPM. It is situated at approximately 40 feet elevation NAVD 88.

Storage and Treatment

The City water reservoir and treatment system are located on Hemlock Street between Dolbeer and W Streets, in Eureka (elevation 180 feet NAVD 88). The raw water reservoir is a partially underground, covered, lined reservoir with a capacity of approximately 20 million gallons. The City's water treatment plant (located adjacent to the reservoir) provides chlorination and fluoridation treatment. Figure 43 shows the location of the City's reservoirs, their distribution system, and the interconnections with HCSD.

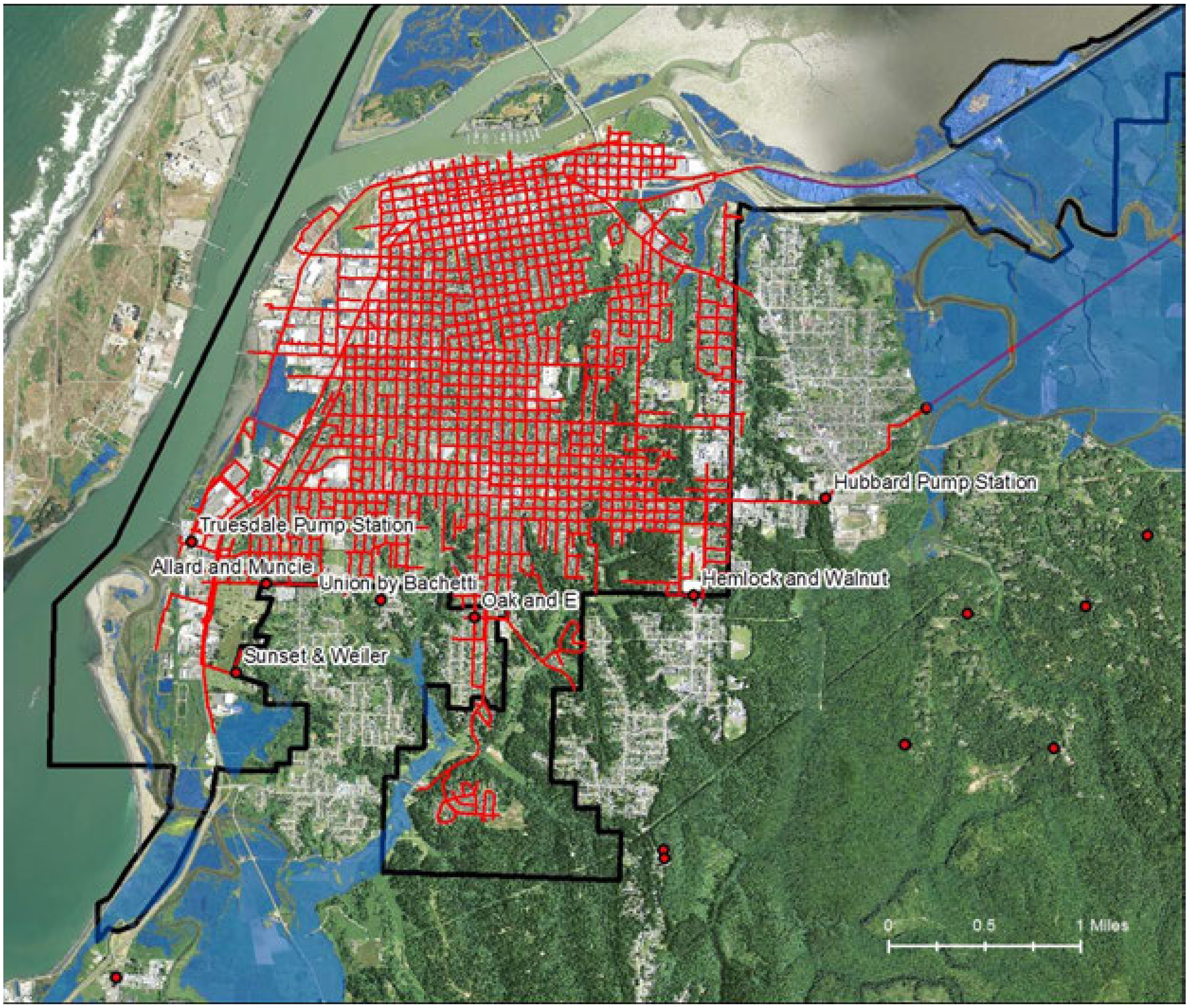

Figure 43. City of Eureka boundary, municipal water distribution system, with City and Humboldt Community Service District's reservoirs, their distribution system, the interconnections with HCSD, and with potential tidal inundation area for 2015 if dikes fail.

In the PA, HCSD total water storage capacity is 5 MG spread out over 10 storage reservoirs. Ground water treatment of the District-owned wells is achieved by chlorination at the well sites.

Distribution

The City water distribution system consists of underground pipe and valves, water meters, various storage tanks, backflow preventers, and booster pump stations. Water is supplied via an underground pipe network to two primary pressure zones: the low zone and the high zone. A 24-inch steel main supplies the low zone by gravity, and a

16-inch steel force main supplies the high zone with pumping. The high zone pumping capacity is 2,400 GPM. The low zone is fed by gravity from the 20-MG reservoir, with an increased capacity flow of up to 6,000 GPM when using two 50-HP vertical turbine pumps and one backup 100-HP pump. The distribution system's total storage capacity is 22.3 MG, comprised of a 20-MG raw water storage reservoir, a 1-MG ground-level steel tank, a 500,000-gallon ground-level steel tank, a 500,000- gallon elevated steel tank, and a 300,000-gallon clear well. The system storage could satisfy demand for the City between four and five days. The distribution system includes a smaller diameter pipe network, valves, meters, and backflow preventers. The City's distribution system has normal deficiencies for a system of its vintage, which includes aging piping materials, leaking pipes, and low-pressure and low fire-flow issues.

In the PA, HCSD distribution infrastructure consists of 14 different pressure zones, 87 miles of water main, 13 booster pumping stations, 10 water storage reservoirs, and 7 water interties with the City. The distribution system has an overall average system loss of 20%. The City's pressure grid is approximately 5 psi greater than the HCSD pressure grid. Service and supply interties capable of moving water from one service zone to another exist. However, the use of these interties is complicated by undersized transmission mains and storage capacity volume capable of serving multiple zones concurrently. HCSD is currently investigating the status of all City interties, but only one intertie at the Truesdale Street pump station is within the potential tidal inundation footprint for 2100 (13.1 feet NAVD 88).

Exposure

The exposure of the municipal water infrastructure (supply, storage/treatment, and distribution) to the effects of tidal inundation and rising ground water elevations and the potential impacts of these types of exposure are evaluated below (Table 14). In the City, storage and treatment components of the water system are well above the predicted inundation areas (high tank ground elevation 150 feet NAVD 88 and the underground reservoir on Hemlock Street at 195 feet NAVD 88) and are not expected to be exposed to impacts from sea level rise or flooding. In the PA, none of the HCSD storage tanks are within the predicted tidal inundation zone for 2100.

Table 14. Municipal water supply infrastructure and potential tidal inundation impacts in the City of Eureka and its Planning Area.

	Total Sites		Inundated by 2015		Inundated by 2030		Inundated by 2050		Inundated by 2100	
Domestic Water	**COE**	**PA**	**COE**	**PA**	**COE**	**PA**	**COE**	**PA**	**COE**	**PA**
Transmission Line (miles)	0	6.3	0	2.4	0	2.4	0	2.4	0	2.4
Pump-Booster Stations	1	4	0	0	0	0	0	1	1	1
Municipal Wells	0	3	0	0	0	0	0	1	0	1

In the City, portions of pipeline and components of the distribution system located in the industrial and commercial areas along the Eureka Waterfront are within the potential 2100 tidal inundation zone for the high projection of MMMW (13.1 feet NAVD 88). By 2100, 96% of the industrial property and 43% of the commercial property could be tidally inundated. Similar to the MRP transmission pipeline, the distribution water mains and valves are underground and may not be directly affected by salt water intrusion or rising ground water. The difficulty in accessing these components for maintenance and repair could impact the system over the long term. Above ground features such as fire hydrants and backflow preventers also need to be maintained and repaired, access could become a problem with rising tides. Some privately-owned water service meters, supply pipes, and hose bibs are also within the inundation areas and will be exposed to the effects of sea level rise. These items are typically underground and/or under pressure and so will not be directly impacted by salt water intrusion or rising ground water. If the supply system pressure drops, back syphoning of sea water in to the supply system could occur, contaminating parts of the distribution system. Water meters may also be difficult to read and could fail if they are repeatedly submerged in salt water. In the PA, by as early as 2030 (MMMW 8.64 feet NAVD 88) the municipal water distribution system operated by HCSD in King Salmon and Fields Landing, could be tidally inundated and by 2050 (MMMW 9.64 feet NAVD 88) the system operated by HBMWD in Fairhaven could become tidally inundated.

2015

In the PA, Figure 42 shows the area along the 6-mile route of the MRP that would be inundated if the existing dikes are breached (water elevation 7.7 feet NAVD 88). Surface elevations of the diked former tidelands (now agricultural lands) along the route range from roughly 4.0 to 6.0 feet NAVD 88. There are six hydrologic units that are currently protected from tidal inundation by earthen dikes. The diked shorelines in these sub-units are owned by numerous private and public entities that are responsible for their maintenance. A dike owned by DFW in the Walker Point area breached and the diked land where the City's MRP traverse is now tidal. DFW does not plan on repairing the dike. Approximately 4.9 miles of the earthen dikes that are protecting the MRP are rated highly vulnerable due to exposure from of erosion and overtopping by just 2 feet sea level rise (9.7 feet NAVD 88), the predicted MAMW elevation by 2030. The valves and corrosion protection systems for the pipelines must be accessed regularly for monitoring, maintenance and repairs. If the dikes were to breach today, much of the area that the pipelines traverse could become tidally inundated by up to two to three feet salt of water and access may become difficult to 2.4 miles of MRP.

Tidal inundation potentially could become more and more likely each year that dike maintenance is deferred and as the sea level rises, and especially during the times of year when MAMW, storm surges or heavy rains are occurring. Ground water elevations will rise along with sea levels and are already at the surface at some locations along the route. The low-lying areas will take on more pronounced wetland characteristics and the ground water (and surface water) may become brackish.

Tidal inundation, rising ground water and storm water flooding in and of themselves will not necessarily impair the ability of the pipes to convey water to the City's reservoir or into the HCSD system. For the most part the pipelines are buried underground and at many locations are already submerged in ground water.

The MRP crosses aerially over Freshwater Slough on a bridge structure. The HBMWD's pipeline that delivers water to the HCSD aerially crosses Mad River Slough and HCSD's pipeline aerially crosses Elk River Slough. These pipeline trestles could be exposed to damage from floating debris during MAMW and 100-year flooding events. Differential settlement of the pipelines caused by seismic liquefaction or the movement of saturated soils could distort and break the pipelines but this could occur even without sea level rise.

2030

By 2030, the high projection for MMMW is 8.6 feet NAVD 88 and MAMW is 9.7 feet NAVD 88. Tidal inundation of the diked former tidelands through which the MRP run could be three to four feet if the dikes are breached. As the diked former tidelands become saturated and/or tidally inundated, the access to the pipelines is likely to become more difficult and expensive. The access road to the Ryan Slough pump station could become tidally inundated if the dikes on Freshwater or Ryan Slough are breached. The access road to the HCSD's South Bay well could also be tidally inundated.

2050

By 2050, the high projection for MMMW is 9.6 feet NAVD 88, and MAMW 10.7 feet NAVD 88, and MAMW could overtop 48% of the dikes on Eureka Slough. Tidal inundation of the diked former tidelands could be 4 to 5 feet in depth. The Ryan Slough pump station is potentially vulnerable and at risk from tidal inundation if the dikes on Freshwater or Ryan Slough are overtopped (Figure 44).

In the PA, HCSD's South Bay well is at elevation 10.0 feet NAVD 88 and it is potentially vulnerable and at risk from tidal inundation (Figure 45). It is assumed that the wellheads and the annulus around the well casing are sealed now and would not allow salt water to enter the well. Impacts would fall into the categories of deferred maintenance and lack of access to complete repair work.

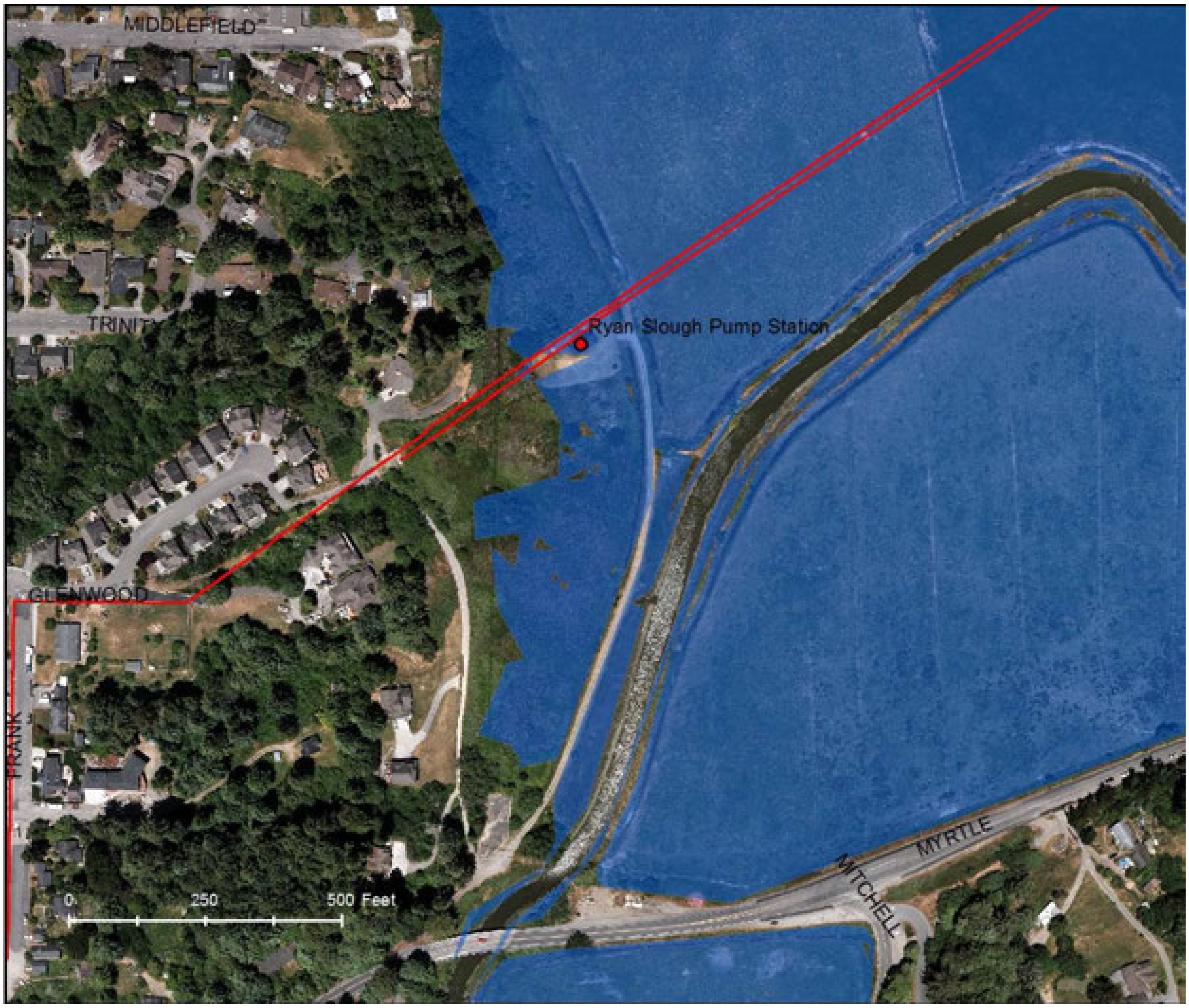

Figure 44. City of Eureka Ryan Slough municipal water pump station, and Mad River Pipe Lines that could potentially become tidally inundated by 2050 by the high projection for mean monthly maximum tides of 9.6 fee NAVD 88t, if the dikes are overtopped.

Figure 45. Humboldt Community Services District's South Bay municipal water well and the potential tidal inundation area by 2050 by the high projection for mean monthly maximum tides of 9.6 feet NAVD 88.

2070–2100

By 2070, MMMW could reach 11.0 feet NAVD 88 and the Ryan Slough and Truesdale pump stations could become tidally inundated (Figure 46). By 2100, with MMMW of 13.1 feet NAVD 88, nearly all of the dikes protecting the MRP potentially could be overtopped, resulting in 7.5 to 8.5 feet of tidal inundation.

The HCSD's Princeton well is located at an elevation of 14.0 feet NAVD 88 and is no longer used, but it could be tidally inundated by the high projection for MAMW in 2100 (14.14 feet NAVD 88).

Figure 46. Humboldt Community Services District's Truesdale municipal water pump station and inter-tie to the City of Eureka water system with the potential tidal inundation area by 2100 by the high projection for mean monthly maximum tides of 13.1 feet NAVD 88.

4.2.2 Susceptibility

The City and PA municipal water system is not very susceptible to tidal inundation by 2050, but by 2100 with a high projection for MMMW of 13.1 feet NAVD 88 the system would become susceptible as two of five booster stations could become tidally inundated. Indirectly the City's water system could become susceptible by 2050 as dikes that are vulnerable and at risk of breaching and may cause the areas that MRP lines traverse to become tidally inundated.

The City's MRP water transmission lines, the storage and treatment systems, and the distribution network are not very susceptible to the adverse effects of sea level rise. Although, the older pipes in the City's supply system (concrete-wrapped steel pipe) are chronically susceptible to corrosion if the cathodic protection systems are not maintained and from differential settlement, should the ground supporting the pipes become saturated and mobile, which is likely to happen with rising ground water and tidal inundation. Indirectly the City's municipal water system may be susceptible to tidal inundation if the City's ability to perform maintenance and emergency repairs of the water transmission lines is impaired. Without regularly scheduled maintenance and repair, the pipeline will develop holes and cracks. By 2050, one of the City's MRP lines will be approaching 100 years old and the probability of emergency repairs may increase at the same time that dikes potentially could be overtopped, the resultant tidal inundation would make access and emergency repairs very difficult. The newer transmission line will still be fairly resilient due to the materials with which it is made (high-density polyethylene). The City's MRP lines could potentially be tidally inundated now and becoming increasing vulnerable and at risk from tidal inundation by 2050 and 2100.

Booster pump stations include mechanical and particularly electrical systems that are very susceptible should they be tidally inundated. The mechanical systems (valves and pumps) need regular maintenance. The high projection for MMMW by 2050 9.64 feet NAVD 88 could tidally inundate one booster station in the PA and by 2100 when MMMW may rise to 13.1 feet NAVD 88 another booster station in the City could become tidally inundated.

Municipal wells are susceptible to tidal inundation. One of four municipal wells in the PA could potentially be tidally inundated by 2050 by the high projection for MMW of 9.64 feet MNAVD 88. Although the overall water supply infrastructure for HCSD is not very susceptible to tidal inundation.

4.2.3 Consequence

Providing a safe and reliable supply of drinking water to the residents and businesses of the City and in the PA is crucial. Any impairment in providing this service would be immediately unacceptable. There are no reliable backup sources of drinking water immediately available to the City if the transmission lines between Arcata and Eureka fail. Extreme water conservation measures and quick emergency repairs would be required.

If the dikes that are preventing tidal inundation of the areas that the City's MRP lines traverse fail, then getting trucks and heavy equipment to the MRP lines for emergency repairs may eventually become impossible. Deferred maintenance could cause long-term, chronic problems with the conveyance system, resulting in significant interruption of service and eventually complete failure of the system. The City has approximately five days of water storage. Repairs that take longer than this would be consequential to the City and likely necessitate drastic conservation efforts.

While the City in an emergency may be able to access water through the HCSD interconnections, it does not have a backup water supply capable of satisfying its needs and is therefore the consequence of having its water supply cut off would be significant.

The MRP water transmission lines are the primary conveyance of potable water to the City. Impairment of the conveyance capacity of these transmission lines would be catastrophic. The loss or impairment of the HCSD's South Bay well could result in a significant impact on the water supply in the PA. The Princeton well is no longer used and the Spruce Point well is not at risk. The HCSD would have to increase the amount of water purchased from the City and/or from the HBMWD.

The Ryan Slough pump station is integral to the conveyance of water to the City. The Truesdale Street pump station is a key component to the City's back-up conveyance system via the HCSD. Impairment of the conveyance capacity of these transmission lines would be catastrophic.

The City's MRP lines would not be damaged directly by tidal inundation. But if the MRP lines were ruptured, the length of time they would be out of service would be prolonged due to the difficulty of repairing underground water lines that are tidally inundated. After approximately five days of average use, the City would be out of water. The HCSD's Truesdale Street pump station includes an intertie with the City's system but the valve is not regularly exercised, and it is unknown if this is a viable backup supply at this time or in the future.

The City has created significant adaptive capacity to its water supply by the redundancy of two main water transmission lines, as well as by having a back-up supply from the intertie with HCSD's Truesdale Street pump station. But there is little adaptive capacity in the existing location of the water transmission lines when it comes to being able to carry out future emergency repairs of the water lines if they become tidally inundated.

4.2.4 Priority

The City's municipal water system has a high priority ranking, by 2050 it is 5 and by 2100 6. Exposure from tidal inundation increases from 2050 to 2100, while susceptibility and consequences remain constant.

4.3 Storm Water

4.3.1 Description

The City of Eureka is responsible for operation and maintenance of storm water collection, conveyance, and discharge infrastructure assets within the City jurisdiction as mandated by the Federal Clean Water Act, State regulatory agencies, and local planning goals and policies. Storm water runoff has increasingly been recognized as a significant source of pollution and flood hazard over the past few decades, and the role of the City in mitigating these potential impacts has developed over time as such. Unfortunately, the City's storm water drainage utility program is currently underdeveloped and underfunded. This condition increases the vulnerability and risk of assets protected by storm water infrastructure to impacts from sea level rise.

Storm water runoff is generated when rain lands on impermeable surfaces (such as asphalt or rooftops) or on ground that is already saturated. The storm water management facilities in the City convey runoff away from property and structures, off streets, into an underground conveyance pipe network, and natural or manmade open drainage channels that eventually discharge runoff into the bay or sloughs. Storm water runoff has the potential to impact water quality and cause flooding. The City has prepared and utilizes a Storm Water Management Plan (2005) for its storm water system because it discharges to listed water bodies, including Elk River and Freshwater Creek.

In the City, the Department of Public Works is responsible for maintaining most of the system. The drainage and conveyance systems along U.S. Highway 101 (Broadway, and 4th and 5th Streets) are maintained by Caltrans. In the PA, storm water infrastructure is under the jurisdiction of Humboldt County Public Works.

In the City, much of the conveyance pipe network is old and in a deteriorating condition. Parts of the pipe network do not have the capacity to convey the runoff that is generated. Some of the discharge points or outlets at the bay have tide gates that are failing to prevent tidal inundation of sea water or cause backwater flooding into natural channels, adjacent lands, or the storm water conveyance system. Currently, during light rain events and high tides some of the low-lying areas around the margins of the bay will flood because the discharge points and conveyance system is submerged or damaged, leaving the runoff nowhere to go.

A storm water collection system includes the streets, gutters, and drainage or drop inlets (DIs). Storm water runoff flows down streets and gutters and into the conveyance pipe network through DIs. If the conveyance pipe network is full or the DI is clogged, the runoff continues to flow downhill to the next DI or may backup and accumulate in low-lying areas, resulting in flooding.

The conveyance system is a network of underground piping consisting primarily of reinforced concrete pipe (RCP) with diameters ranging from 8 to 42 inches, with a total pipe length of approximately 25 miles. At regular intervals, manholes allow access to the pipe network and monitoring of the flows. The conveyance system includes the pipe network, man-made ditches, and natural tributary channels. The diameter of the pipe, and generally the width of ditches and natural channels, gets larger at points along the system to accommodate the increasing flow volumes. Eventually, the conveyance pipes discharge into ditches or natural channels, the bay, or one of the sloughs.

Storm water discharged into a ditch or natural channel or slough typically flows unrestricted out the end of a culvert or down an armored or natural channel to join the tidal flows in the slough. Storm water discharged into the bay typically flows out the end of the conveyance pipe into an armored channel or directly into the bay through a tide gate. Tide gates are installed on outfalls that discharge below the elevation of the high tide. They are a hinged and weighted gate that seals the end of the pipe and keeps tide waters from flowing back up into the conveyance pipe network. If the sea water in the bay and the storm water in the conveyance network are at the same elevation, the hydrostatic pressure will be the same on both sides of the tide gate and it will remain closed. The high tide back-pressure causes storm water to back up within the conveyance system, pipes or natural channels, to the same elevation as the high tide. As the tide goes out, the gate swings open to allow the storm water to discharge.

Of the 81 tide gates that have been identified on Humboldt Bay, 38 (47%) are located in the City and its PA. The City owns and maintains at least 16 tide gates along the bay, spanning the northeast region of Eureka Slough behind Murray Field Airport, to the southwest region of the City on Elk River Road. In the PA near King Salmon, Field’s Landing, Myrtletown, and Cutten, there are an estimated 22 tide gates that are privately owned, or are currently being maintained by the County.

The City and adjacent portions of the PA are segmented into 16 separate storm water drainage basins, hydrologic units, or watersheds, encompassing an area of approximately 7,034 acres (Figure 47, Figure 48, and Figure 49). The basins discharge into Elk River Slough to the southwest, Humboldt Bay to the west and north, and Eureka Slough to the northeast. The storm water system relies solely on gravity to move storm water from upland areas in the basins to low-lying discharge points (or outfalls), either to the bay or to one of the sloughs. The characteristics of each of the basins are described below.

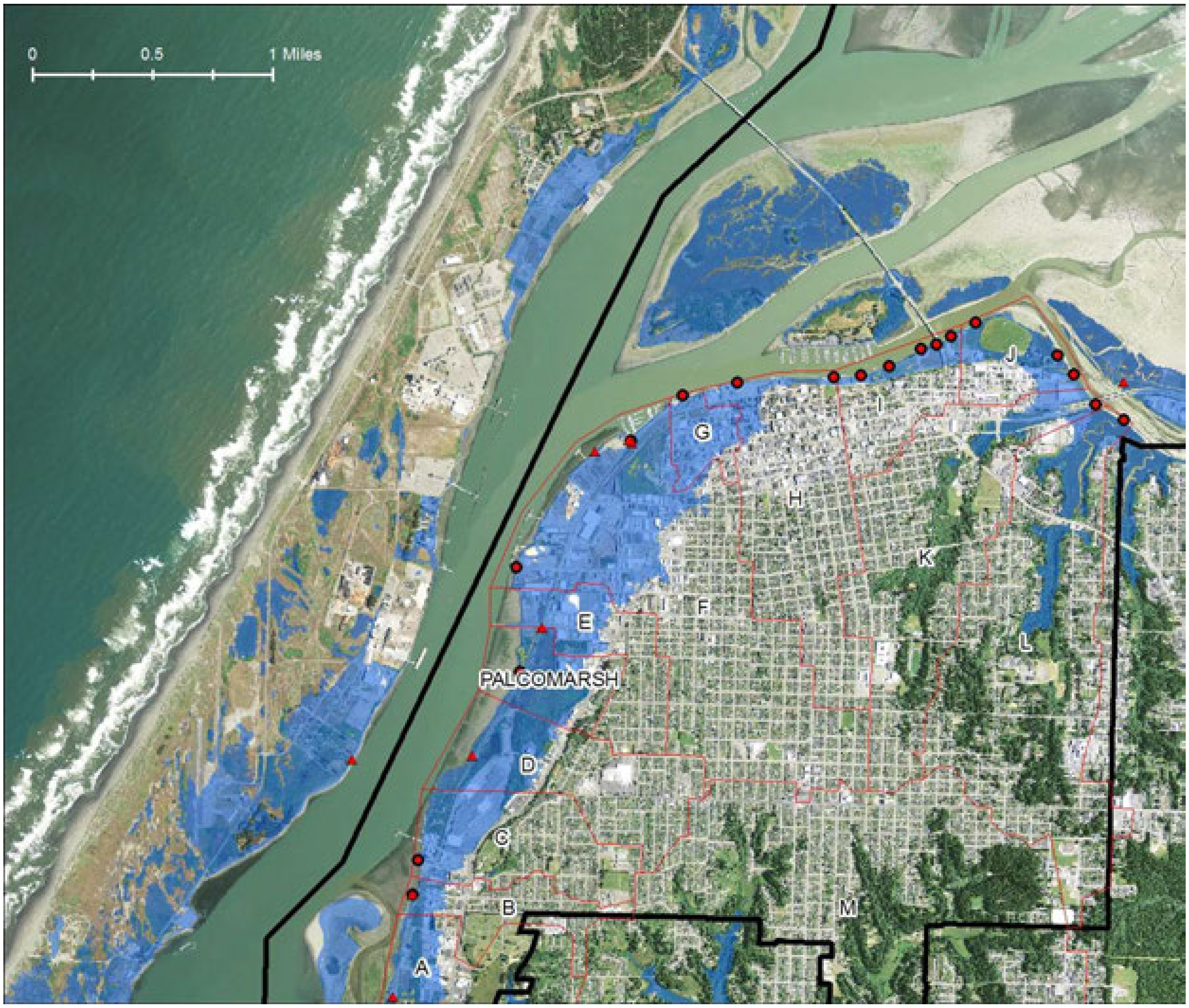

Figure 47. City of Eureka storm water basins A-L, outfalls (circles), and tide gates (triangles) and the area that could potentially be tidally inundated by 2100 by the projected mean monthly maximum tide of 13.1 feet NAVD 88.

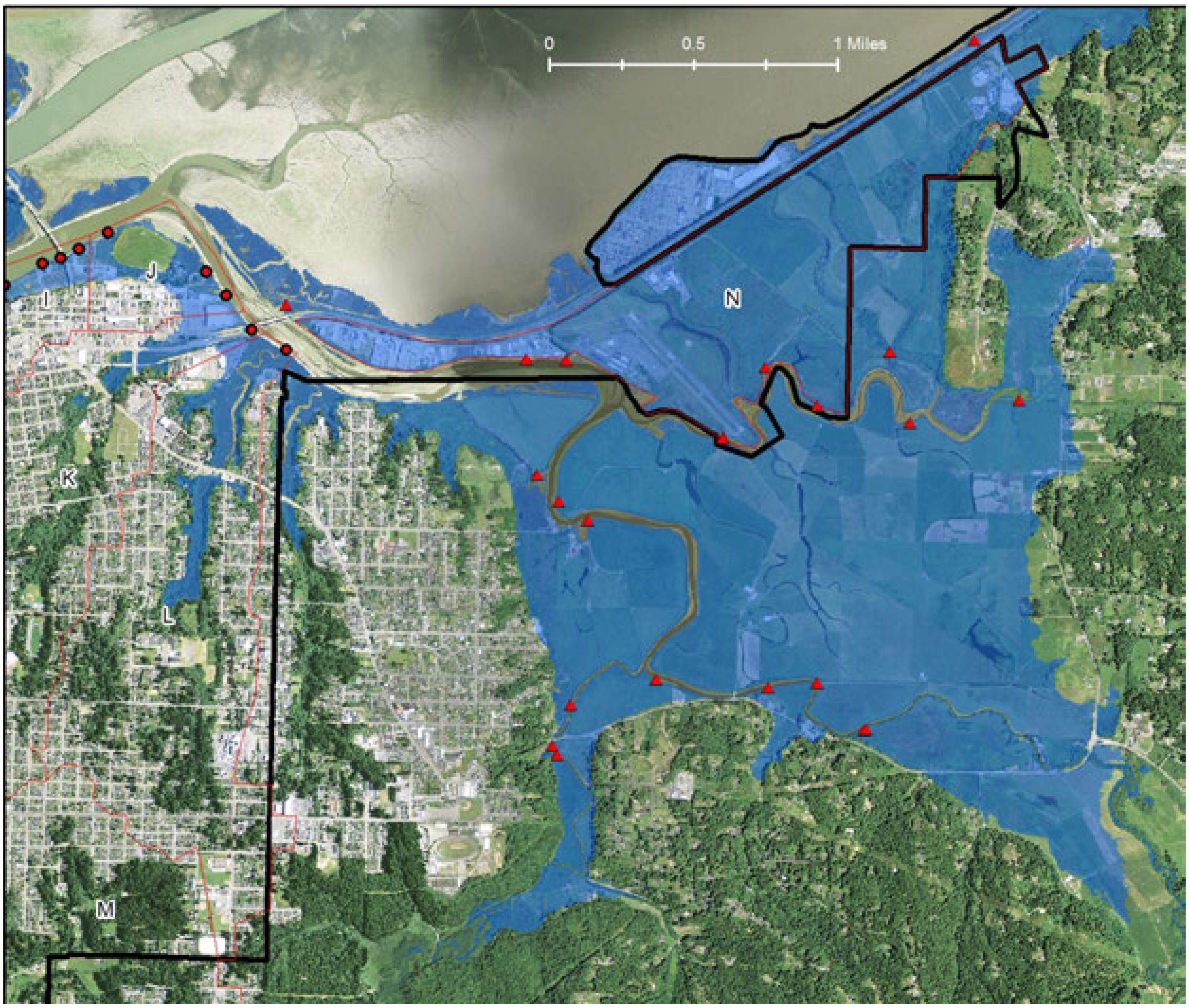

Figure 48.   City of Eureka and its Planning Area storm water basins J-M and N, outfalls (circles), and tide gates (triangles) and the area that could potentially be tidally inundated by 2100 by the projected mean monthly maximum tide of 13.1 feet NAVD 88.

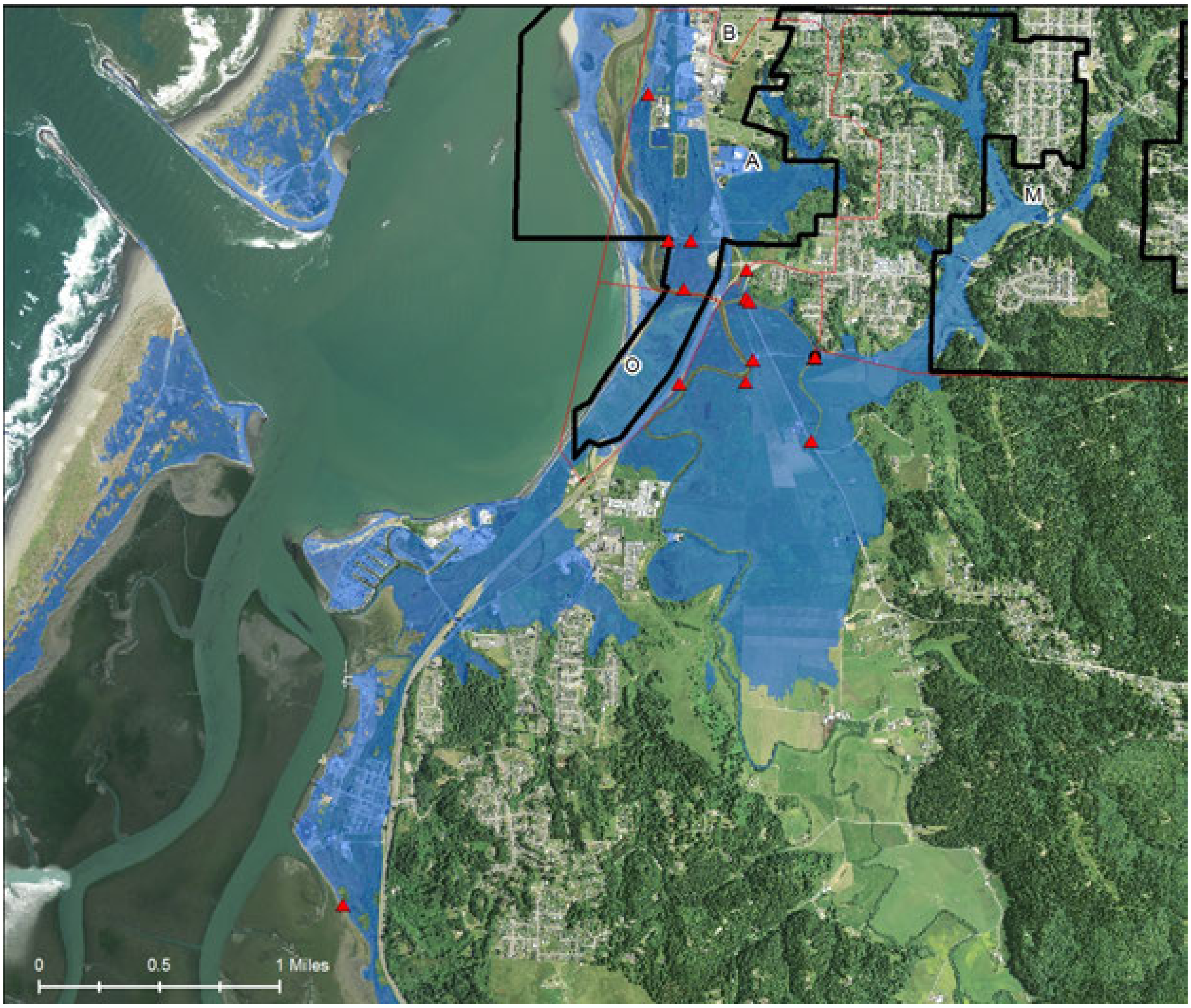

Figure 49. City of Eureka and its Planning Area storm water basins A, B, M and O, outfalls (circles), and tide gates (triangles), and the area that could potentially be tidally inundated by 2100 by the projected mean monthly maximum tide of 13.1 feet NAVD 88.

There are 19 designated outfalls in the 16 drainage basins that convey storm water through the City to the bay or sloughs. Interviews with City staff indicate that there are additional locations where storm water is discharged into water bodies that have not been classified at this time. Also, some of the designated outfalls have been destroyed or no longer function as the main storm water discharge point. Many of the designated outfalls are equipped with tide gates or culverts.

The discharge points or outfalls under the jurisdiction of the City or affected drainage areas in the City are associated with the 16 storm water basins described below, which have varying mixes of permeable (i.e., natural areas, agricultural lands, public areas, and undeveloped property) and impermeable surface areas (i.e., CDI, industrial, commercial, residential, streets and parking areas). There are no engineered storm water detention basins owned and maintained by the City to manage storm water runoff in these 16 basins. Each basin includes a collection system, conveyance system, and a discharge point.

Basin A

Basin A is at the southwest edge of the City and encompasses an area of 640 acres, much of which is composed of permeable surfaces (Figure 47 and Figure 49). It includes commercial property to the west of U.S. Highway 101 and a small residential area outside of the City limits but inside the PA. It also includes a natural area and a drainage channel into which runoff drains. Basin A also includes the Elk River Wastewater Treatment Plant and freshwater and inter-tidal wetlands. The low-lying commercial and natural areas are in the potential tidal inundation zones for 2030, 2050, and 2100, but the upland residential areas in this basin are not. There are 5 tide gates and 10 culverts that allow storm water to drain from these areas and prevent tidal water from entering them. The current condition of these structures is unknown.

Basin B

Basin B includes a residential area located east of U.S. Highway 101 that drains into a conveyance system above the projected 2100 tidal inundation area (Figure 47 and Figure 49). Basin B includes a series of culverts, drainage inlets, storm water mains, and associated manholes covering an area of 109 acres. It also includes CDI, commercial and industrial areas and a residential trailer park located west of U.S. Highway 101. The basin is nearly entirely developed except for the abandoned CDI property and railroad right-of-way. Other than these open spaces, there is no area to receive backwater or to retain storm water runoff. The area west of U.S. Highway 101 is in the potential tidal inundation zone for 2070 (11.0 feet NAVD 88) and 2100 (13.1 feet NAVD 88). This basin drains to the bay through a non-functioning tide gate that is believed to be permanently open.

Basin C

Basin C includes CDI and abandoned property on the waterfront, commercial property west of U.S. Highway 101, and a residential area located east of U.S. Highway 101 (Figure 47) that drains into a natural channel then through a conveyance pipe to a tide gate south of Del Norte Street that discharges to the bay (207 acres total). The residential area is above the projected tidal inundation areas for 2100. Retail stores and the Chevron bulk fuel terminal are located west of Broadway Avenue/U.S. Highway 101. These CDI and commercial areas and U.S. Highway 101 drain into abandoned CDI property and inter-tidal and freshwater wetland areas (Devil's Playground and Palco Marsh), which drain into the bay through tide gates. Palco Marsh is in the 2015 tidal inundation area and Devil's Playground is in the potential 2030 and 2050 tidal inundation areas and almost all of the rest of the area west of U.S. Highway 101 is in the potential 2070 (11.0 feet NAVD 88) inundation area.

Basin D

Basin D includes coastal wetlands, commercial property and a residential area located east of U.S. Highway 101 (Figure 47), above the potential 2100 inundation area that drains into a conveyance system and discharges into the Palco Marsh, covering 247 acres. Palco Marsh drains through a tide gate to the bay and is currently tidally inundated in 2015. The commercial properties on the west side of U.S. Highway 101 also drain into the Palco Marsh. The freshwater wetlands south of Bayshore Way could potential become tidally inundated by 2030. The Bayshore Mall and some commercial properties are in the potential tidal inundation zone for 2070 (10.9 feet NAVD 88). The commercial properties on Bayshore Way and south are in the potential tidal inundation zone for 2100, while the commercial property to the north along Broadway/U.S. Highway 101 is not.

Basin Palco Marsh

Basin Palco Marsh includes a small residential area east of U.S. Highway 101 (Figure 47), above the predicted tidal inundation area for 2100 (112 total acres). The residential area appears to drain into natural areas then under U.S. Highway 101 in culverts and into Palco Marsh, then through a tide gate into the bay. It also includes the Humboldt Waste Management Authority's (HWMA) Hawthorne Street transfer station. Palco Marsh is tidally inundated now in 2015; by 2070, the commercial areas south of Hawthorne Street could potentially be tidally inundated and by 2100, the west of Broadway also could start to be tidally inundated.

Basin E

Basin E includes CDI, commercial properties, and a residential area east of U.S. Highway 101 (Figure 47) that drains into pipes and an open ditch to a tide gate near the Del Norte Street pier, covering an area of 154 acres. The CDI and commercial properties west of U.S. Highway 101 drain into the same conveyance system and tide gate into the bay. There is also a coastal freshwater wetland north of Hawthorne Street and west of Felt Street. The basin is nearly entirely developed except for the coastal wetland. There is no area to receive backwater or to retain storm water runoff other than this wetland. By 2070, the CDI and commercial properties west of Broadway Avenue potentially could become tidally inundated by MMMW of 11.0 feet NAVD 88 and almost all of this area is could be tidally inundated by 2100 (13.1 feet NAVD 88).

Basin F

Basin F is 699 acres with CDI property and the abandoned Balloon Track along the waterfront and Industrial and Commercial properties west of Broadway (Figure 47). Residential areas east of Broadway are above the tidal inundation area for 2100. Basin F's conveyance system discharges to the bay through two separate discharge points, one of which is controlled by a tide gate. The basin is nearly entirely developed except for the abandoned Balloon Track, which functions as a de facto open space. Other than this open space, there is no area to receive backwater or to retain storm water runoff.

By 2070, tidal inundation is predicted to affect CDI, industrial, and commercial properties up to an elevation of 10.9 feet west of Broadway Avenue. Nearly all of the basin west of Broadway is expected to be tidally inundated by 2100.

Basin G

Basin G consists of 57 acres of CDI, commercial and residential properties located north of 7th Street and west of D Street to the bay (Figure 47). It includes a conveyance system of underground pipes that discharges to the bay near the end of A Street. The basin is nearly entirely developed except for the railroad right-of-way. Other than this open space, there is no area to receive backwater or to retain storm water runoff. The shoreline in the vicinity of A Street is predicted to be overtopped by 2030, with increasing tidal inundation of 9.6 feet extending south to 3rd Street by 2050. By 2070, potential tidal inundation of 11.0 feet could reach 4th Street and over to D Street; by 2100, MMMW is projected to be 13.1 feet and could reach nearly to 5th Street.

Basin H

Basin H covers 357 acres between C and J Streets (Figure 47). The basin is mostly residential south of 6th Street and commercial north of 6th Street. The area drains to a conveyance system of underground pipes and into the bay at two outlets through culverts near the foot of C and J Streets. The basin is nearly entirely developed except for an area next to the waterfront between C and F Streets. There is no area to receive backwater or to retain storm water runoff. The residential areas are above and outside of the potential MMMW inundation area for 2100. A small portion of the commercial district north of 4th Street over to D Street could be inundated by 2070; by 2100, a slightly larger section over to E Street could be included in the tidal inundation area.

Basin I

Basin I covers an area of 130 acres total from J Street to S Street (Figure 47). Storm water drains through a conveyance system of underground pipes and ditches. This basin has five designated outlets with culverts on the bay. One of the outfalls is believed to have been destroyed (eastern most outfall in basin), and is no longer identifiable. The area north of Waterfront Drive includes undeveloped open space. This open space area could receive backwater or detain storm water runoff, but there are no developed storm water detention basins. This is the only area in Basin I potentially vulnerable and at risk from tidal inundation by MMMW of 13.1 feet NAVD 88 by 2100.

Basin J

Basin J lies east of State Highway 255 and covers 107 acres north of 5th Street to the bay and over to Eureka Slough (Figure 47). Similar to Basin I, potential tidal inundation from MMMW of 13.1 feet NAVD 88 by 2100 is could occur predominately north of Waterfront Drive and the railroad grade, affecting mostly undeveloped property along the bay and slough. By 2070, potential tidal inundation of 11.0 feet NAVD 88 potentially could cover the residential properties north of the railroad grade and commercial properties east of Y Street. By 2100, potential tidal inundation of 13.1 feet NAVD 88 could expand west towards X Street. There are three designated outlets, two draining to Eureka Slough and one to the bay. Storm water drains through a natural conveyance system that often floods, creating a natural detention system for runoff. Other than the open space areas north of the railroad grade, there are no developed storm water detention basins.

Basin K

Basin K includes U.S. Highway 101 (4th/5th Streets couplet), commercial property along the couplet, and mostly residential areas around Cooper Gulch and Eureka High School (464 acres total; Figure 47). Those areas drain into the gulch mostly through surface flow. Some parts of the basin are supported by conveyance systems of underground pipes and ditches that discharge into the gulch. Other than Cooper Gulch open space, there are no developed storm water detention basins. There are no tide gates and only the lower section of the gulch is currently subject to tidal inundation below Myrtle Avenue. By 2070, the commercial area east of Y Street north of U.S. Highway 101 could potentially become tidally inundated.

Basin L

Basin L is very similar to Basin K but larger. It covers 646 acres and drains to Second Slough, a tributary of Eureka Slough (Figure 47). It includes commercial properties near Eureka Slough, and mostly residential areas and open space inter-tidal wetlands along the slough. The upland property areas discharge into the slough, mostly through surface flow. Some parts are supported by underground pipe conveyance systems that discharge into the natural areas leading to the slough. The inter-tidal wetlands on Second Slough and its channel upstream of Myrtle Avenue are open space that can serve as detention areas, but there are no developed storm water detention basins. There are no tide gates. The slough is currently subject to tidal inundation up to Myrtle Avenue, which is a tidal barrier, and the area above is fresh water. By 2070 and 2100, the commercial property currently an RV park could potentially become tidally inundated.

Basin M

Basin M is the largest storm water basin, covering an area of 2,326 acres. It is located partly in the PA (Figure 48, Figure 49). It drains predominately residential areas in the Martin Slough watershed. The residential areas discharge mostly through surface flow, through underground culverts and piping, into the slough. Other than the open space in the alluvial bottom land on Martin Slough and its upstream channel, there are no developed storm water detention basins. Martin Slough is protected from current tidal inundation by a tide gate at Swain Slough and an unfortified dike along Swain Slough. If the dikes on Swain Slough are breached, Martin Slough could become tidally inundated up through the Eureka Municipal Golf Course. By 2070, potential tidal inundation could reach the northern Fairway Drive crossing on Martin Slough.

Basin N

Basin N, the Eureka–Fay Slough unit, is in northeast Eureka across Eureka Slough (Figure 48). Basin N encompasses approximately 584 acres of land paralleling U.S. Highway 101. This basin is composed of diked former tidelands. A large portion is owned by the State of California and managed as a wildlife reserve. Much of the undeveloped area in this basin can serve as a storm water detention area. A CDI property west of U.S. Highway 101 in the PA drains to this sub-unit through Caltrans' drainage system. There are three commercial areas in the basin: Jacobs Avenue, Harper Motors, and Indianola. Humboldt County owns and operates the Murray Field Municipal Airport. Portions of the basin drain west to the Caltrans drainage along U.S. Highway 101, and through a double tide gate to Eureka Slough. There are two tide gates on the County's property that drain east to Eureka and Fay Slough, and two tide gates on the wildlife reserve draining east to Fay Slough.

Basin O

Basin O includes City property and private property in the PA that covers 195 acres primarily used for agricultural grazing (Figure 49). This basin is separated from the bay by the railroad grade and shoreline fortifications, and from Elk River to the north by an upland reach, and by U.S. Highway 101 to the east. Runoff from the highway drains in to the basin. There are no developed storm water detention basins. A tide gate allows surface water runoff to discharge into Elk River during low tides.

4.3.2 Exposure

The storm water infrastructure that may be impacted by the effects of sea level rise include those portions of the collection system, conveyance system, and discharge points that are close to the bay and/or are situated below 14.1 feet NAVD 88, the high projection for MAMW by 2100. The mode or pathway for tidal inundation of areas in the City and PA that are vulnerable can be from: rising tides overtopping the shoreline of the bay and sloughs, or from rising tides encroaching upstream in the City's 16 storm water drainage basins and inundating adjacent low-lying areas.

Sea level rise will delay drainage and result in backwater that will affect conveyance pipes or natural or man-made drainages that may flood adjacent property if overbank discharge occurs. Most of the residential areas in the City are located in the upper portions of the drainage basins above 14.0 feet NAVD 88 and not subject to the effects of sea level rise. Most of the commercial and industrial areas are located on the waterfront along the margins of the bay and are subject to inundation by higher tides and rising ground water elevations. The Jacobs Avenue area in the Eureka–Fay Slough unit is located behind dikes on former tidelands that are below the elevation of current MMMW of 7.7 feet NAVD 88. Storm water drainage from this low-lying area is prolonged during high tides. Some areas are also already impacted during MAMW and storm surges. Backwater flooding areas have not been modeled or mapped by this project.

Many of the areas in the City and PA that potentially could be affected by sea level rise contain natural drainage areas, such as stream or slough channels, and storm water related infrastructure, such as the tide gates, conveyance pipe networks, drop (or drain) inlets, gutters and streets. Drainage channels without tide gates that connect to tidal waters (bay or slough) allow tidal inundation to occur upstream. Rising sea levels may allow tidal inundation to occur farther upstream and overbank in adjacent low-lying areas. With sea level rise, drainage channels or conveyance pipes with functioning tide gates may remain closed for longer periods of time. Some of these features may experience regular tidal inundation, and a mixture of storm water and sea water will back up in the conveyance system and flood streets, parking lots, buildings and vacant land. Increased drainage time during storm water runoff events may likely cause water elevations to rise and flooding to occur in adjacent low-lying areas. Eventually, rising sea levels could keep tide gates closed permanently.

The collection and conveyance systems are not expected to be significantly impacted by the effects of sea level rise. They are designed to be wet and inundated with water. Likewise, rising ground water elevations and salt water intrusion will have little effect on their functionality. The problem with rising sea levels is that the storm water runoff will only drain out of the system to the surface water elevation of the bay and can backflow into the system through malfunctioning tide gates and drainage ditches.

Top hinged tide gates are prone to getting stuck partially open or closed and require regular maintenance to keep them functioning. If a gate is stuck closed, it will keep tide waters from entering the conveyance pipe or the protected areas behind the dikes, but it will also keep the storm water runoff building up behind the dikes from discharging into the bay. The resulting flooding would not dissipate as the tide goes out but would be trapped behind the closed tide gate. If the tide gate is stuck open, the rising tide would inundate the conveyance system and areas protected by the dikes and run back out as the tide drops. In reality, the tide gates usually get stuck in a partially open condition. The result is a muted tidal cycle with the areas slowly and only partially filling and draining, a little out of sync with the tides.

Functioning tide gates and intact dikes will reduce the backflow of sea water into the storm water system and tidal inundation in the areas protected by the dikes. Without functioning tide gates, the conveyance system acts as a tide water inundation pathway, back feeding natural drainage systems and culverts, underground storm mains, and overflowing out of the DIs.

All of the drainage basins have some predicted impact areas. Most of the impacts are limited to the commercial and industrial areas, in the lower sections of the basins near the discharge points. There is expected to be very little impact in the upper elevation residential areas.

2015

Flooding and tidal inundation of low-lying areas and streets occurs now during combined high tide and rain events. Assets vulnerable and at risk from MMMW of 7.7 feet NAVD 88 include streets and buildings, with a total storm water basin inundation area of approximately 920 acres in 2015, given failure of water control structures and protective dikes. Natural storm water basin discharge points are beginning to migrate inland as a result of rising tides for Basin M on Elk River Slough, and for Basins J, K, and L on Eureka Slough. The storm water system within Basin N is likely experiencing flooding impacts from sea level rise now, but there is not enough information for this area to provide an accurate analysis.

2030

By 2030, the flooding and tidal inundation of areas are predicted to increase, resulting in inundation of approximately 1,084 acres, which would temporarily limit access to streets and buildings. Flooding along sections of Waterfront Drive and Second Street in Basins G and H during light rain and high tide events is expected to increase. Furthermore, drainage of Railroad Avenue and Koster between Washington and 14th Street (Basin F) could be impaired by flooding and tidal inundation.

2050

By 2050, 1,195 acres are predicted to be impacted from flooding and tidal inundation. Palco Marsh drainage will likely be impacted by flooding and tidal inundation and this would affect the neighboring wetland area, as well as Humboldt Waste Management Authority (Section 4.8).

2100

By 2100, access limitations are expected to increase, with an estimated 1,819 acres inundated by the MMMW of 13.1 feet NAVD 88. All designated storm water discharge points and associated water control structures in each basin are predicted to experience longer periods of time under water or be submerged due to higher high tides and low tides.

4.3.3 Susceptibility

The storm water infrastructure would be adversely affected by tidal inundation from sea level rise and flooding from 100-year storms. It will cease to function not because it is damaged but because of the change in system hydraulics. With nowhere to go, storm water will back up into the lower sections of the collection system and high tides will back flow up the conveyance system, inundating the same low-lying areas, roads, and property affected by storm water. All of the tide gates will be adversely affected by rising tide elevations.

A number of actions can be taken by the City to delay and/or avoid flooding due to storm water and tidal inundation. Some of these actions include:

- Repair and/or maintain the existing tide gates and conveyance system.
- Install new tide gates on outfalls that do not have them.
- Fortify and elevate the shorelines and dikes that may be overtopped or breached by the king tides, storm surges, or rising sea level.
- Reduce the amount of storm water runoff entering the collection system. This can be accomplished by installing Low Impact Development (LID) features such as permeable pavement, rain gardens, and vegetative strip in the collection areas. These work to retain the rain water where it falls by percolating it into the soil.
- Delay the peak discharge of runoff into the system by constructing detention basins in the collection areas. Detained runoff is slowly released into the system over a longer period of time, flattening the hydrograph and reducing the peak discharge flow rate. This may also reduce surface flow and increase drainage into the ground, helping to alleviate regular street flooding events.
- Manage the storm water with pump stations. The conveyance system could discharge into ponds or underground tanks/vaults situated in low-lying areas. The collected runoff could be pumped over the dikes and into the bay rather than allowed to discharge by gravity. As the sea level rises past a certain point, this type of system may be required as the gravity discharge points will always be submerged and storm water will not be able to escape.
- Move storm water discharge points and associated control structures inland.

Repair and maintenance of the tide gates is a short-term fix that is relatively inexpensive, and could provide protection from inundation and flooding through 2050, when the high projection for sea level rise is 1.9 feet. Fortifying the shoreline and dikes is another temporary solution, but will be more expensive. After 2050, the tide gates and dikes are expected to become less and less effective and the City may have to start detaining and pumping the runoff out of the low-lying areas. The LID features and detention basins would help to alleviate the effects of flooding but would not address tidal inundation.

4.3.4 Consequence

Functional loss of the storm water drainage system could significantly impact the residential, commercial, and industrial users in low-lying areas that are within close proximity to the bay and sloughs. Impairment of the storm water drainage and control system may likely cause temporary street closures due to flooding, and contribute to unregulated pollution point discharges. Buildings may be damaged by flooding as a direct result of storm water system failures. Natural discharge points that are not fortified or equipped with a tide gate may migrate further inland as a result of rising tides. The consequences of an impacted storm water system will be less to those land uses and development not in low-lying areas of the City and its PA.

4.3.5 Priority

There are 19 designated outfalls (17 tide gates) in the 16 drainage basins that convey storm water through the City to the bay or sloughs, and 26 tide gates in the PA. The storm water infrastructure that may be adversely impacted by the effects of sea level rise include those portions of the collection system, conveyance system, and discharge points that are close to the bay. By 2050, all of the tide gates are expected to be adversely affected by the high projection for sea level rise of 1.9 feet, and 1,460 acres in the City may be susceptible to flooding. By 2100, the high projection for sea level rise is 5.4 feet and existing stormwater infrastructure is likely to be significantly impaired.

The outfalls for the drainage basins will be exposed and their performance impaired by 2050, increasing with rising tide elevations through 2100. The susceptibility of the system will also increase with rising tide elevations. The consequences to the City and in the PA will be significant in low-lying areas. The priority ranking for the storm water system by 2050 is 5 and by 2100 6.

4.4 Energy

4.4.1 Description

In the City and PA, energy infrastructure is composed of electrical, natural gas, and bulk fuel facilities. These energy facilities are all privately owned. In the City, energy facilities include Pacific Gas and Electric (PG&E) Humboldt Bay Generating Station (HBGS), electrical sub-stations, electric transmission towers and distribution poles, and natural gas transmission and distribution lines. The City does own and operate a few small-scale energy generation systems that offset energy costs for certain City facilities using biogas and solar photovoltaic systems, through net metering agreements with PG&E. In the City and PA, the major supplier of bulk fuel for the Humboldt region is Chevron, via its Eureka Terminal. Fuel delivery is by marine transport via a barge. The Tosco Refinery (formerly Conoco Phillips) bulk fuel terminal in the City was used historically for receipt of petroleum products, but is no longer in operation.

Located in the PA, PG&E provides electrical service and natural gas service to the City and surrounding unincorporated areas. PG&E owns the majority of electricity generation capacity, the electrical transmission towers and distribution poles, and natural gas lines. Energy infrastructure assets within the PA include the HBGS in King Salmon, DG Fairhaven Biomass Power Plant on Samoa Peninsula, five electrical transmission substations with associated power lines, one major natural gas compressor station, and four natural gas regulating stations with associated pipelines. Also in the PA is the former Humboldt Bay (Nuclear) Power Plant (HBPP), located next to PG&E's HBGS. The HBPP is currently being decommissioned but will continue to serve as a nuclear materials storage site. Also at the PG&E King Salmon property is an independent spent fuel storage installation (ISFSI), which contains spent nuclear fuel rods from the former HBPP.

Electrical

In the City, PG&E has electrical transmission and distribution infrastructure. There are two electrical substations (Eureka A and Eureka E) east of Short Street between 14th and 15th Streets, ranging in elevation from 9.9 to 11.9 feet NAVD 88, and overhead and underground high voltage (12kV to 138kV, nominal) lines, and transmission towers and distribution power poles (Figure 50).

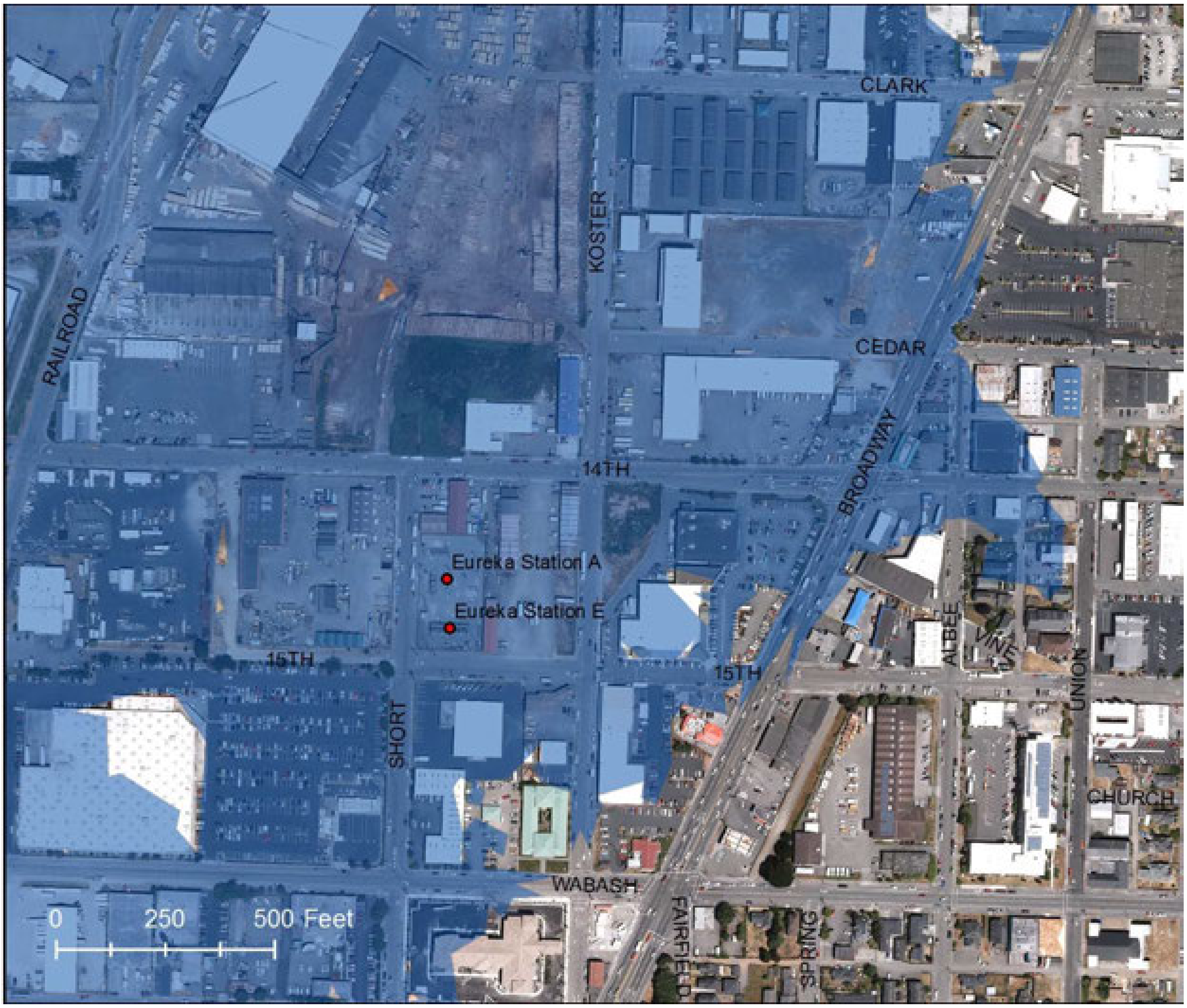

Figure 50. City of Eureka PG&E electrical substations A and E and access streets that could potentially be tidally inundated by 2100 by mean monthly maximum tides of 13.1 feet NAVD 88.

The City owns a few electrical generation systems that help to offset onsite electricity requirements. These systems include the Fisherman's Terminal Building solar PV system, Corporate Yard solar PV system, and Elk River Wastewater Treatment Plant cogeneration system. The City does not currently own any net electricity generation equipment capable of back feeding the grid with a net positive excess of electricity, and there are no additional privately owned commercial electrical generation facilities in the City.

In the PA, commercial generation of electricity is provided by two facilities located in King Salmon and Fairhaven. PG&E's HBGS is a local natural gas-fired power plant in King Salmon, across from the entrance of Humboldt Bay (elevation 12 feet; Figure 51). It is the major electrical generation station supplying power to the City, as well as Humboldt County through high voltage overhead transmission lines (69 kV and 138 kV, nominal) to sub-stations and then through 12 kV distribution lines supported by numerous wooden distribution poles. HBGS is a 163 MW electric generation facility consisting of 10 Wartsila 18V50DF 16.3 megawatt (MW) reciprocating engine-generator sets and associated equipment that are suited to changes in demand and in the intermittent supply of renewable electricity. In the PA, there are three electrical substations: The Humboldt Bay substation in King Salmon, ranging in elevation between 9.6 to less than 10.9 feet NAVD 88; the Harris substation, located above 15.0 feet NAVD 88 and above the projected tidal inundation elevation for 2100, and Humboldt substation on Mitchell Heights Drive, also above 15.0 feet NAVD 88. The HBGS is supplied with natural gas via an underground onsite 10-inch-diameter, high-pressure, natural gas pipeline owned and operated by PG&E, which is critical to HBGS's continued operation. The HBGS uses approximately 2,400 gallons of water per day (2.7 acre-feet/year) on average for cooling or other industrial purposes. HBGS discharges industrial and sanitary wastewater into the HCSD sanitary sewer system at an average rate of about 860 gallons per day. Raw water for industrial processes and site landscape irrigation is supplied from PG&E's existing ground water well via a direct connection to an onsite 6-inch-diameter water pipeline. Domestic water required for non-process uses is provided from a 4- to 6-inch-diameter on-site pipeline running 1,200 feet to a connection with the existing HCSD line that runs along King Salmon Avenue.

Figure 51. City of Eureka's Planning Area, with PG&E's HBGS, HBPP, Humboldt Bay electrical substation and ISFSI that could potentially be inundated by 2100 by mean monthly maximum tides of 13.1 feet NAVD 88.

The DG Fairhaven Power Company's biomass plant is also in the PA. It is an 18 MW electric generation facility located on Samoa peninsula (elevation 19 feet NAVD 88). Since operations began in 1987, the power generated has been supplied to PG&E under a long-term power purchase agreement. The plant uses over 250,000 tons of various forms of wood waste from local sawmills and forest operations annually.

Humboldt County has two major connections to the larger state-wide electric grid. These connections are critical to the City, as well as the County, and are located within the City's PA. High voltage electrical transmission lines are shown in Figure 52, along with electrical substations, and power plants. The total electrical transmission capacity into Humboldt County through the existing transmission lines is approximately 70 MW, less than half of the county's current peak demand. Therefore, continued local generation of electricity is critical to meeting electrical demand of the City and PA. In the City and PA, in addition to the high voltage systems, stepped down-12 kV over-head and underground electrical transmission lines, and pole-mounted and ground-mounted electrical transformers, feed commercial, industrial, governmental, and residential customers on nearly every City block and extend out to the majority of rural properties.

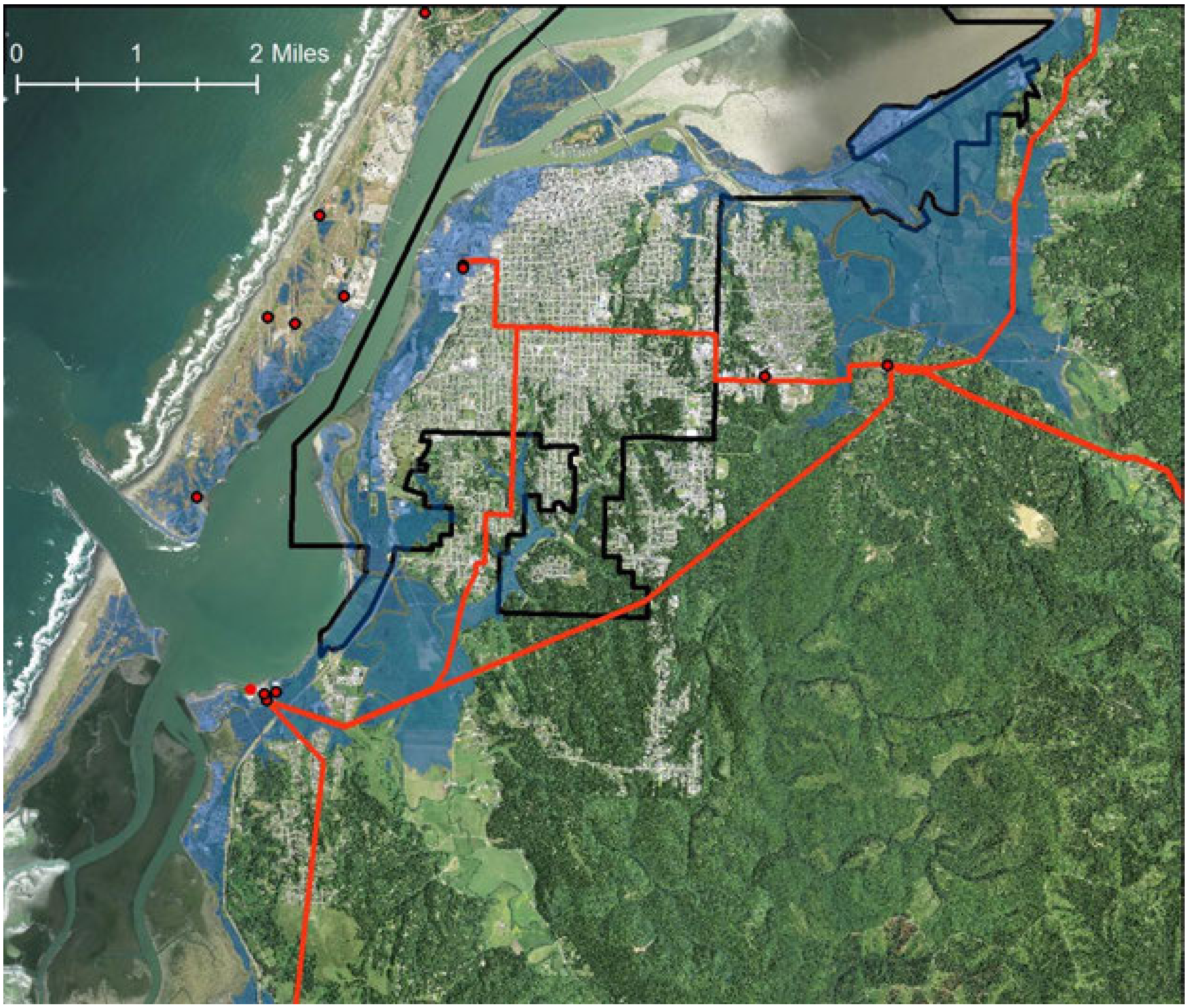

Figure 52. City of Eureka and Planning Area, with PG&E's power plants and electrical substations and high voltage electrical transmission lines that could potentially be inundated by 2100 by mean monthly maximum tides of 13.1 feet NAVD 88.

4.4.2 Exposure

In the potential MMMW inundation zone for 2100 (13.1 feet NAVD 88), electrical facilities, generating stations, and sub-stations could be exposed to tidal inundation and flooding. Rising ground water could also cause flooding of underground infrastructure. It is not known if the HBGS facility has been designed to withstand the impacts of direct tidal inundation, and whether emergency response procedures will be sufficient to safeguard employees from arc fault and additional hazards associated with high voltage electricity generation. Electric transmission towers and distribution poles in low-lying areas could be destabilized by tidal inundation and rising ground water. Pole-mounted electrical distribution lines, transformers, and service panels run throughout low-lying areas along the bay and across Eureka and Elk River Sloughs. Diked former tide lands and other low-lying areas could potentially be tidally inundated if the shoreline structures fail resulting in: loss of adequate support of poles and guy wires due to increased and continuous soil saturation, exposure of ground mounted transformers and electrical equipment to salt water and flooding causing burnout, and increased rates of equipment corrosion. Tidal inundation caused by dike failure or rising tide elevations may limit maintenance access to electrical infrastructure during high tide and extreme weather events, leading to prolonged power outages, or may eliminate access all together.

In the City, there are no commercial electrical generation facilities.

In the PA, commercial electrical generation facilities are located at Fairhaven on the Samoa Peninsula and in King Salmon. The Fairhaven facility is above the high projection for sea level rise by 2100 (13.1 feet NAVD 88). The King Salmon electrical facilities (HBGS and Humboldt Bay substation) are less than 13.1 feet NAVD 88 and could potentially be tidally inundated by 2100. The King Salmon electrical facilities are located in an area that is connected to Humboldt Bay via a former inlet canal to the south and protected from Humboldt Bay on the north by a fortified shoreline. The electrical generating infrastructure at King Salmon ranges in elevation between 11.0 and 14.3 feet NAVD 88. The King Salmon electrical facilities are vulnerable and at risk from tidal inundation, and may be structurally compromised by rising ground water levels and regular tidal inundation.

The HBPP a former nuclear power site, is located at the King Salmon site in an area ranging in elevation between 9.6 to 10.9 feet NAVD 88. Tidal inundation of this site could potentially occur should the shoreline of the former inlet canal be overtopped. Nuclear contamination of the site could be mobilized and discharge into Humboldt Bay in the event of tidal inundation of the former HBPP. However, the level of contamination is currently unknown, as decommissioning and remediation of the site has commenced. The ISFSI that contains the spent nuclear fuel rods of the HBPP is located above 14.3

feet NAVD 88, which is above the high projection for sea level rise by 2100, and that facility may not be impacted by tidal inundation, but the high projection for the 100-year storm in 2100 is 15.2 feet NAVD 88.

2015

In the City and PA, major electrical transmission and distribution systems are located on diked lands in Eureka and Elk River Sloughs, which are less than 7.7 feet NAVD 88. The diked lands are vulnerable and at risk from MMMW tidal inundation if the shoreline structures are breached or overtopped. If these areas are tidally inundated, water depths could reach 2 to 3 feet during high tides.

2050

In the City, access from 14th Street to Eureka E & Eureka A electrical substations could be affected by tides rising to 9.6 feet NAVD 88. Access will remain via Short and 15th Streets.

In the PA, many of the dikes in Eureka (17%) and Elk River (77%) Sloughs protecting major electrical transmission and distribution systems are vulnerable and at risk of being overtopped by MMMW of 9.6 feet NAVD 88. Indirect vulnerability of the HBGS to tidal inundation by 2050 stems from water and sewer utilities exposure of HCSD underground assets that serve the King Salmon area. Sewage lift stations that convey waste water from HBGS to the City's WWTP may be susceptible to failures caused by I/I issues that are exacerbated by tidal inundation and rising ground water levels, including; longer pump run times, pipe and pump corrosion, and control equipment malfunction. PG&E and HCSD wells that serve the facility may experience salt water intrusion or be impaired by corrosion.

2070

In the PA, nearly half of the dikes in Eureka (48.2%) and almost all of the dikes on Elk River (92.4%) Sloughs protecting major electrical transmission and distribution systems are vulnerable and at risk of being overtopped by MMMW of 11.0 feet NAVD 88. Under existing road conditions, tidal inundation of King Salmon Avenue potentially could occur by 2070 as tides rise 3.2 feet. King Salmon Avenue is the only point of land based ingress and egress to the HBGS and HBPP/ISFSI facilities. The Humboldt Bay substation and HBPP could also be tidally inundated from overbank flows via the former inlet canal to the south.

2100

In the City, Eureka E & Eureka A electrical substations, which are less than 13.1 feet NAVD 88, could potentially be tidally inundated by MMMW, as could all of the access roads to the substations. In the PA, the HBGS could potentially be tidally inundated by MMMW of 13.1 feet NAVD 88. Buhne Point and the ISFSI could become an island separated from the mainland. By 2100, nearly all of the dikes (97%) in Eureka Slough could potentially be overtopped and the major electrical transmission towers and distribution poles could be tidally inundated by up to 8.0 feet. The electrical generation plant at Fairhaven due to its high elevation is not predicted to be tidally inundated in 2100.

4.4.3 Susceptibility

Electrical facilities are very susceptible to tidal inundation and flooding.

In the City and PA electric transmission towers and distribution poles in diked low-lying areas could be destabilized by tidal inundation and rising ground water. Areas protected by earthen dikes are vulnerable and at risk from tidal inundation now and increasingly with high projections for sea level rise from 2050 (1.9 feet) to 2100 (5.4 feet). Tidal inundation of these diked lands could significantly impact transmission and distribution support structures.

Electrical substations are very susceptible to tidal inundation and flooding, and by 2100 three out of five substations may be tidally inundated. The electrical generation capacity and transmission from the HBGS may be adversely impacted by 2070, flooding of electrical equipment, facilities, and substations could be significant and may affect electrical transmission. Current access to the HBGS via King Salmon Avenue may also be flooded. By 2100, large portions of the King Salmon HBGS facility could be tidally inundated, based on the high projection for sea level rise of 5.4 feet.

4.4.4 Consequence

The sustainability of the City and PA is predicated on having secure and reliable electricity. The stability of the transmission towers and distribution poles are essential to delivering electricity to the City and PA. These electrical distribution structures can be made resilient to tidal inundation. A loss of functionality or impairment of the HBGS from tidal inundation would reduce the overall electricity generating capacity of Humboldt County by approximately 80%. The impacts to the electrical transmission and generating facilities would be significant to the City and in the PA.

4.4.5 Priority

By 2050, sea level rise impacts are not likely to the electrical infrastructure other than the transmission and distribution structures which are vulnerable and at risk from tidal inundation should protective dikes fail. Electrical facilities are very susceptible to tidal inundation and flooding. By 2100 sea level rise impacts to the system could be significant and the loss or impairment of generating and transmitting electricity to the City and in the PA would be consequential. The priority ranking for electrical system in 2050 is 2 but by 2100 it would 6.

4.5 Natural Gas

4.5.1 Description

In the City, PG&E has underground natural gas pipelines that traverse the City along Broadway, Albee, and 14th Streets (Figure 53) and along U.S. Highway 101 in the Eureka–Fay Slough unit (Figure 54). In the PA, PG&E's natural gas infrastructure includes underground pipelines ranging in size from 3 to 12 inches in diameter that traverse Elk River Slough, Martin Slough (Figure 55), and Eureka Slough, four regulating stations, and one major compressor station (located near the HBGS). Humboldt County has one connection from the south to the larger state-wide natural gas grid. This connection is critical to the City and Humboldt County, and supplies fuel to the HBGS. The exact location of natural gas regulating stations and the compressor station has not been made available for this Assets-At-Risk analysis. In addition to the systems shown, underground natural gas distribution infrastructure and regulators supply individual customers with service within the City and PA.

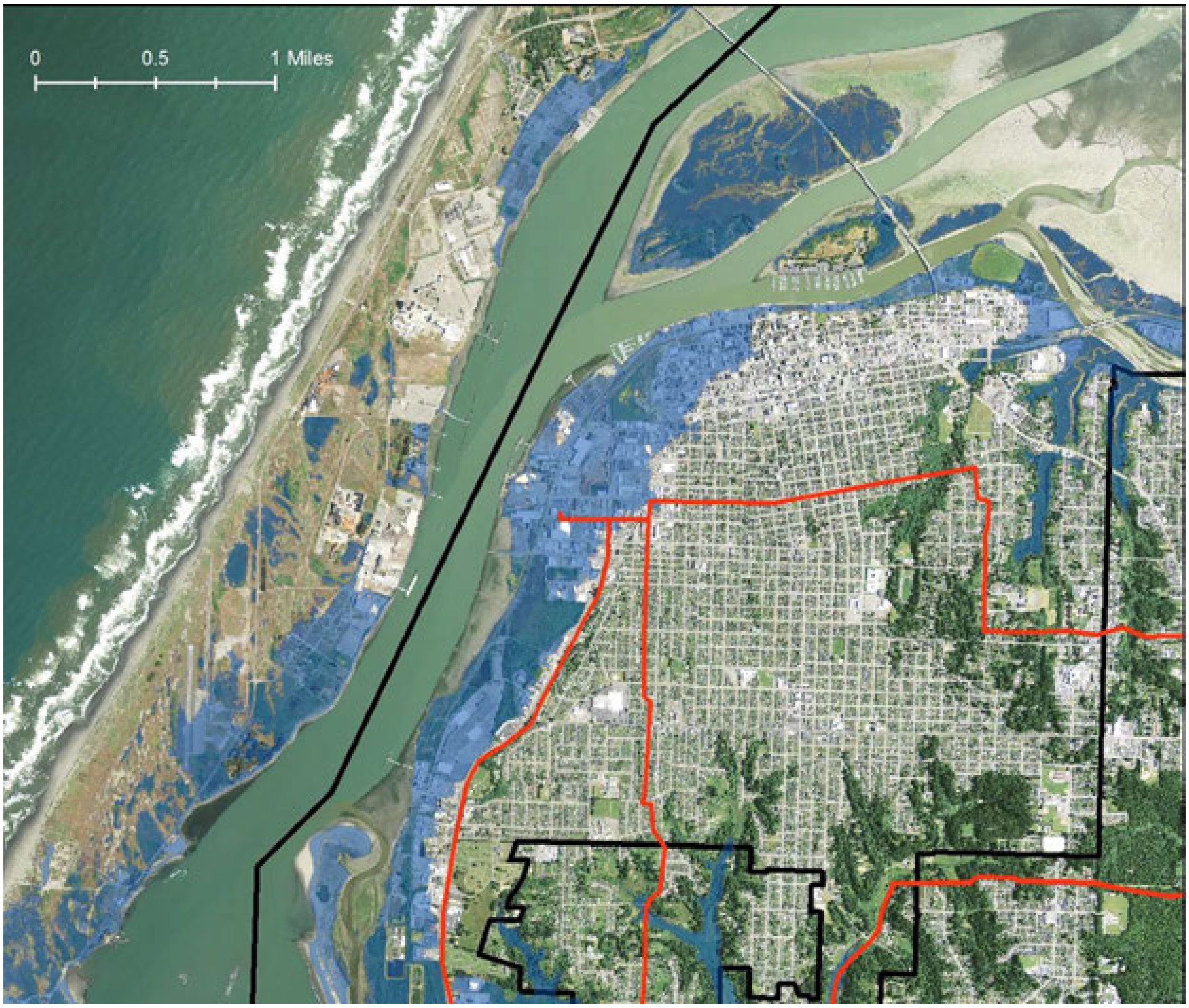

Figure 53. PG&E natural gas transmission lines in the City of Eureka and high projection for mean monthly maximum tides (13.1 feet NAVD 88) potential inundation area by 2100.

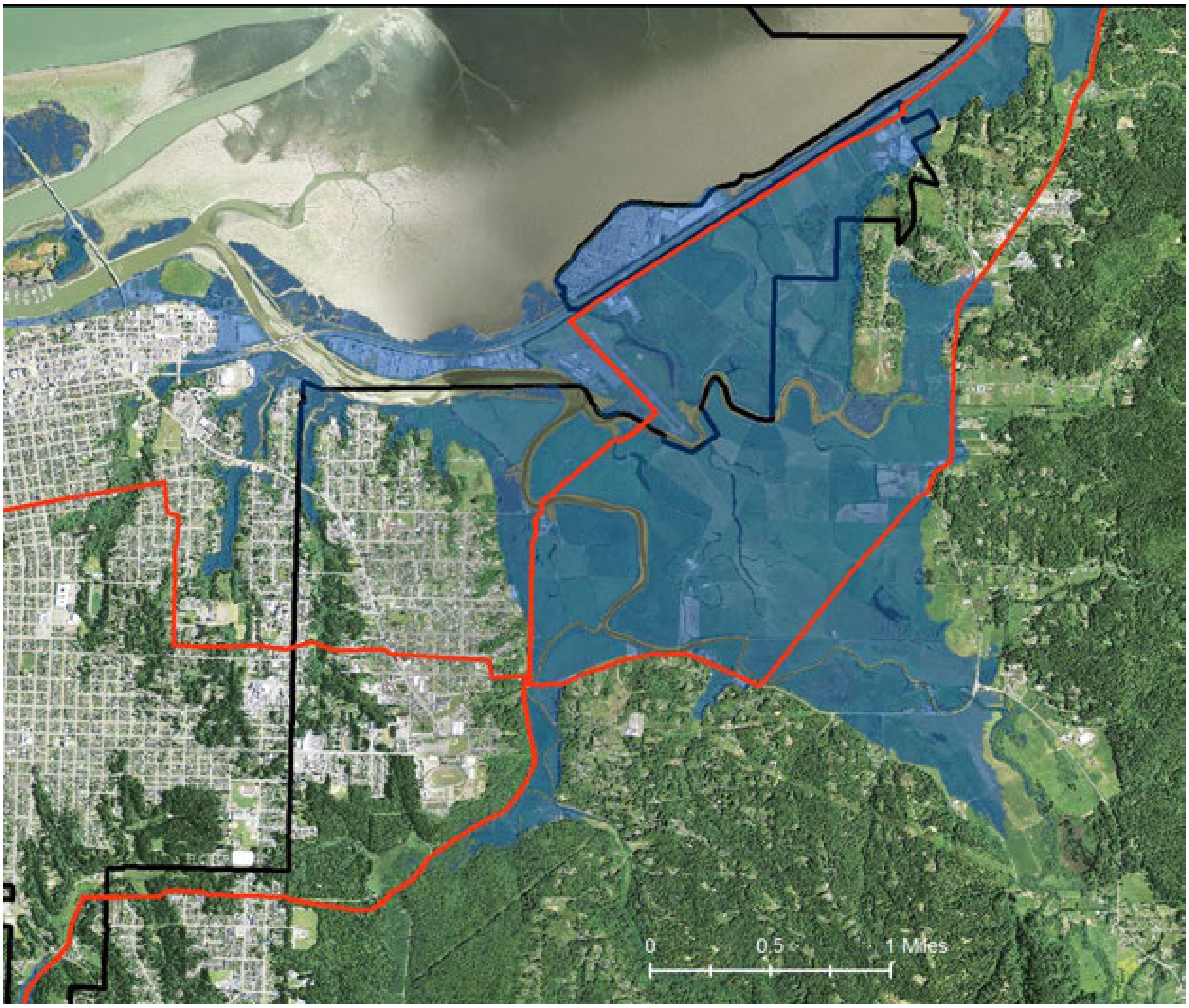

Figure 54. PG&E natural gas transmission lines in the City of Eureka and its Planning Area and high projection for mean monthly maximum tides (13.1 feet NAVD 88) potential inundation area by 2100.

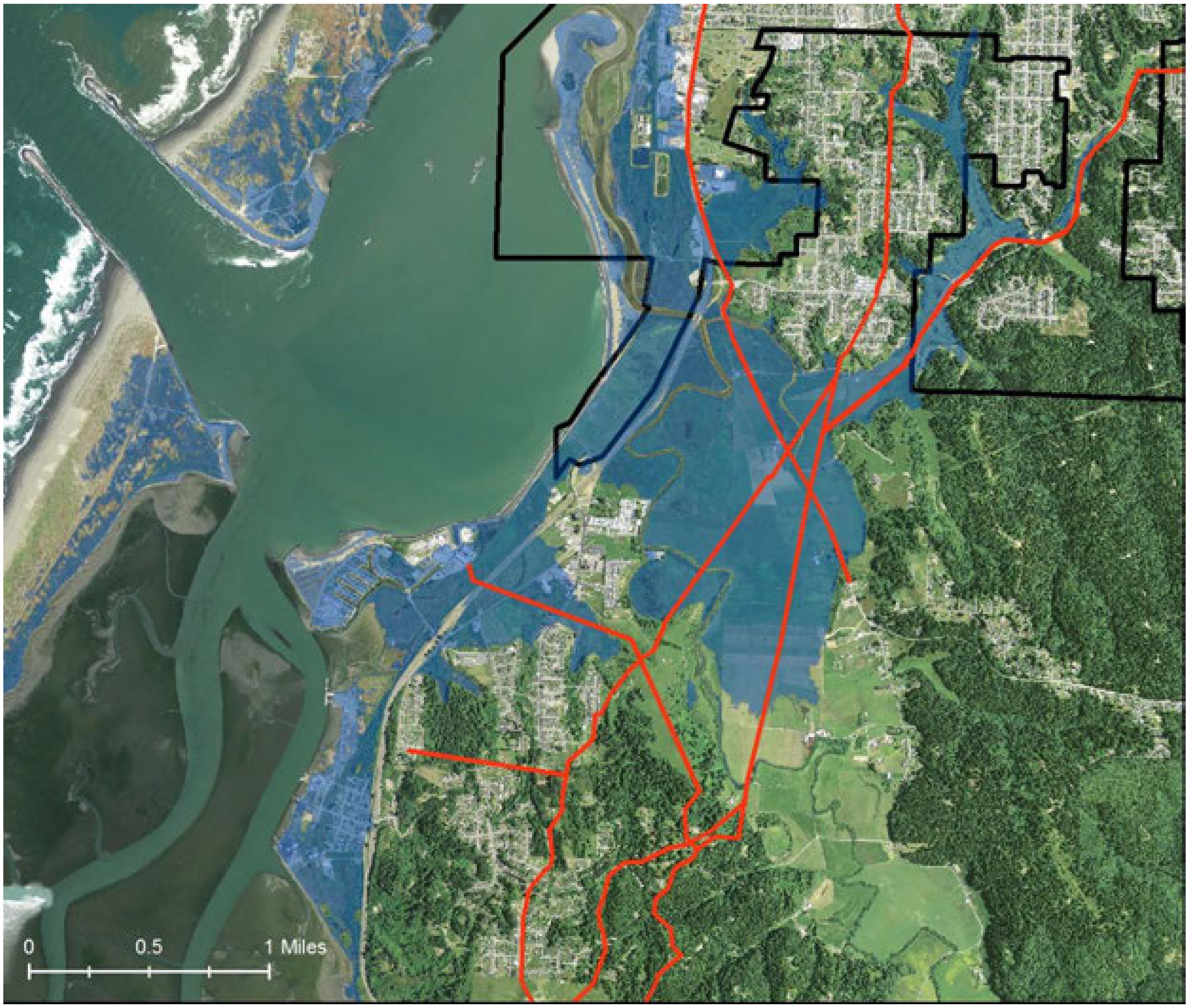

Figure 55. PG&E natural gas transmission lines in the City of Eureka and its Planning Area and high projection for mean monthly maximum tides (13.1 feet NAVD 88) potential inundation area by 2100.

4.5.2 Exposure

Natural gas transmission and distribution systems within the City and PA are vulnerable and at risk from tidal inundation as they are located in low-lying areas and can experience loss of access by maintenance personnel during tidal inundation and storm water-created flood events. Additional detail is unavailable at this time, as this is a privately owned asset. We have not been able to secure specific natural gas infrastructure descriptions, or address exposure of natural gas infrastructure to potential impacts of sea level rise. We need verifiable descriptions of the material composition, age, condition, depth, and so on, of the natural gas system to provide more details to the exposure section.

2015

In the City and PA, natural gas transmission and distribution systems are located on diked lands in Eureka and Elk River Sloughs that are vulnerable and at risk from tidal inundation if the shoreline structures are breached or overtopped. If these areas are tidally inundated, water depths for the MMMW (7.7 feet NAVD 88) could reach 2 to 3 feet.

2030

In the City and PA, natural gas transmission and distribution systems located on diked lands in Eureka, Elk River, and Martin Sloughs are vulnerable and at risk from tidal inundation as tides potentially rise 1.9 feet to an elevation of 8.6 feet NAVD 88. Should the dikes breach, the low-lying areas behind these dikes could have water depths of 3 to 4 feet during MMMW, making maintenance and emergency repairs difficult.

2050

In the PA, many of the dikes in Eureka Slough (17%) and Elk River Slough (77%) protecting natural gas transmission and distribution systems are vulnerable and at risk of being overtopped by MMMW rising to 9.6 feet NAVD 88.

2070

In the PA, nearly half of the dikes in Eureka Slough (48.2%) and almost all of the dikes on Elk River Sloughs (92.4%) protecting natural gas transmission systems are vulnerable and at risk of being overtopped by MMMW of 11.0 feet NAVD 88. Under existing road conditions, potential tidal inundation of King Salmon Avenue, the only point of land-based ingress and egress to the HBGS facilities, could potentially occur by 2070 as tides rise 3.2 feet.

2100

In the PA, PG&E's HBGS could potentially be tidally inundated by the high projection for MMMW of 13.1 feet NAVD 88. Nearly all of the dikes (97%) in Eureka Slough could be overtopped and major natural gas transmission and distribution systems could potentially be tidally inundated by up to 8.0 feet of salt water.

4.5.3 Susceptibility

Very little is known about the underground gas lines other than their approximate location. Tidal inundation is likely to infiltrate into the gravel bedding and potentially into the pipes through cracks and/or leaking joints. It is possible that increasingly long periods of ground saturation could result in settlement or movement of the pipes.

While saltwater may not affect underground gas lines significantly, tidal inundation and flooding could adversely affect access to these gas lines for emergency repairs and maintenance.

Natural gas lines in the City and in the PA may not be very susceptible to sea level rise impacts.

4.5.4 Consequence

A loss or interruption of access to natural gas would be a significant impairment to the City.

4.5.5 Priority

By 2050, approximately 8 miles of natural gas lines located in areas that are protected by earthen dikes are vulnerable and at risk from tidal inundation should protective dikes fail. By 2100 approximately 14 miles of natural gas lines could be tidally inundated and access to the gas lines for maintenance and emergency repairs could be impacted significantly. Underground gas lines may not be susceptible to tidal inundation or flooding. The priority ranking for electrical system in 2050 is 3 and by 2100 5.

4.6 Bulk Fuel

4.6.1 Description

In the City, there are two bulk fuel marine terminals; one is active and the other is not. Chevron’s Eureka Terminal is located along the bay, just north of the mouth of the Elk River Slough (property elevation is less than 11 feet NAVD 88; Figure 56). The terminal consists of a timber dock, wharf, and a bulk fuel storage facility on the adjacent parcel. The dock is ‘T’ shaped with an approximately 600-foot long trestle, approximately 150-foot long wharf head, and five dolphins connected by timber catwalks. The dock is believed to have been constructed in the early 1900’s. Since then, the facility has been expanded, upgraded, and repaired numerous times. The Chevron Terminal is serviced by fuel barge traffic only, with barges typically arriving once every 10–12 days. Barges provide hoses and pumps; therefore, the terminal does not have any equipment, rack, towers, or loading arms on the wharf. Approximately 80% of the fuel used in the City and PA is delivered via barge to the Chevron Terminal. Eleven steel storage tanks on the site have a combined total capacity of approximately 105,000 barrels. There is a sea wall along the west and north perimeter of the property. Access to the property is from Truesdale Street to Christie Street, both of which are less than 11.0 feet NAVD 88 in this area. The property is potentially exposed to future tidal inundation and flooding from the north and then along the eastern perimeter. Fuel is delivered to end use stations by truck via surface streets.

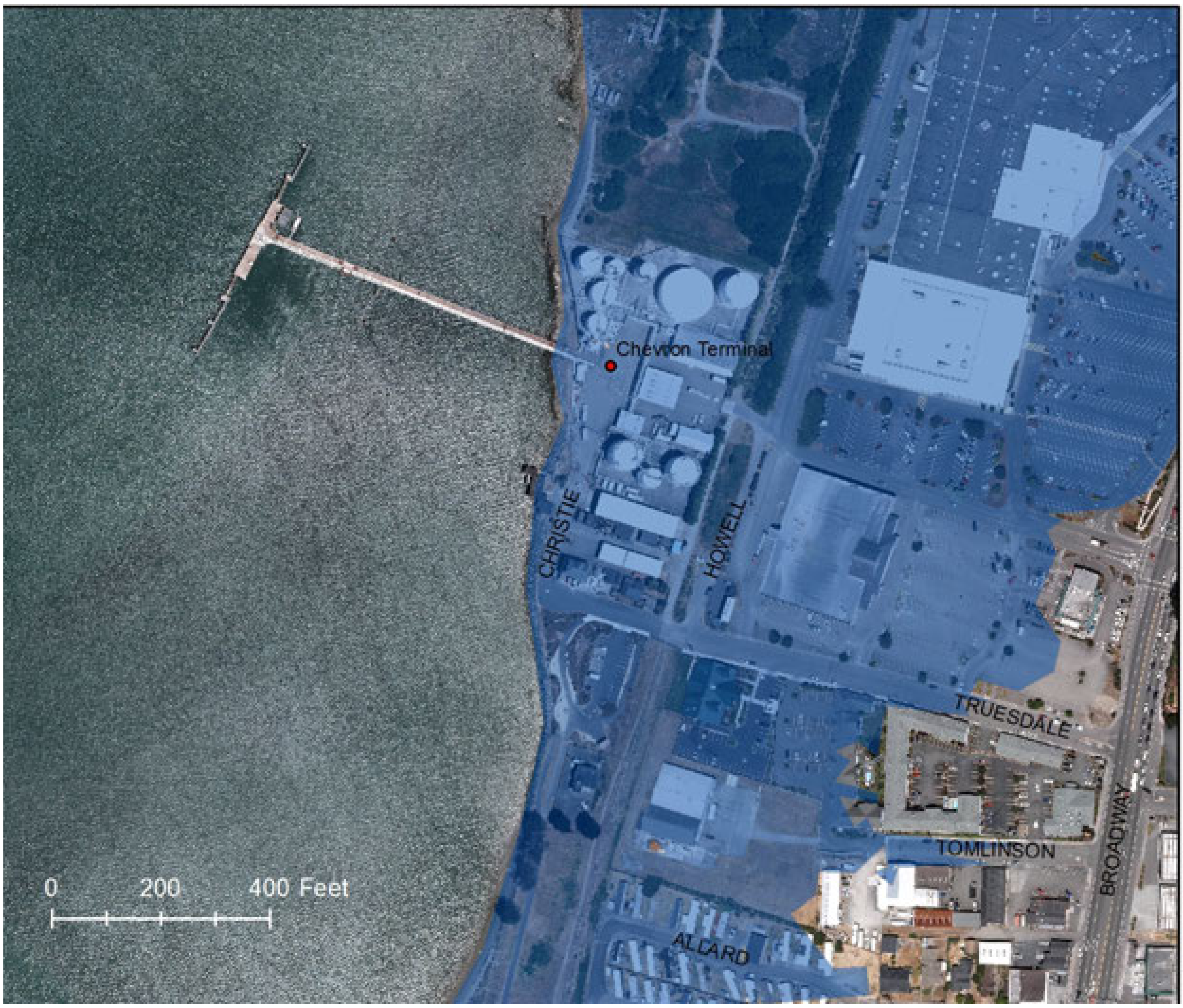

Figure 56. City of Eureka Chevron bulk fuel property and access streets that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tides of 13.1 feet NAVD 88.

The Tosco Eureka Terminal is located on the bay just northwest of 14th Street (property elevation is 10 to 12 feet NAVD 88; Figure 57). The terminal was formerly used for receipt of petroleum products, but has been inactive since 1999 or earlier. Facilities consist of timber piles, a timber-decked offshore wharf with six timber dolphins in line with face; and two timber-mooring dolphins at rear of line of face, all connected by catwalks to the upper and lower sides. Three 6-inch pipelines with three 6-inch hose connections extend to eight steel storage tanks at the rear of facility with a total capacity of 110,000 barrels. Access to the property is from Railroad Street, which is less than 11.0 feet NAVD 88 in this area.

There are no bulk fuel terminals in the PA.

Figure 57. City of Eureka Tosco bulk fuel property and access streets that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tides of 13.1 feet NAVD 88.

4.6.2 Exposure

The Chevron Bulk Fuel Terminal property is could potentially be exposed to tidal inundation coming from the north. Shoreline overtopping or failure of the sea wall facing the bay and on the northern perimeter could lead to tidal inundation. The Tosco property has a crudely fortified shoreline on the bay, ranging in elevation from 9.6 to 10.9 feet NAVD 88 that could potentially be overtopped by rising tide elevations. Both bulk fuel properties are also vulnerable and at risk from tidal inundation from the east should their access streets flood. The terminal wharf structures at these two facilities may need to be elevated with rising tide elevations. Without adaptation measures, access to the facility may be limited by tidal inundation.

2015

Neither bulk fuel terminal is currently affected by MMMW of 7.7 feet NAVD 88.

2030

Rising tides of 0.9 feet to 8.6 feet NAVD 88 may cause tidal inundation of the northeast portion of the Chevron Terminal property, particularly by the high projection for MAMW of 9.6 feet NAVD 88.

2050

The north and eastern perimeters and northern portion of the Chevron Terminal property may become tidally inundated during MMMW of 9.6 feet NAVD 88. The Tosco facility and property, while low-lying, would not be hydrologically connected to the bay.

2070

By 2070, MMMW is projected to rise to 10.76 feet NAVD 88 and both the Chevron and Tosco facilities and properties could become tidally inundated, as may the streets that provide access to these sites.

2100

By 2100, MMMW of 13.1 feet NAVD 88 at these facilities could result in up to 3 feet of tidal inundation.

4.6.3 Susceptibility

The bulk fuel properties may be exposed to sea level rise by 2070. Tidal inundation of the bulk fuel properties would cause corrosion of metal storage tanks and likely result in the degradation of water quality by petroleum products. Access to the properties could also be impacted by sea level rise. By 2100, these properties and facilities could be tidally inundated by 3 feet of salt water. Tidal inundation would significantly impact the bulk fuel facilities.

4.6.4 Consequence

The sustainability of the City and in the PA is currently dependent on petroleum products but alternative energy such as electricity may reduce that dependency in the future. The bulk fuel terminals could be fortified or relocated to accommodate or avoid rising tidal elevations. Alternative means of delivery of petroleum products by land based vehicles could be developed. The loss of these bulk fuel facilities may not a significant consequence to the City by 2070.

4.6.5 Priority

The bulk fuel facilities are not likely to be exposed to sea level rise by 2050 but could be by 2070 and may be tidally inundated significantly by 2100. The facilities are susceptible to tidal inundation as is access to these facilities. The consequences of the loss or impairment of these facilities in 2070 could be less than significant if alternative fuel systems are available or the facilities are relocated. The priority ranking for these facilities by 2050 is 0 and by 2100 5.

4.7 Communications

4.7.1 Description

Communications infrastructure and operations within the City are essential assets for daily operation of businesses, government agencies, utilities, emergency responders, educational institutions, and public and social connectivity. The communications industry is privately owned and operated. Communications service providers within the City and surrounding PA include: AT&T, Suddenlink, Verizon, Sprint, T-Mobile, Metro-PCS, Virgin Mobile, US Cellular, Tracfone, Cox Cable, IP Networks, Renaissance Internet, and Bicoastal Media. Communications can be classified by service type as: Telephone, Television and Cable Services, Radio, and Internet. Increasingly, these services are bundled and transmitted through high speed optical fiber networks. Additional communications network media types include: twisted pair, coaxial cable, broadcast radio frequency, satellite, terrestrial microwave, and wireless local area networks (LAN).

Location-specific data for major communications infrastructure assets and operations within the City and its PA has not been made available by private service providers, due to security concerns. Assets identified for the purpose of this report include publicly disclosed microwave service towers, cellular towers, and AM/FM antennae within the City and PA.

Optical fiber is the most significant resource for high speed data transmission, and although mapping of specific locations was not achieved, general routes through the City and PA were provided during conversations with service providers. The City and its PA are served by two major optical fiber connections. AT&T owns and maintains one optical fiber line that runs from San Francisco to Eureka. The location of the fiber was described in general as following U.S. Highway 101 along the perimeter of Humboldt Bay, and may also share a joint utility easement with PG&E. The second optical fiber line is owned by IP Networks and was constructed in 2012. This fiber line runs from the Old Town Eureka area to a hub in Red Bluff following a route adjacent to State Highway 36, and shares PG&E's utility easement (CPUC 2011).

In the City, there are 21 communications towers spread throughout the City. These towers are licensed to private, governmental, and educational institutions and include 16 microwave towers, two AM transmission towers, two FM transmission towers, and one cell phone tower. Only five communications towers are located in the projected tidal inundation zone for 2100 (13.1 feet; Figure 58).

In the PA, there are an additional 17 communication towers, including: 13 microwave towers, two AM transmission towers, and two cell phone towers. There are three communications towers located in the potential tidal inundation zone for 2100 (13.1 feet NAVD 88; Figure 59, and Figure 60).

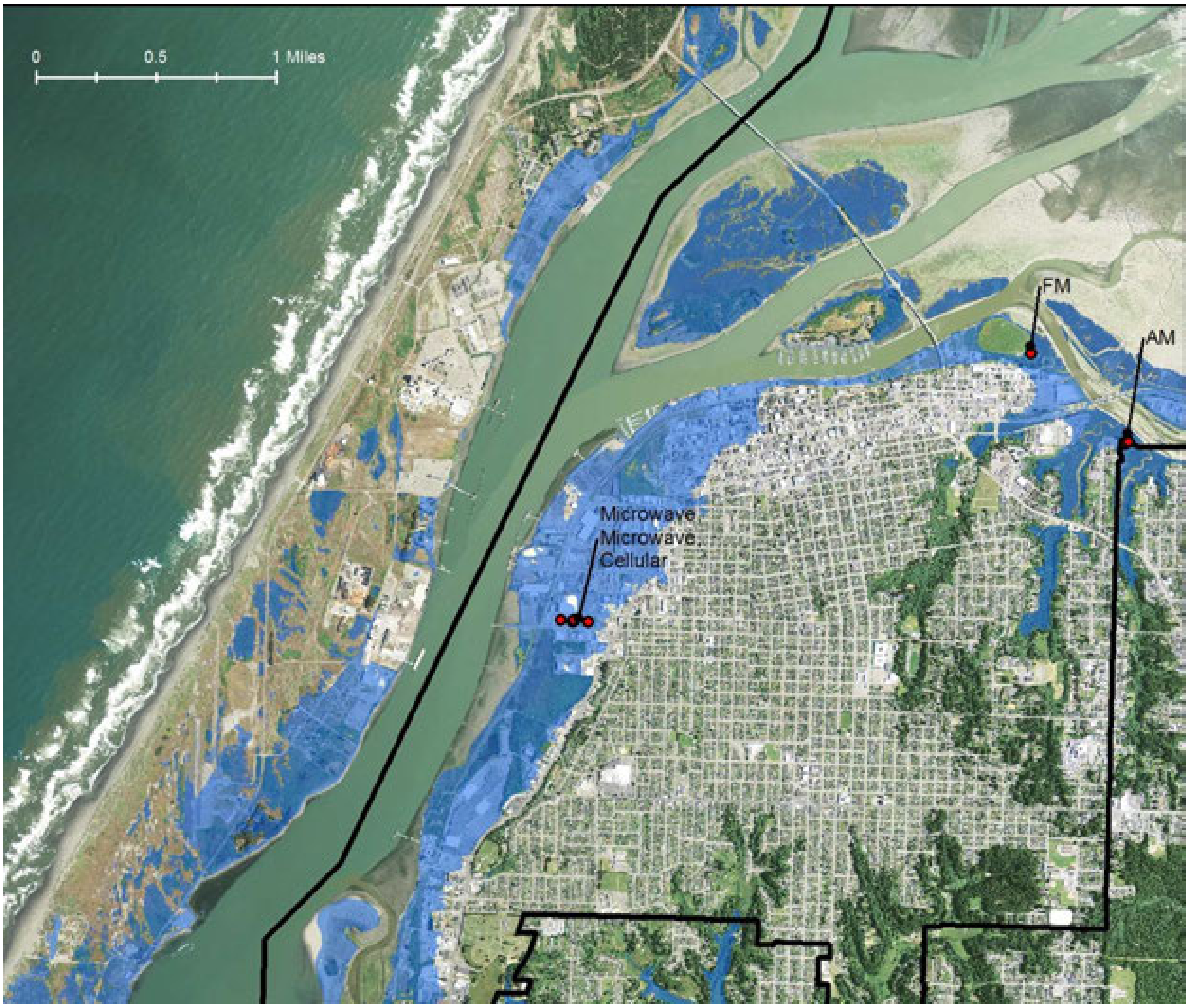

Figure 58. City of Eureka location of three publicly-disclosed cellular and microwave towers, and AM/FM antennae and the area that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tides of 13.1 feet NAVD 88.

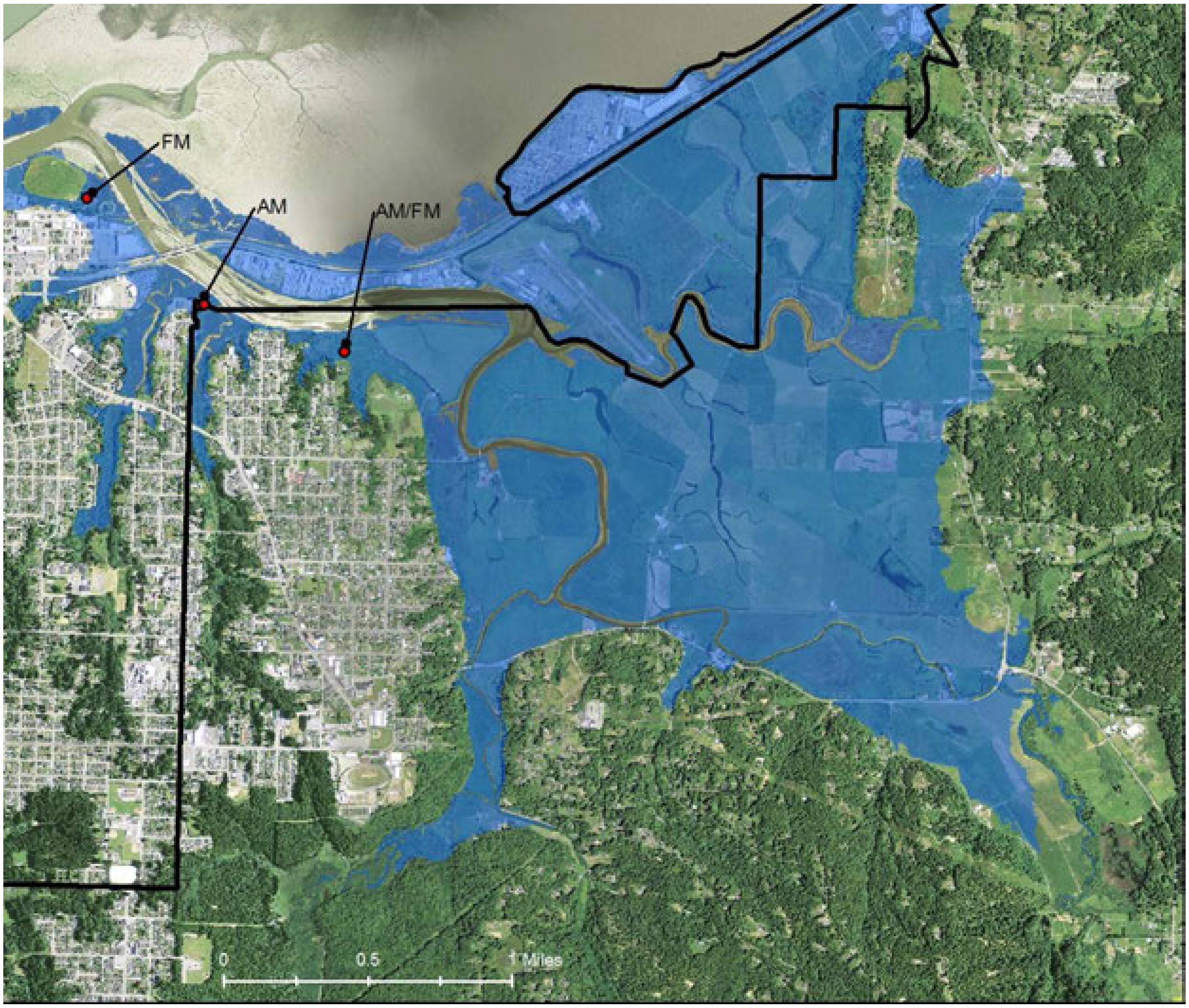

Figure 59. City of Eureka and Planning Area AM/FM antennae and the area that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet NAVD 88.

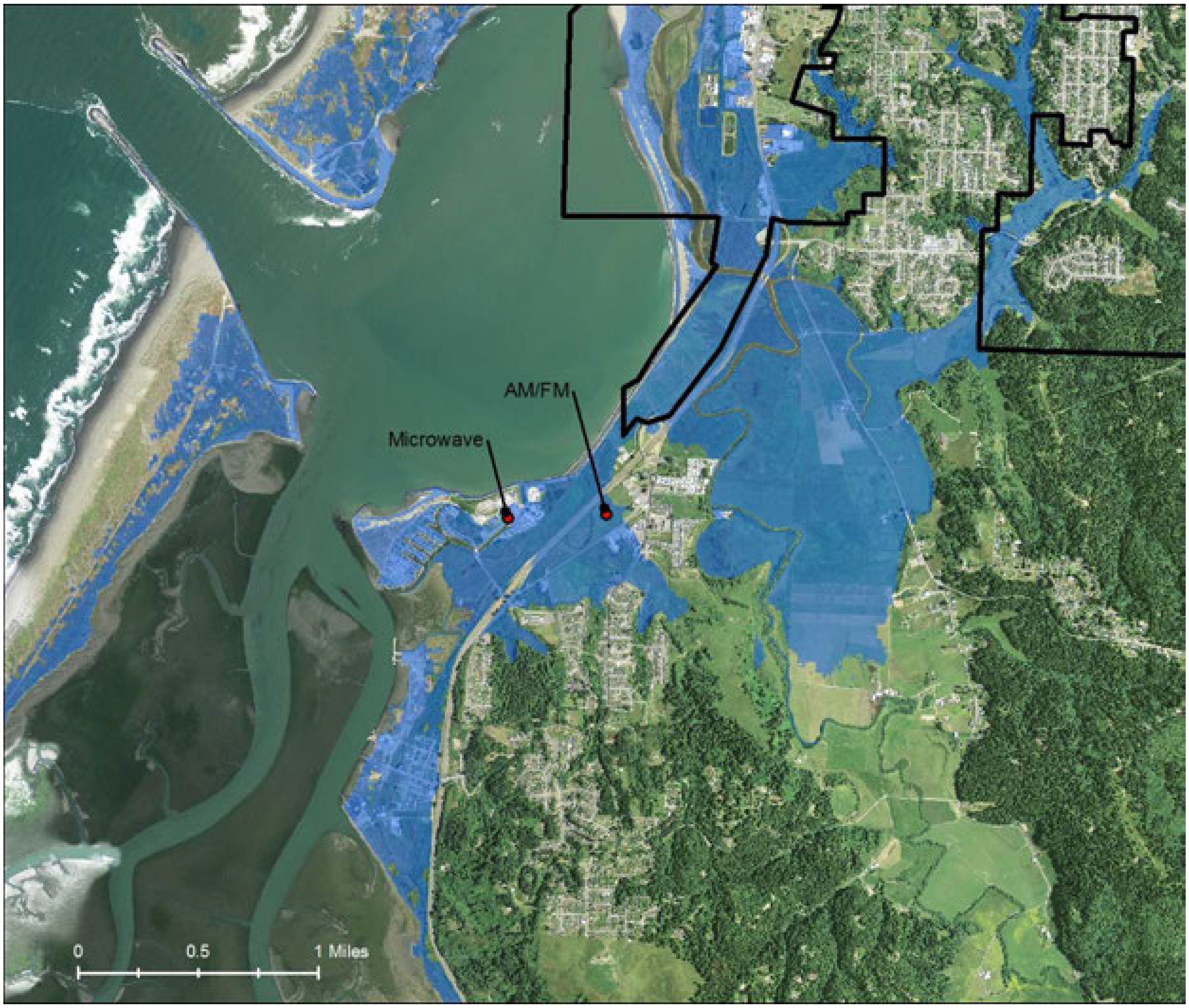

Figure 60. Planning Area location of microwave tower and AM/FM antenna, and the area that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet NAVD 88.

4.7.2 Exposure

For the 38 above-ground communications facilities in the City and PA, 8 potentially could be affected by rising sea levels by 2100 (Table 15). Communication tower footings would become more susceptible to liquefaction during an earthquake as the ground water or tide levels rise. Increased rates of corrosion of structural attachment members may occur due to tidal inundation. Electrical equipment and connections that are not rated for exposure to a marine environment will also be compromised. Tidal inundation of local streets will make access for maintenance difficult at first and eventually impossible

Close to half of the fiber optic cable lines in the City and over half in the PA are vulnerable and at risk from rising sea levels by 2100 (Figure 61, Table 15). While underground optical fiber, twisted pair, and coaxial cable may not be damaged by regular tidal inundation, access for repairs and upgrades could become much more difficult if tidal inundation U.S. Highway 101 and its right-of-way occur. Cable junction boxes and service connection equipment located in tidally inundated areas are likely to experience some increased rates of corrosion and signal noise caused by a lack of adequate grounding.

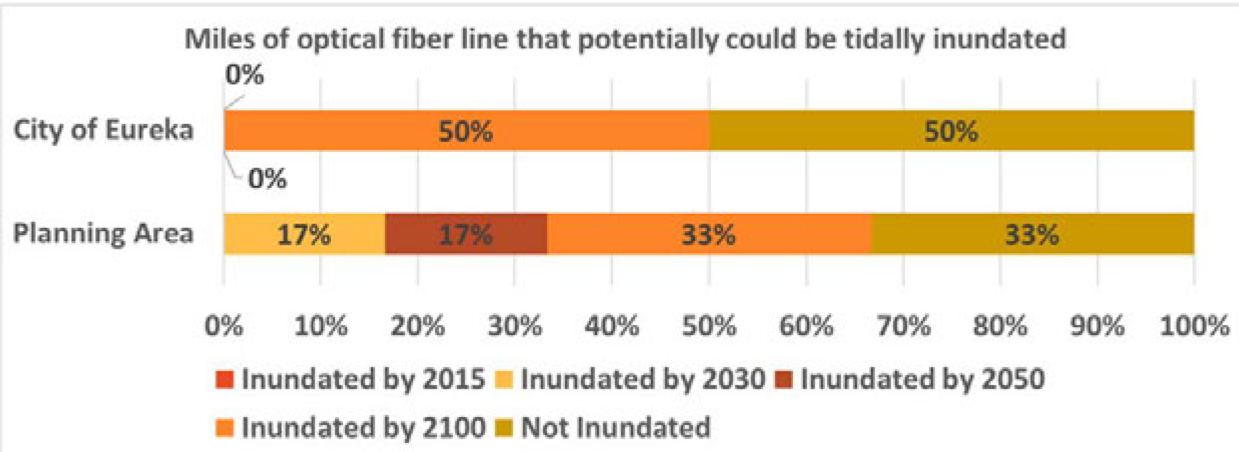

Figure 61. Miles of optical fiber line in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the miles of fiber line that is not likely to be inundated.

Table 15. Underground optical fiber and coaxial cable lines (miles) vulnerable and at risk from tidal inundation in the City and its PA.

OPTICAL FIBER LINES (miles)	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	0	0	0	3	3	6
Planning Area	0	1	2	4	2	6

2015

In the City, there are no towers impacted by MMMW of 7.7 feet NAVD 88 during this planning period. There is one AM antenna located along Eureka Slough in an area that is exposed to tidal inundation now in 2015 during MAMW (8.8 feet NAVD 88). In the PA, there are two communications towers, one along Eureka Slough and one east of U.S. Highway 101 near South Broadway Avenue, that are located in an area that is exposed to tidal inundation now in 2015 during MAMW (8.8 feet NAVD 88).

In the PA, the underground fiber optic lines coming from San Francisco and Red Bluff are believed to follow U.S. Highway 101 and could potentially be tidally inundated in areas along Elk River Slough and Eureka Slough in the event of dike failure now. This cannot be verified without confirmation of the easement by AT&T.

2030

In the City, there is one AM antenna located along Eureka Slough in an area that could potentially be tidally inundated by MMMW of 8.6 feet NAVD 88. In the PA, there are no additional towers impacted by MMMW of 8.6 feet NAVD 88.

2050

No additional towers are expected to be impacted during this planning period.

2100

In the City, there are four more communications towers located in areas that could potentially be tidally inundated by MMMW of 13.1 feet NAVD 88; one FM antenna near X Street, and three on Wabash Avenue (two microwave and one cellular). In the PA, there is one microwave communications tower located near the PG&E HBGS that could potentially be tidally inundated by MMMW of 13.1 feet NAVD 88.

4.7.3 Susceptibility

Underground optical fiber and coaxial cable lines are not likely to be impacted by tidal inundation or rising ground water. However, associated junction boxes and service connection equipment will degrade in the presence of salt water. Optical fiber and coaxial cable lines apparently parallel U.S. Highway 101 and traverse areas that are protected by earthen dikes that if they fail by 2050 1.9 miles could be tidally inundated and by 2100 6.2 miles could be tidally inundated. Access, emergency repairs, and maintenance will become much more complicated and expensive when tidal inundation occurs. Interruptions to service caused by equipment malfunction or storm damage will be more difficult to trouble shoot by service providers in locations that experience regular tidal inundation. Optical fiber and coaxial cable lines could be impacted significantly by 2100 if they have not been relocated.

Instability of communication tower footings and rates of corrosion of structural attachment members can be expected to increase with tidal inundation. By 2050 three of 38 communication towers are located in areas that would be tidally inundated and by 2100 8 towers. Electrical equipment and connections that are not rated for exposure to a marine environment may also be compromised. Maintenance of above ground facilities when tidal inundation of local streets occurs would make access difficult. The communication systems supported by the towers could be impacted significantly by 2100 if the towers have not been relocated or fortified.

4.7.4 Consequence

The loss of service provided by underground optical fiber lines along U.S. Highway 101 would be catastrophic to the City and its PA. There is redundancy in the number of above ground communications towers if the eight towers at risk from tidal inundation by 2100 were impaired or removed.

4.7.5 Priority

By 2050, the optical fiber lines and communications towers may be impacted by sea level rise if protective dikes fail, but by 2100 nearly 50% of the fiber line miles in the City and PA could be tidally inundated. Access to the fiber lines for maintenance and emergency repairs could be impacted significantly. The loss of service provided by underground optical fiber lines would be significant to the City and its PA. It is likely that the 8 communication towers that would be exposed to tidal inundation by 2100 would be relocated, and there may not be any interruption to communications supported by these towers. Priority rankings for optical fiber lines in 2050 is 3 and for the towers 2 and by 2100 a ranking of 6 for the optical fiber lines and 3 for the towers.

4.8 Solid Waste

4.8.1 Description

The Humboldt Waste Management Authority (HWMA) provides solid waste processing and disposal for the City, as well as other cities and unincorporated communities throughout Humboldt County. HWMA is a Joint Powers Authority made up of the following municipalities: Arcata, Blue Lake, Eureka, Ferndale, Rio Dell and Humboldt County. HWMA owns and/or manages a transfer station, recycling center, and composting facility, which accept and process wastes from the public and various contracted waste haulers servicing communities throughout Eureka, and Humboldt County. Recology Humboldt County, a private company in the City, has facilities adjacent to HWMA’s station and is a provider of solid waste collection and removal services for residents living in the City, as well as those living in the unincorporated communities within the PA. These solid waste operations serve the City by collecting, processing, and removing solid waste from the City. In general, residents living in the City limits are offered a wider variety of collection and removal services than those living in the unincorporated communities.

The HWMA Transfer Station is located at 1059 West Hawthorne Street in Eureka (elevation approximately 12 feet NAVD 88; Figure 62). The Hawthorne Transfer Station consists of a waste transfer station, and waste collection and removal service. The transfer station surface elevation ranges from 10 to 13 feet NAVD 88 and is bordered by inter-tidal wetlands (Palco Marsh) to the west and south. An approximately 14.0 foot NAVD 88 earthen dike protects the facility from tidal inundation via Palco Marsh. The truck loading dock for waste removal is 8 feet lower than the surrounding surface elevation. Ingress and egress to the transfer station is limited to Hawthorne and Felt Streets. Two storm water DI are hydraulically connected to Palco Marsh, and fitted with oil–water separators. The transfer station accepts garbage, green waste, household hazardous waste, tires, electronics, and fluorescent lighting tubes and bulbs. The Hawthorne Transfer Station receives approximately 5,000 tons of green waste annually, which is then processed by Mad River Hardwoods Inc., through a service agreement with HWMA. The Eureka Recycling Center, operated by Recology, is located adjacent to the Transfer Station at 949 West Hawthorne Street. The approximate elevation ranges from 11.0 to 13.1 feet NAVD 88 (Figure 62).

Figure 62. City of Eureka, Humboldt Waste Management Authority Hawthorne Transfer Station and Recology recycling facility with the area that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet NAVD 88.

Residual waste that cannot be recycled or composted is sent to either the Anderson Landfill in Anderson California, or exported out of state to the Dry Creek Landfill in White City, Oregon. In 2012, the Anderson landfill received 15,696 tons of solid waste, which accounted for approximately 56% of the total solid waste generated in the City. An additional 12,267 tons was exported to the Dry Creek Landfill.

4.8.2 Exposure

Sea level rise is predicted to overtop surrounding streets and dikes, resulting in tidal inundation of the Transfer Station and Recology facility. Rising ground water in response to sea level rise may likely cause flooding of these facilities. Both tidal inundation and rising ground water in response to sea level rise could expose these facilities to storm water flooding. Reduced effectiveness of the storm water system could cause flooding that impairs ingress and egress to these facilities. Tidal inundation of these facilities may create hazardous materials and garbage storage issues, and/or limit the holding capacity of the transfer station. Waste collection and removal services may be impacted by street flooding and tidal inundation that could limit the ability of the providers to access routes in low-lying areas.

The Hawthorne Transfer Station borders Palco Marsh in a close proximity to Humboldt Bay. Tidal inundation mapping from 2015 to 2100 indicates that the likely pathway for flooding of the Transfer Station and Recology facility would be from Palco Marsh to the west as it overtops Felt Street to the northwest, as well as from the southeast.

2030

By 2030, MMMW is projected to reach 8.6 feet NAVD 88, which is approximately the MAMW in 2015. The two solid waste facilities on Hawthorne Street do not currently experience flooding during MAMW.

2050

By 2050, MMMW is projected to reach 9.6 feet NAVD 88 and rising ground water levels and elevated tides may reduce the effectiveness of storm water systems to drain from the transfer station and Recology facility to the Palco Marsh inter-tidal wetland. Although the facilities may not be inundated, access to the facilities from Felt Street may be flooded by storm water runoff. A potential breach of the earthen dike at the northeast corner of Palco Marsh (elevation approximately 9.0 feet NAVD 88) could cause flooding of Felt Street and restrict access to the facilities on Hawthorne Street.

2070

By 2070, the HWMA Hawthorn Transfer Station property is vulnerable and at risk from tidal inundation when MMMW rises to 11.0 feet NAVD 88. The Recology facility would not be at risk at this time. Solid waste, including electronic, heavy metal, chemical waste, and hazardous waste have the potential to be discharged into Palco Marsh if water inundates the waste staging areas. The deep pit that is used for trucks to deliver and remove garbage could become flooded by storm events and backflow from the oil–water separator connected to Palco Marsh. Backed up storm water may need to be removed with sump pumps to protect the truck loading/unloading area. Brackish marsh water inundating the parking area and driveways could have a corroding impact on pumps and vehicular equipment.

2100

By 2100 with a high projection of 13.1 feet NAVD 88 for MMMW, both the transfer station and Recology facilities could potentially be tidally inundated. The majority of the transfer station site could be tidally inundated by overtopping of the protective dikes around the facility and old railroad grade protecting Palco Marsh or flooding of the wetland area north of Hawthorne Street. Flooding on Hawthorne Street would effectively shut down the facility.

4.8.3 Susceptibility

The two solid waste facilities are not likely to be impacted by sea level rise until 2070. Impacts to these two solid waste facilities from tidal inundation or storm water backwater flooding will first impair access to these properties and flood the concrete pit used at the transfer station. The services provided by these solid waste facilities and the City streets that serve these properties are not very resilient to continual disruption from tidal inundation or flooding. The continued use of these facilities for solid waste collection and processing when they and the access streets are being tidally inundated without protective adaptation measures would be low. These facilities are very susceptible to tidal inundation.

4.8.4 Consequence

Disruption to the waste collection and removal system within the City may impact commercial and residential services, creating a public nuisance and public health issue due to a buildup of waste material. Discharge of waste material into the storm water or natural ecosystems would degrade water quality, potentially impact habitat and wildlife (including listed species), endanger public health, and could result in regulatory citation(s).

At their present location, the solid waste facilities would be impacted by tidal inundation, which would adversely affect commercial and residential customers who utilize the services provided by these facilities, due to a lack of access, service, or delays. While solid waste collection and processing services are vital to the City and PA, these facilities where they are currently sited are not. Solid waste collection and processing facilities are not coastally dependent uses. These facilities could be replaced by other facilities located outside of the 2100 tidal inundation and flood zone.

4.8.5 Priority

By 2050, there are likely to be no impacts to the two solid waste facilities in the City, by 2100 they both could be tidally inundated. The facilities and services rendered at these facilities would be significantly impacted by tidal inundation. The solid waste facilities could be relocated before they become tidally inundated as they are not coastally dependent. The priority ranking for 2050 would be 0 and by 2100 4.

5 Transportation

There are currently three modes of transportation in the City and its PA: surface, marine, and air. A fourth transportation mode, rail, was closed down in 1998 by the Federal Railroad Administration. Infrastructure for all modes of transportation on Humboldt Bay are located in areas that are vulnerable to sea level rise by 2100. Surface transportation infrastructure in the City and its PA are primarily vulnerable and at risk from tidal inundation as a result of shoreline erosion or overtopping, backwater effects from storm water runoff, and secondarily from rising ground water.

5.1 Surface

In the City, there are two surface transportation authority's responsible for infrastructure maintenance: City maintains its streets and drainage structures, and Caltrans is responsible for U.S. Highway 101, including Broadway and the $4^{th}/5^{th}$ Streets couplet and State Highway 255. In the PA, Humboldt County is responsible for streets, and Caltrans is responsible for U.S. Highway 101 and State Highway 255. The three levels of surface transportation facilities (local streets, State Highway 255, and U.S. Highway 101) will be described and their exposure to sea level rise analyzed. In the City by 2100, tidal inundation may occur on 12.2 miles of streets, 2.4 miles of U.S. Highway 101, and the segments of Highway 255 between the bridges spanning Humboldt Bay (Figure 63). In the PA, 17.6 miles of streets are vulnerable and at risk from tidal inundation by 2100 and 3.4 miles of U.S. Highway 101 (Figure 64 and Figure 65).

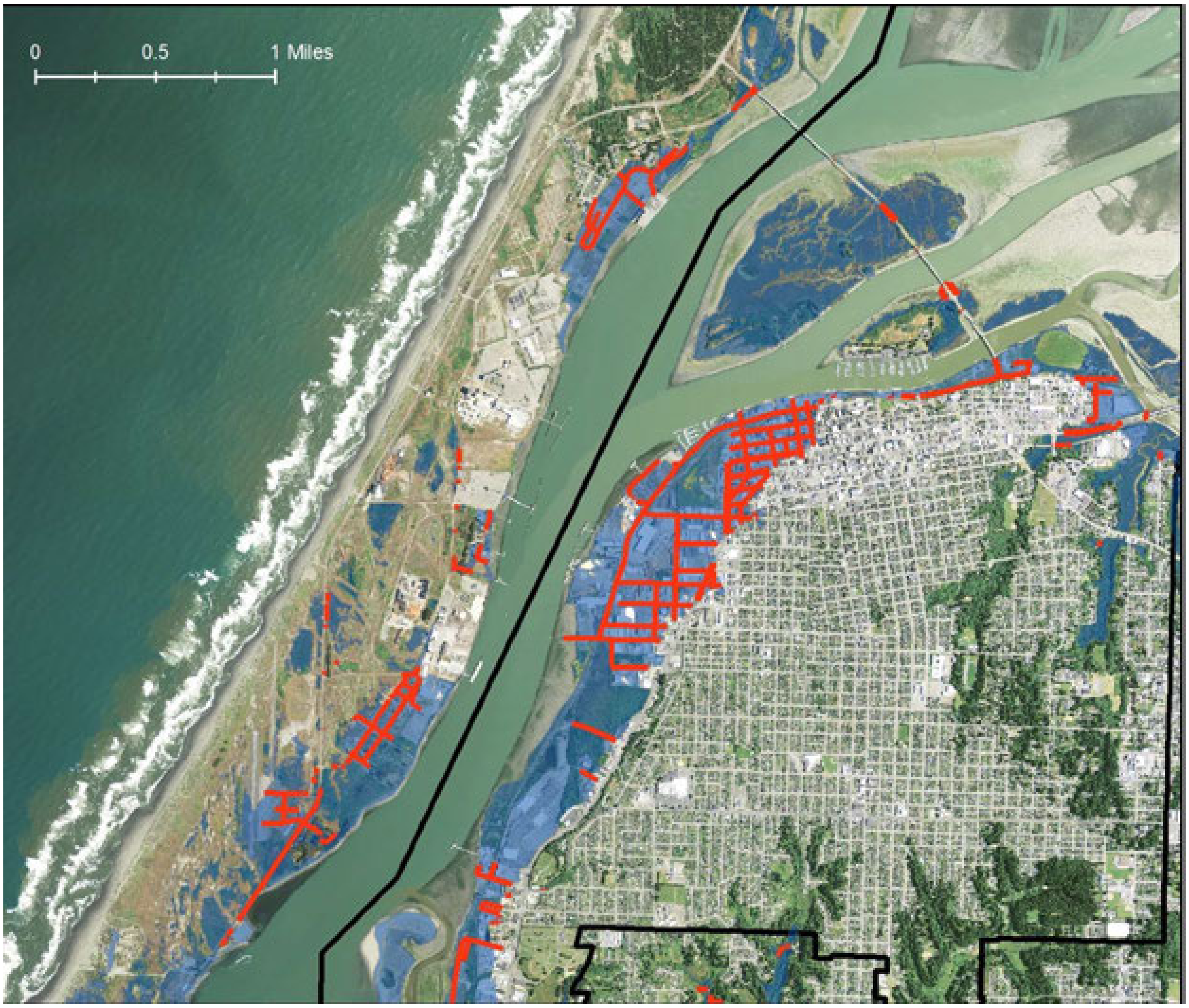

Figure 63. Local streets and roads in the City of Eureka and its Planning Area on Samoa Peninsula that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

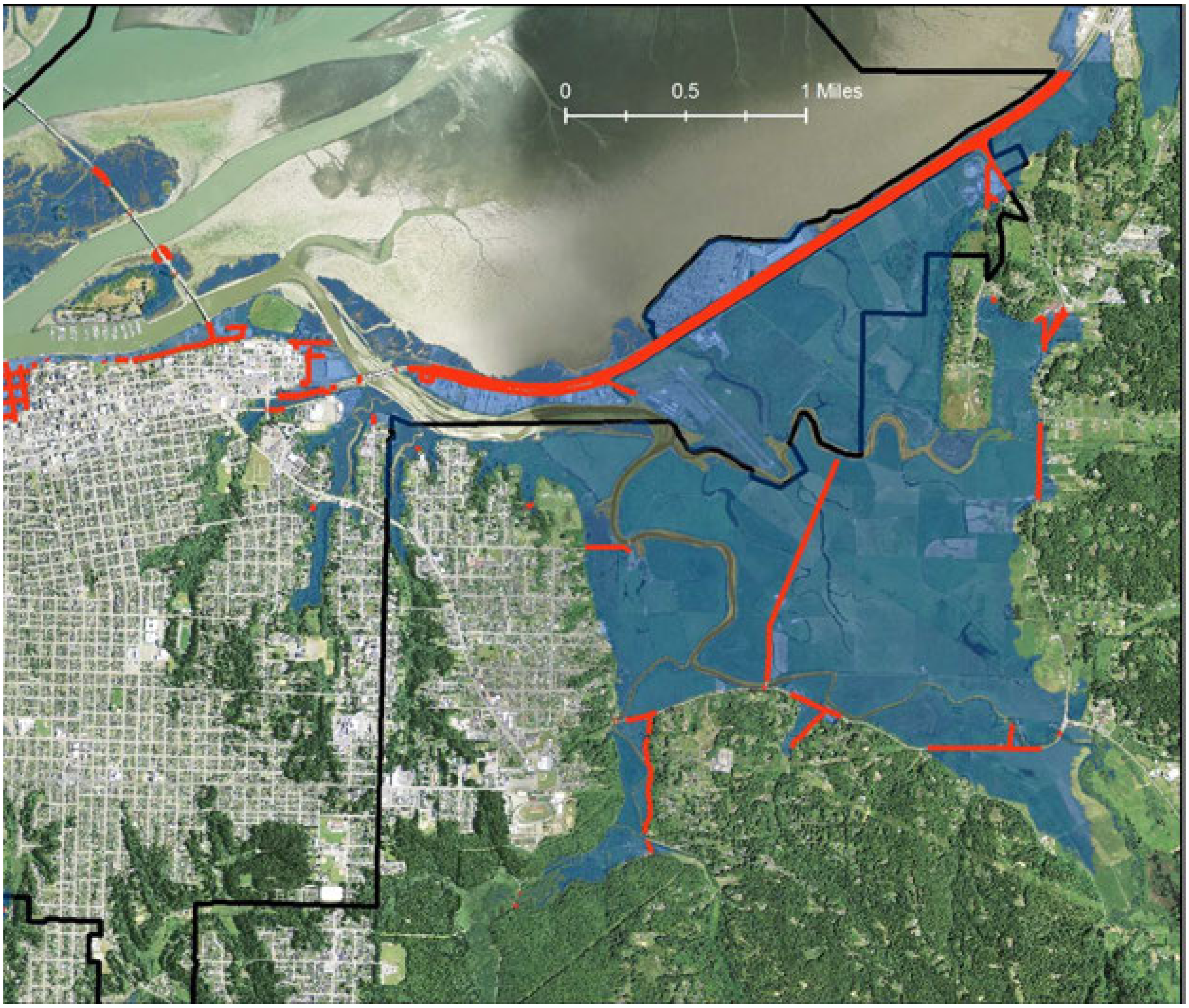

Figure 64. Local streets and roads in northwest City of Eureka and its Planning Area in Eureka Slough that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

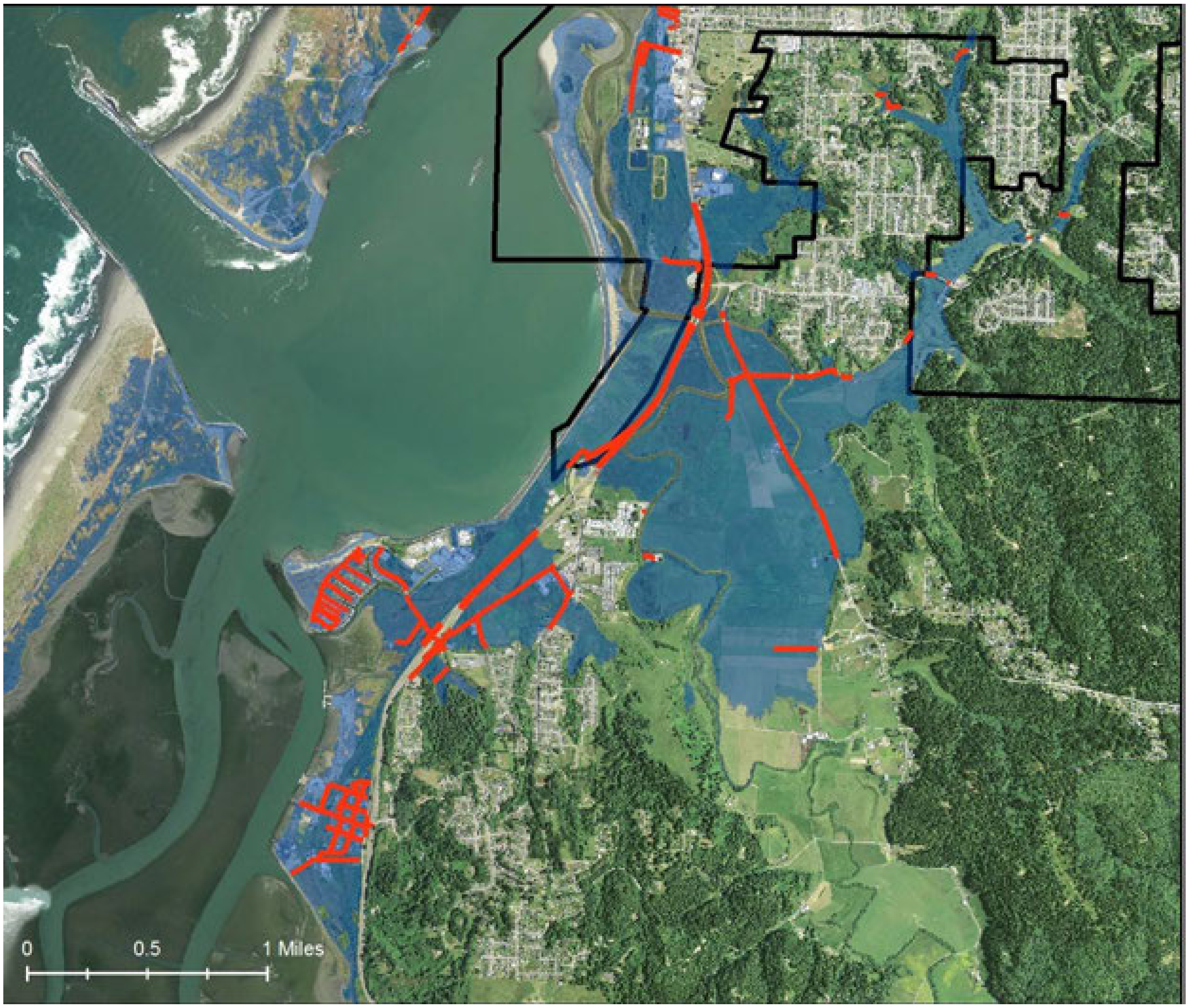

Figure 65. Local streets and roads in south City of Eureka and its Planning Area in Elk River Slough, King Salmon, and Fields Landing that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

5.1.1 Local Streets

Description

In the City, there are 142.2 miles of streets and local roads. Generally, the streets that are vulnerable and at risk from tidal inundation occur west of Broadway, and from Grant Street north over to California and E Street, then north of Waterfront Drive and 1st Street, east of X Street, the north end of Bay Street, and behind the dikes on Eureka and Fay Sloughs including Jacobs Avenue, Airport Road, and Indianola Cutoff (Figure 63, Figure 64, and Figure 65).

In the Planning Area, there are 162.7 miles of streets. The streets and roads vulnerable and at risk from tidal inundation generally occur on the Samoa Peninsula (New Navy Base Road, all streets in Fairhaven and Fin Town, east of Bayview Avenue in Samoa, and Vance Avenue), behind dikes on lands that drain to and through Eureka Slough (West Indianola, Myrtle Avenue in several segments south of Indianola Roundabout to Ryan Slough, Mitchell Road, and East Park Street), in the Elk River Slough area (Elk River Road, Pine Hill Road, and Herrick Avenue), and along Entrance and South Bay (South Broadway Street/Hill Road, Humboldt Hill Road, Purdue Road, Loma Avenue, Aspen Way, and all streets in King Salmon and Fields Landing) (Figure 63, Figure 64, and Figure 65).

Exposure

Over time and under repeated tidal inundation or flooding, a street's road base will become saturated, causing the asphalt to buckle and requiring resurfacing. Rising tides can also impair the capacity and function of water controls structures such as tide gates and culverts associated with City streets, which could increase flooding of adjacent areas.

In the City, streets are vulnerable and at risk from tidal inundation when the shoreline is overtopped, or from flooding in low-lying areas in response to high tides, and when storm water runoff backs up. In the area along Eureka and Fay Sloughs, Jacobs Avenue, Airport Road, and Indianola Cutoff are vulnerable and at risk from tidal inundation if segments of protective dike shoreline on Eureka and Fay Sloughs are breached or overtopped.

In the PA, local streets and roads particularly at risk from tidal inundation are located behind dikes on Eureka, Fay, Freshwater and Ryan Sloughs, and Elk River and Swain Sloughs. Streets in King Salmon and low-lying areas like Fields Landing and south Broadway Street Fields Landing and south Broadway Street are also vulnerable and at risk now from MAMW (8.78 feet NAVD), 100-year storms (9.99 feet NAVD 88) and sea level rise.

In the City, only 2% (3.5 miles) of the streets may be tidally inundated by 2050 and 8% (12.2 miles) by 2100, and 92% (130 miles) are likely to not be inundated (Figure 66 and Table 16).

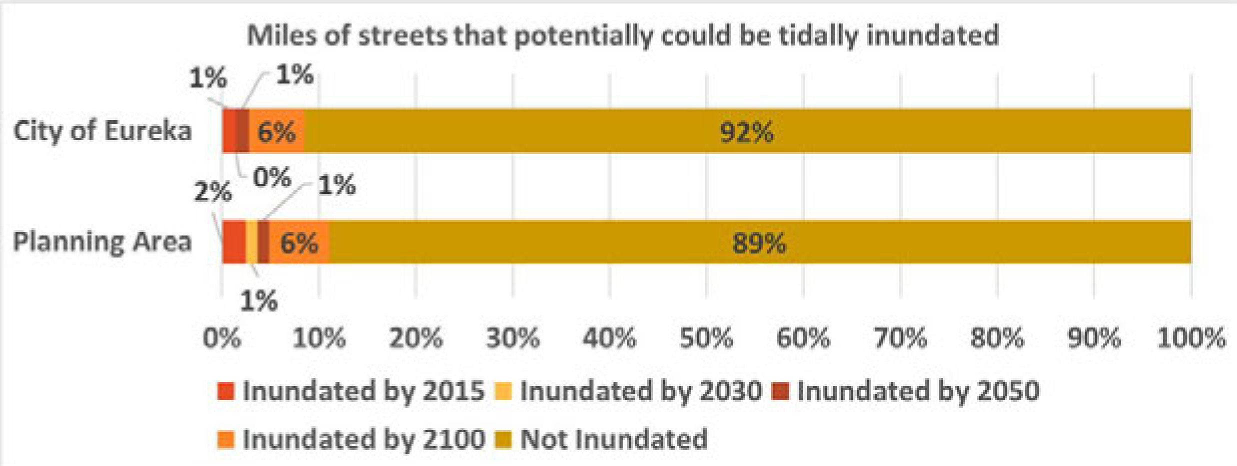

Figure 66. Miles of streets in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the miles of streets that are not likely to be inundated.

Table 16. Miles of streets that are vulnerable and at risk from tidal inundation in the City and its PA.

STREETS	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	1.6	2.1	3.5	12.2	130.0	142.2
Planning Area	4.0	6.2	7.7	17.6	145.1	162.7

2015

In the City, there are currently 1.6 miles of streets that are potentially vulnerable and at risk from tidal inundation, as they are located in low-lying areas behind protective shoreline dikes that could be breached or overtopped on Eureka and Fay Sloughs (e.g., Jacobs Avenue, Airport Road, Indianola Cutoff and Indianola Road). In the PA, there are 4 miles of local streets and roads located in low-lying areas that are potentially vulnerable and at risk from tidal inundation if segments of protective shoreline structures on Freshwater and Fay Sloughs are breached or overtopped during MAMW (Myrtle Avenue and side streets in several segments south of Indianola Roundabout to Flying Ranch Road, East Devoy Road, and Park Street). If dikes on Elk River and Swain Sloughs are breached or overtopped, segments of Elk River Road and Pine Hill Road are vulnerable and at risk from tidal inundation. In King Salmon, Crab, Perch, and Halibut Streets are vulnerable and at risk from tidal inundation if the shorelines are overtopped by MAMW. In Fields Landing, nearly all of the streets are in low-lying areas that may flood if the shorelines are overtopped by extreme tides or 100-year storms.

2030

In the City, in addition to the areas that are vulnerable and at risk from tidal inundation now, there are an additional 0.5 miles of streets that are located in low-lying areas, less than MMMW (8.6 feet NAVD) elevation that could be tidally inundated west of Broadway Avenue: Washington Street, a portion of West 15th Street, Felt Street, a portion of Bayshore Way, and Pound Road. In the PA, in addition to the areas vulnerable and at risk from tidal inundation now, there are an additional 2.2 miles of streets that are located in low-lying areas, less than MMMW (8.6 feet NAVD) elevation that could be tidally inundated: north of Samoa (Park Street and Vance Avenue), portions of Fairhaven (Park and Broadway Streets), near Humboldt Hill (South Broadway/Hill Road, Eich Road, Humboldt Hill Road, and Purdue Drive), most of the residential streets in King Salmon east of Buhne Drive, and Depot Road in Fields Landing.

2050

In the City, by 2050 when MMMW reaches 9.6 feet (NAVD 88), in addition to areas vulnerable and at risk from tidal inundation between 2015 and 2030, there may be another 1.4 miles of streets that could be tidally inundated: North Bay Street, Waterfront Drive between C Street and the Marina, West 2nd and 3rd Streets between C and Commercial Streets, Commercial Street north of 4th Street, A Street north of 3rd Street, Koster Street between Washington and 14th Streets, Railroad Avenue at 14th Street, 14th and 15th Streets west of Broadway, Bayshore Way, Howell Street, Hilfiker Lane, and Pound Road. In the PA, by 2050 when MMMW reaches 9.6 feet (NAVD 88), in addition to areas vulnerable and at risk from tidal inundation in 2030, there may be another 1.5 miles of streets that could be tidally inundated: on the Samoa Peninsula (New Navy Base Road and Lindstrom Avenue in Fairhaven, Spears Road, Mitchell Road); King Salmon (Buhne Drive), and Fields Landing (Railroad Avenue).

2100

Between 2050 and 2100, an additional 8.7 miles of City streets could potentially be tidally inundated by the high projection for relative sea level rise of 5.3 feet (13.1 feet NAVD 88): Bay Street, 6th Avenue north of Myrtle Avenue, Y Street, X Street, 1st and 2nd Streets east of W Street, Front Street, Waterfront Drive from T Street to I Street, from E Street west and north of 4th Street to Waterfront Drive, all streets west of Summer Street from 5th Street to West Grant Street, West Washington Street, and West 14th Street, almost all streets west of Broadway, Broadway from Cedar Street south to 15th Street, and Tooby Road.

In the PA, by 2100 an additional 9.9 miles of streets could potentially be inundated by the high projection for relative sea level rise of 5.3 feet (13.1 feet NAVD 88): on the Samoa Peninsula on Samoa Cookhouse Road; in Finn Town on Fay Street, Cole Avenue, Comet Street, and Bendixon Street; in Fairhaven, all the streets, and New Navy Base Road south of Lincoln Avenue; on Myrtle Avenue west of Freshwater Creek to Bettie Lane from Pigeon Point Road to Tower Drive and Mitchell Road to Ryan Slough; in south Eureka on Fairway Drive, Elk River Road, Pine Hill Road, and South Broadway Street, in Humboldt Hill on Meadowbrook Drive, Humboldt Hill Road, Loma Avenue, and Aspen Way; in King Salmon on King Salmon Avenue and Buhne Drive; all streets in King Salmon; and in fields Landing, all streets west of U.S. Highway 101.

By 2070, with the high projection for relative sea level rise of 3.2 feet (11.0 feet NAVD 88). King Salmon Avenue could be tidally inundated. King Salmon Avenue provides the only surface access to the HBGS and the ISFSI. Nearly all of the streets in King Salmon except for a segment of Buhne Drive could also be tidally inundated. While residences and commercial business in King Salmon may have started to relocate by 2050, the HBGS and ISFSI will likely still need to be operational in 2070 and beyond.

Susceptibility

Over time and under repeated tidal inundation or flooding, a street's road base will become saturated, causing the asphalt to buckle and requiring resurfacing. Rising tides can also impair the capacity and function of water controls structures such as tide gates and culverts associated with City streets. Some street segments could be elevated to accommodate sea level rise; others may need to be relocated or abandoned. Tidal inundation of these local streets would be part of the larger overall rising sea level impacts to the storm water system too. Surface streets would be susceptible to frequent and prolonged tidal inundation.

Consequence

By 2050 there are 3.5 miles (2%) of streets in the City and 7.7 miles (5%) in the PA that are vulnerable and at risk from tidal inundation. There are 12.2 miles (9%) of streets in the City and 17.6 miles (11%) in the PA that are vulnerable and at risk from tidal inundation by 2100. In the City, a significant portion of the streets at risk from tidal inundation by 2100 provide access to the waterfront. Reduction in service to this area would impact the local economy, tourism and community events, the use of port facilities and CDI properties, and access to the bay. In the PA, road segments at risk of tidal inundation would create a significant impact to rural communities by impairing or blocking connectivity to the City or to U.S. Highway 101. Also significant, as sea levels rise, would be the loss of ingress and egress to several communities in the unincorporated area of the County: King Salmon, Fields Landing, and Fairhaven.

Priority

Streets are susceptible to tidal inundation. Local streets that serve areas that could be tidally inundated may likely not be receive a high priority ranking if those communities are relocated. Streets that provide connectivity between areas not tidally inundated such as Myrtle Avenue, or that are essential to maintain access to infrastructure, such as

King Salmon Avenue to the HBGS and ISFSI, would likely receive a higher priority ranking. Overall due the limited number of miles that could be impacted the priority ranking for both 2050 and 2100 is 4.

5.1.2 State Highway 255

Description

In the City, State Highway 255 extends west from U.S. Highway 101 approximately 1.9 miles to the Samoa Peninsula then north along the western shore of Arcata Bay to the town of Manila and then proceeds across diked former tidelands to Arcata where it rejoins U.S. Highway 101. The reach of State Highway 255 that crosses the bay with three bridges between two islands is almost entirely in the City (1.4 miles). The PA encompasses very little of State Highway 255 (0.5 miles).

Exposure

The reaches of highway on islands between the bridges have likely been designed to withstand being tidally inundated and would suffer no new impacts from sea level rise tidally inundating the embankments. The embankments, if not fortified, would be susceptible to wave induced erosion. Tidal inundation of the road surface in the reaches between the bridges would cause the road base to become saturated, causing the asphalt to buckle and require resurfacing.

While not in the City's PA, there is a 2.6-mile reach of Highway 255 that traverses diked former tidelands, which are vulnerable if the protective diked shoreline on Arcata Bay, Mad River Slough, or Liscom Slough are breached or overtopped. The shoreline on Mad River and Liscom Sloughs is rated highly vulnerable (Figure 67). If this reach is closed, State Highway 255 from Eureka to Samoa Peninsula would become the sole source of access for the communities of Fairhaven, Samoa, and Manila.

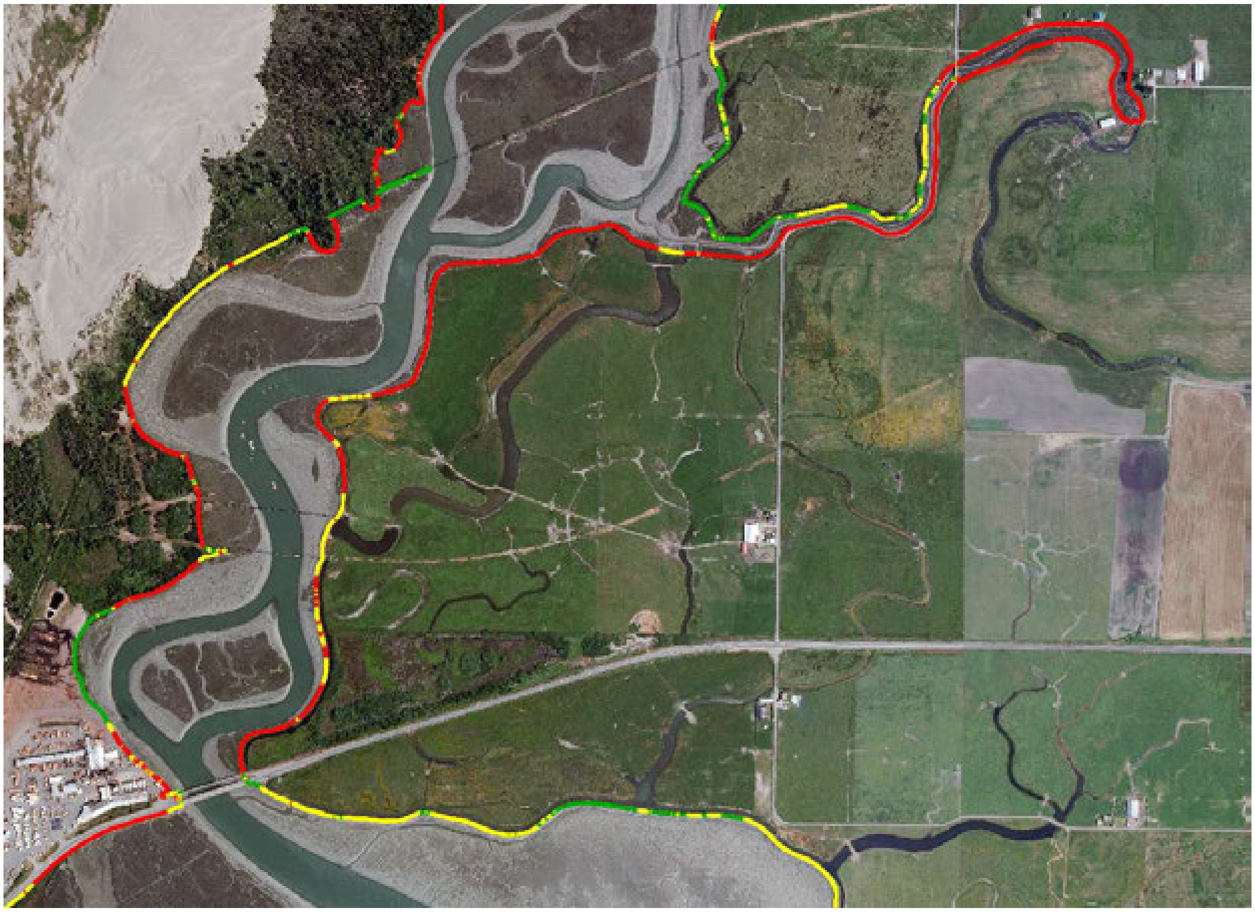

Figure 67. State Highway 255 near Mad River and Liscom Sloughs and dike shoreline vulnerability rating (red=high, yellow=moderate, and green=low).

2015 to 2100

In the City, State Highway 255 is not at risk of being tidally inundated until sometime around 2050, when a 0.1-mile segment of highway on Indian Island could potentially be tidally inundated by 1.9 feet (9.64 feet NAVD 88) the high projection for relative sea level rise. By 2100, State Highway 255 up to 0.3 of mile could potentially be tidally inundated in the City and just 0.03 miles in the PA.

2015

Outside the PA, State Highway 255 traverses diked former tidelands in the Arcata Bottoms. This reach of highway is vulnerable and at risk now if the protective shoreline dikes on Mad River Slough are breached or overtopped.

2030

Outside the PA, the dikes along the left bank of Liscom Slough could potentially be overtopped as MMMW rises to 8.6 feet and MAMW to 9.7 feet (NAVD 88), and this reach of State Highway 255 could be tidally inundated.

2050

Outside the PA, the length of diked shoreline on the left bank of Liscom and Mad River Sloughs that could potentially be overtopped by 1.9 feet of sea level rise increases. The reach of State Highway 255 at risk of tidal inundation would also lengthen.

2070

By 2070, the high projection for sea level rise of 3.2 feet (11.0 feet NAVD 88) would overwhelm most of the dikes outside the PA on Mad River Slough and Arcata Bay, causing State Highway 255 to be tidally inundated from both directions for 1.75 miles. A 0.1-mile segment of the highway north of Manila before Samoa Bridge would be tidally inundated too. It is likely that State Highway 255 will need to be elevated or the reach of highway that is vulnerable and at risk from tidally inundation closed, which would make State Highway 255 from Eureka the only point of ingress and egress.

2100

Tidal inundation of State Highway 255 north of Manila would increase by 0.5 miles.

Susceptibility

The highway embankments, if not fortified on the reaches of highway between the bridges on islands could be susceptible to wave induced erosion. Tidal inundation of the highway surface in the reaches between the bridges could cause the road base to become saturated, causing the asphalt to buckle and require resurfacing. The short sections of highway vulnerable and at risk from tidal inundation between the bridges spanning Humboldt Bay is limited (0.1 mile by 2050, and 0.3 miles by 2100) and could be protected by increasing their elevation.

Consequence

In the City, State Highway 255 will likely not be significantly impacted until near 2100. But there are 2.3 miles of the highway that are vulnerable and at risk from tidal inundation by MMMW of 13.1 feet (NAVD 88). If these sections of highway are not adapted to rising tides, then the State Highway 255 loop from Eureka to Arcata could be severed. Ingress and egress to Samoa Peninsula and the port facilities located there would have to occur over the bridges from Eureka to Samoa.

Continued access to the CDI properties, port and harbor facilities on the Samoa Peninsula may be essential to the region if Humboldt Bay is to remain a viable harbor and port. Without the connectivity provided by State Highway 255 to the Samoa Peninsula, the CDI properties and bulk cargo docks located there would no longer be able to be utilized for export or import. Vehicular access to the U.S. Coast Guard Station would be lost, as would access to the North Jetty for repair. Also significant would be the complete loss of ingress and egress to the several communities in the unincorporated area of the County: Fairhaven, Samoa, and Manila.

The loss of State Highway 255 could be significant to the Humboldt Bay region.

Priority

While exposure to State Highway 255 from tidal inundation is low by 2050, it would increase significantly on the segment from the City to Samoa and from Arcata south to Manila, Samoa, Fairhaven, and to the port facilities that may be essential to the Humboldt Bay region by 2100. The highway would be susceptible to tidal inundation. The consequences of the tidal inundation impacts to the highway by 2050 would be low but significant by 2100. The priority ranking for 2050 is 3 and 2100 6.

5.1.3 U.S. Highway 101

Description

U.S. Highway 101 is the primary north–south transportation corridor on the northern California coast; Caltrans is responsible for the maintenance of U.S. Highway 101. U.S. Highway 101 is classified as a freeway to the south of the City (K-mart traffic light), as a major arterial roadway as it traverses the City, and as an expressway to the north of the City. There are 6.2 miles of U.S. Highway 101 in the City (Table 17). In the City, there are 1.1 miles of U.S. Highway 101 north of Eureka Slough that traverse low-lying diked former tidelands.

In the PA, there are 5.5 miles of U.S Highway 101 (Table 17), which traverses 3.4 miles of low-lying coastal areas in two segments: Eureka to Bracut (2.1 miles ranging in elevation between 8.8 to 14.3 feet on Arcata Bay) and between Eureka and King Salmon (1.3 miles ranging in elevation from 11.0 to 13.0 feet (NAVD 88) on Eureka Bay).

Exposure

In the City and PA, U.S. Highway 101 is vulnerable and at risk from tidal inundation if segments of protective shoreline dikes on Eureka and Fay Sloughs (Figure 68) are breached or overtopped; water could drain towards the highway. U.S. Highway 101 is also vulnerable and at risk where it traverses Elk River Slough where shoreline dikes are vulnerable and at risk from breaching or overtopping (Figure 69). If these protective dikes fail, U.S. Highway 101 could become a causeway with open water potentially on one or both sides. Under these conditions, the road prism could be exposed to wind-induced wave erosion and slumping from over saturation. Over time and under repeated flooding, the road base will become saturated, causing the asphalt to buckle and require resurfacing. Rising tides can impair the capacity and function of water control structures, such as tide gates and culverts, associated with U.S. Highway 101, which could increase flooding of adjacent areas.

Table 17. Miles of U.S. Highway 101 that are vulnerable and at risk from tidal inundation in the City and its PA.

U.S. HIGHWAY 101	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	0.0	0.0	0.0	2.4	3.8	6.2
Planning Area	0.0	1.0	1.9	3.4	2.1	5.5

Figure 68. Eureka–Fay Slough unit shoreline vulnerability rating: red is high, yellow is moderate, and green is low, failure of shoreline protection could potentially make U.S. Highway 101 vulnerable and at risk from tidal inundation.

Figure 69. Elk River Slough shoreline vulnerability rating: red is high, yellow is moderate, and green is low, failure of shoreline protection could potentially make U.S. Highway 101 vulnerable and at risk from tidal inundation.

In the City, up through 2050 U.S. Highway 101 is not exposed to tidal inundation but by 2100 approximately 39% (2.4 miles) of U.S. Highway 101 may be tidally inundated. In the PA 35% by 2050 (1.9 miles) of the highway may be vulnerable and at risk from tidal inundation and by 2100 62% (3.4 miles). In the City by 2100 61% (3.8 miles) of the highway are likely to not be tidally inundated, and in the PA 38% (2.1 miles) may not be (Figure 70 and Table 17).

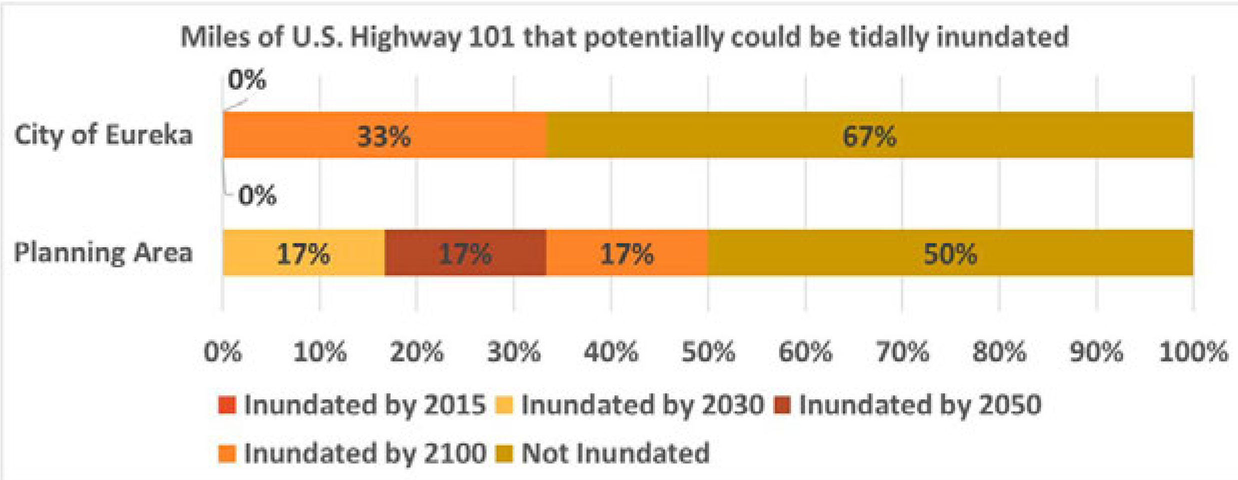

Figure 70. Miles of U.S. Highway 101 in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the miles of highway that are not likely to be inundated.

2015

In the City and PA, U.S. Highway 101 in Arcata Bay could become a causeway if the protective dike shoreline along Eureka and Fay Sloughs are breached or overtopped by an MAMW or 100-year storm event. Its road embankments could become tidally inundated by MMMW elevation of 7.74 feet (NAVD 88) but its road surface would not be tidally inundated. In the PA, on the Eureka Bay reach, the protective dike on Elk River Slough has already been breached and the road embankment on the east side of the highway is tidally inundated now by MAMW of 8.78 feet (NAVD 88). If the protected railroad grade shoreline on Eureka Bay is breached by an extreme tide or 100-year storm event, the highway could become a causeway.

2030

In the City, if the protective shoreline dikes along Eureka and Fay Sloughs are breached or overtopped by an extreme tide or 100-year storm event, the highway on Arcata Bay in the City could potentially become a causeway.

In the PA, if the protective shoreline dikes along Eureka and Fay Sloughs are breached or overtopped, several segments of U.S. Highway 101 in Arcata Bay totaling 1.0 miles of the north-bound lanes could potential be tidally inundated. If the protected shoreline on Eureka Bay is breached by an extreme tide or storm event, the highway could potentially become a causeway.

2050

In the City, U.S. Highway 101 and Broadway and the 4th/5th Streets couplet in their current conditions are not vulnerable or at risk from tidal inundation by rising tides of 9.6 feet (NAVD 88).

In the PA, the Arcata Bay reach, 1.9 miles of the north-bound lanes and 1.0 miles of the south bound lanes could potentially be tidally inundated if the railroad grade to the west and/or the dikes on Eureka–Fay Slough are breached or overtopped by MMMW of 9.6 feet (NAVD 88) and MAMW of 10.7 feet (NAVD 88). The Elk River Slough reach is not vulnerable or at risk more than what has been described for 2015 and 2030.

2070

In the City, MMMW may reach 10.9 feet (NAVD 88) and on U.S. Highway 101 on Arcata Bay, there may be 0.6 miles of north-bound lanes and 0.9 miles of the south bound lanes the could potentially be tidally inundated if both the railroad grade to the west and the dikes to the east are overtopped or breached. The 4th/5th Streets couplet could experience tidal inundation of 0.3 miles on 4th Street and 0.2 miles on 5th Street. Broadway Avenue could have 0.3 miles tidally inundated. U.S. Highway 101 in south Eureka could have 0.2 miles in the south-bound lanes and 0.1 miles in the north-bound lanes tidally inundated.

In the PA, by 2070 with the high projection for relative sea level rise of 3.2 feet, both north and south-bound lanes for 2.1 miles on the Arcata Bay reach could be tidally inundated if both the railroad grade to the west and the dikes to the east are overtopped or breached. South of Eureka in the Elk River Slough reach, 0.8 miles of the south-bound lanes and 0.6 miles of the north-bound lanes may be tidally inundated when MMMW reaches 10.9 feet (NAVD 88).

2100

In the City, when the high sea level projection reaches 13.1 feet (NAVD 88), 1.1 miles of U.S. Highway 101 on Arcata Bay could potentially be tidally inundated, as could 0.5 miles of the 4th/5th Streets couplet, 0.5 miles of Broadway, and 0.3 miles of both north and south-bound lanes in south Eureka. Cumulatively, 2.4 miles of U.S. Highway 101 could become tidally inundated in the City by 2100.

In the PA, in the Arcata Bay reach, 2.0 miles of both north and south-bound lanes could become tidally inundated, and 1.4 miles of both north and south-bound lanes south of Eureka in the Elk River Slough reach could also be tidally inundated. Cumulatively, 3.4 miles of U.S. Highway 101 could potentially be tidally inundated in the PA by 2100.

Susceptibility

If protective dikes are breached and tidal waters allowed to reach U.S. Highway 101 then under these conditions, the road prism could be exposed to wind-induced wave erosion and slumping from over saturation. Over time and under repeated flooding, the road base will become saturated, causing the asphalt to buckle and require resurfacing. Rising sea levels could inundate the highway, which could interrupt traffic on a frequent basis.

Consequence

In the City and its PA, U.S. Highway 101 is vulnerable and at risk from tidal inundation where it traverses low-lying reaches of Arcata Bay and Elk River Slough behind protective shoreline structures (railroad grade and dikes) that are not maintained by Caltrans. Any flooding of the highway on a regular basis will be a significant disruption to the use of this important transportation corridor. By 2050, nearly 2 miles of the highway on Arcata Bay are vulnerable and at risk of being tidally inundated, and by 2070, nearly 3 miles. On Elk River Slough, nearly 1 mile could be vulnerable and at risk from tidal inundation. By 2100, U.S. Highway 101 north and south of the City and the U.S. Highway 101 corridor in the City are vulnerable and at risk from tidal inundation, as are reaches farther north in Arcata Bay and on South Bay. U.S. Highway 101 is one of the most critical assets for the City and the Humboldt Bay region. Any interruption of service on U.S. Highway 101 would be unacceptable.

Priority

U.S. Highway 101 exposure to tidal inundation by 2050 could be nearly two miles, increasing significantly to potentially 5.8 miles by 2100. The highway is susceptible to tidal inundation and wave induced erosion. The consequences to the City and the Humboldt Bay region of any tidal inundation of U.S. Highway 101 would be significant whether it is two miles or six miles. Therefore, the priority ranking for 2050 is 5 and 2100 6.

5.2 Marine

Humboldt Bay provides a safe harbor for marine-based transport and commerce. Humboldt Bay is the only deep water harbor between San Francisco and Coos Bay, Oregon, a distance of 438 miles. Humboldt Bay is a type of bar-formed lagoon, with South and North Spits separating the bay from the ocean. The Humboldt Bay Harbor, Recreation and Conservation District (District) is the Port Authority for Humboldt Bay. In 1973, the state legislature made a grant of State Sovereign Lands to the District in

Humboldt Bay not previously granted to the City. The District was also granted authority to regulate shoreline development, up to Mean Higher High Water (MHHW) elevation (6.9 feet NAVD 88) on Humboldt Bay and its sloughs, and to Mean High Water (MHW; 5.8 feet NAVD 88) on the islands of Humboldt Bay. The City and Humboldt County in the PA regulate land use above MHHW on Humboldt Bay and Eureka and Elk River Sloughs and the City above MHW on the Islands of Humboldt Bay. In the City, marine transport and commerce is supported by public and private waterfront facilities located in areas zoned CDI, Industrial, Commercial Waterfront, and Public Facilities. In the PA, marine transport and commerce facilities are located in unincorporated areas that Humboldt County has designated CDI, Industrial General, Coastal Recreation, and Public Facilities.

Marine transport infrastructure in the City and PA will be described and its exposure to sea level rise analyzed for the Harbor, Coastal Dependent Industrial property/bulk cargo docks, and commercial fishing fleet and recreational boating facilities (Table 18).

Table 18. Summary of marine transportation assets (Port facilities) vulnerable and at risk in the City of Eureka and its Planning Area to current conditions (2015) and high projections for relative sea level rise by: 2030, 2050, and 2100.

			Inundated by 2015		Inundated by 2030		Inundated by 2050		Inundated by 2100	
PORT FACILITIES	**COE**	**PA**	**COE**	**PA**	**COE**	**PA**	**COE**	**PA**	**COE**	**PA**
Jetty (miles)	0.0	3.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	2.2
Industrial	5	5	0	0	0	0	1	0	5	2
Commercial	8	5	0	0	2	0	3	2	7	4
Recreational	8	5	0	0	0	3	8	4	8	5

5.2.1 Humboldt Bay Harbor

Description

The Humboldt Bay Harbor entrance consists of two rock jetties, a bar and an entrance channel, which are maintained by the U.S. Army Corps of Engineers (ACE) and the District. The ACE constructed and maintains the two jetties that form the entrance to Humboldt Bay. The North Jetty is approximately 1.4 miles long and currently 0.5 miles are waterward of the vegetated shoreline. The South Jetty is approximately 1.6 miles long and 0.8 miles are waterward of the vegetated shoreline. The ACE regularly dredges 2.1 miles of the bar and entrance channels (approximately 2,300 and 9,000 feet in length) and turning basin, as well as two main navigational channels to North Bay and Fields Landing (South Bay), and their respective turning basins (Figure 71).

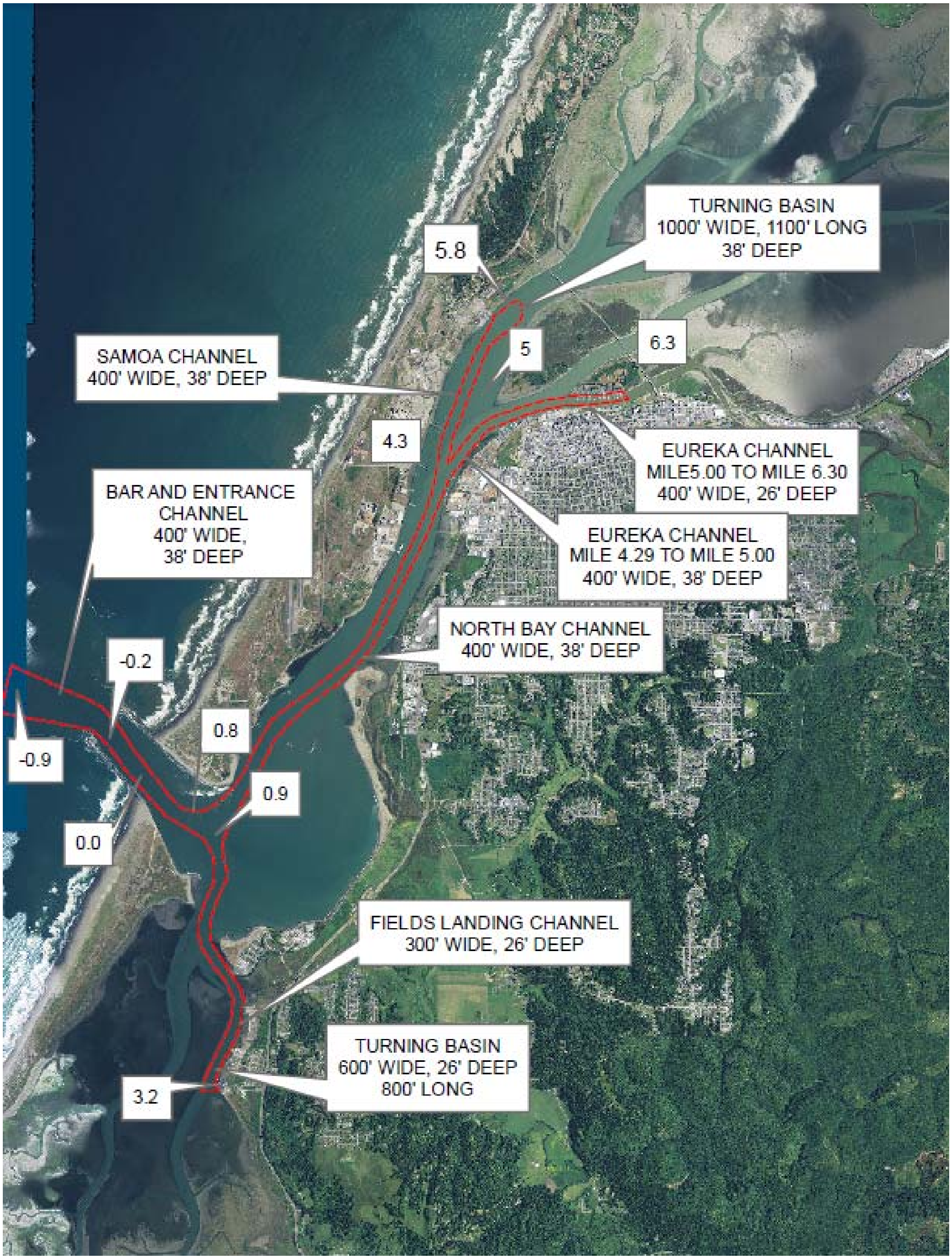

Figure 71. Humboldt Bay navigational channels maintained by U.S. Army Corps of Engineers.

The entrance channel is maintained to a depth of 48 feet. The main North Bay channel is approximately 3.5 miles (18,500 feet) in length and is maintained to a depth of 38 feet. Nearly all of the bulk cargo docks are located on the main North Bay channel, with the exception of one bulk cargo dock on the Fields Landing channel. The North Bay channel eventually branches into the Eureka channel 1.8 miles in length (approximately 9,700 feet) and Samoa channel 1.5 miles in length (approximately 8,000 feet long). The Eureka channel is maintained to a depth of 38 feet for 0.71 miles (3,749 feet) and then to a depth of 26 feet for 1.3 miles (6,700 feet). Both the Eureka and the Woodley Island Marinas are located in the City on the Eureka channel. The Samoa channel is maintained to a depth of 38 feet. The main South Bay channel is approximately 2.3 miles (12,000 feet) in length and is maintained to a depth of 26 feet. There are turning basins at the end of the Samoa and Fields Landing channels. Together the District and City are responsible for dredging two public marinas (Eureka and Woodley Island), which are located in the Eureka Channel and in the City. The District also assists private dock-owners with dredging.

Exposure

Rising sea levels and continued tectonic subsidence may affect the processes that maintain the morphology of the South Spit, which is relatively low elevation (less than 20 feet). Shoreline erosion and retreat could pose a hazard to the South Spit. Rising sea levels will inundate the jetties and the access roads to the jetties. It is not known whether being submerged will affect the jetties' performance. However, submerged jetties could become a navigational hazard. Tidal inundation of access roads could impact the ability of vehicular equipment to reach the jetties for future repairs.

The 1997–98 El Niño increased runoff from the Eel River, and elevated sea levels filled the bar and entrance channel with over a million cubic yards of sand. In 2000, the District and the ACE completed a channel deepening project. Climate change could increase storm discharge magnitude in the Eel River, which combined with increased sea level elevations, could result in El Niño-like conditions off the coast of Humboldt Bay. If these conditions occur, they could increase the frequency of sediment filling the bar and entrance channel, requiring more frequent dredging to maintain the entrance to the harbor.

The diked former tidelands on Humboldt Bay are protected from tidal inundation by 41 miles of earthen dikes. If these dikes are breached, the former tidelands could become tidally inundated, which could expand the bay's footprint by as much as 52% and possibly increase the tidal prism on Humboldt Bay. It is not known if an increased tidal prism would affect conditions in the bar and entrance channels.

2015

MAMW of 8.8 feet (NAVD 88) could overtop approximately 0.2 miles on the bay side of the North Spit jetty.

2030

The MMMW is projected to rise by 0.9 feet (8.6 feet NAVD 88) by 2030. Approximately 0.2 miles (790 feet) of the North Spit jetty located in the bay could become submerged.

2050

The high projection for MMMW by 2050 is 1.9 feet (9.6 feet NAVD 88) and approximately 420 feet of South Jetty Road, which provides vehicular access to the South Jetty, could be tidally inundated, and 475 feet of New Navy Base Road that services the North Jetty could also be tidally inundated. Approximately 0.2 miles (1,214 feet) of the North Jetty could become submerged.

2100

By 2100, nearly 1.7 miles of New Navy Base Road and 1.1 miles of South Jetty Road could become tidally inundated by 5.3 feet of sea level rise (13.1 feet NAVD 88). Approximately 1.2 miles (87%) of North Jetty and approximately 0.9 miles (61%) of South Jetty could be submerged with the high projection for relative sea level rise by 2100.

Susceptibility

The impacts from sea level rise on the harbor related to sediment transport, channel scour or aggradation, dune-spit formation and maintenance, and jetty function are not known at this time. Changes in these processes and functions may become more pronounced between 2050 and 2100, when the high projections for sea level rise may reach 1.9 to 5.3 feet. Access to the jetties on South and North Spits may be affected by tidal inundation and shoreline erosion. The roadway accessing the jetties may need to be protected from sea level rise. It is not known if tidal inundation would impact the function of the jetties. Changes in sediment supply, transport, and deposition in the navigation channels could be a significant impact.

Consequence

Should the South Spit breach, it will likely have a significant effect on sediment transport and circulation in South Bay and the harbor entrance. If the bar and entrance channels aggrade significantly in response to sea level rise and changes in offshore sediment movement, the cost of maintaining the entrance and navigation channels will increase.

Dredging the navigational channels is a major expense for the District and may increase substantially. Access to the jetties via surface roads or by barge is not required on a frequent basis, as the jetties have not required frequent maintenance or repair.

The Spits, jetties, entrance, and navigation channels are critical to Humboldt Bay and the City if it is to continue to provide a safe harbor and port.

Priority

The exposure to the spits, jetties and navigation channels from sea level rise is difficult to assess. While by 2100 73% (2.2 miles) of the jetties could be tidally inundated they may still continue to function and may not be susceptible to sea level rise. Access roads to the jetties could be vulnerable and at risk from tidal inundation and they would be susceptible. How sediment supply, transport, and deposition in the navigation channels might respond to sea level rise is not known. Humboldt Bay as a harbor is one of the most significant assets to the City if it is to remain a viable port. By 2050 these Harbor structures and features are not expected to be impacted very much by tidal inundation but by 2100 exposure, susceptibility, and consequence will increase. The priority ranking for 2050 is 0 but a 6 by 2100.

5.2.2 Coastal Dependent Industrial/Docks

Description

According to the District's Humboldt Bay Management Plan, there are 10 industrial docks in the City and PA (Figure 72 and Figure 73): 8 dry-cargo and 2 liquid-cargo docks (HBMP 2007). In 2015, only four industrial docks are active in exporting or importing cargo: three dry-cargo (Sierra Pacific, Schneider, and Green Diamond) and one liquid-cargo (Chevron); the other six docks are currently not actively used for shipping.

Five of the docks are located in the City (active and inactive) on CDI properties. Two dry-cargo docks, Sierra Pacific and Schneider, are used primarily to ship forest products (wood chips and logs). The Schneider dock is also occasionally used for non-cargo vessels, including the Navy, Coast Guard, and cruise ships. There is one active liquid-cargo dock operated by Chevron Oil Company. There is an inactive dry-cargo dock owned by the City, Dock B, which is designated as a Foreign Trade Zone, and one inactive liquid-cargo dock owned by Phillips Petroleum (formerly Tosco).

In the PA, there are five industrial dry-cargo docks located on CDI properties. On Samoa Peninsula, there are four dry-cargo docks: one active dock, Green Diamond, that ships wood chips, and three inactive docks, District's Redwood Terminal 1, District's Redwood Terminal 2 (former Evergreen Pulp Mill dock), and one dock at the former Simpson Pulp Mill (Fairhaven Business Park). In Fields Landing, there is one inactive dock, Humboldt Bay Forest Products, which is designated as a Foreign Trade Zone.

Figure 72. City of Eureka on the right and its Planning Area on the left and their bulk cargo docks: (1) Chevron, (2) Sierra Pacific, (3) Phillips, (4) Schneider, (5) Dock B, (6) Redwood Terminal 1, (7) Redwood Terminal 2, (8) Green Diamond, and (9) Fairhaven.

Figure 73. Bulk cargo dock in the Planning Area, (10) Humboldt Bay Forest Products in Fields Landing.

In the City, the liquid bulk cargo dock properties (Chevron and Phillips) are less than 11 feet (NAVD 88) in elevation. The three dry bulk cargo dock properties (Sierra Forest Products, Schneider, and Dock B) are less than 13 feet (NAVD 88) in elevation.

In the PA, the Redwood Terminal 1 Dock on Samoa Peninsula is less than 11 feet (NAVD 88) in elevation. The other three dock properties (Redwood Terminal 2, Green Diamond, and Fairhaven) are greater than 14 feet (NAVD 88) in elevation, which is above the high projection for 2100. The dry-cargo dock property in Fields Landing is less than 11.0 feet (NAVD 88).

Exposure

In the City, one of its bulk cargo docks and CDI property may be impacted by tidal inundation. By 2100 all of its bulk cargo docks and CDI properties are projected to be tidally inundated with the exception of the City's CDI property associated with Dock B. In the PA 2050 U.S. Highway 101 is not exposed to tidal inundation but by 2100 approximately 39% (2.4 miles) of U.S. Highway 101 may be tidally inundated. In the PA none of the bulk cargo docks and their CDI properties appear to be tidally inundated by 2050 and by 2100 two bulk cargo docks and CDI properties could potentially be tidally inundated (Figure 74 and Table 19).

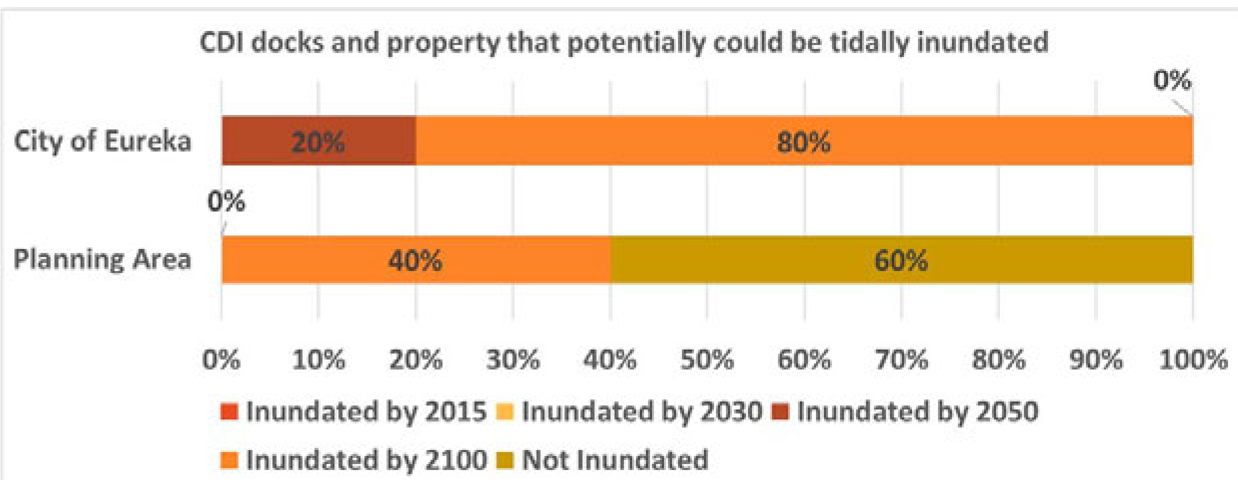

Figure 74. Percentage of Coastal Dependent Industrial docks and property in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100, as well as the percentage that is not likely to be inundated.

Table 19. Number of Coastal Dependent Industrial docks that are vulnerable and at risk from tidal inundation in the City and its PA.

CDI DOCKS and PROPERTY	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	0	0	1	5	0	5
Planning Area	0	0	0	2	3	5

When sea level rise overtops the shoreline, it is expected to tidally inundate the bulk cargo dock facilities and their CDI properties, as well as access streets. By 2100, all five docks within the City and the Redwood Terminal 1 dock in the PA are projected to potentially be tidally inundated by MMMW of 13.1 feet (NAVD 88). Only three of the bulk cargo docks on the Samoa Peninsula may not be vulnerable and at risk from tidal inundation (Figure 75). Regional transportation corridors (U.S. Highway 101 and State Highway 255) funnel mainly forest products from inland sources to the bulk cargo shipping facilities on the bay. As these transportation corridors are impacted by sea level rise, they may in turn impact shipping from these Harbor facilities. All 10 of these bulk cargo dock properties have fortified shorelines that are not likely to erode, with the exception of the property adjacent (north-side) to the Chevron Fuel Terminal, which could provide a pathway for tidal inundation.

Figure 75. City of Eureka on the right and its Planning Area on the left and their bulk cargo docks: (1) Chevron, (2) Sierra Pacific, (3) Phillips, (4) Schneider, (5) Dock B, (6) Redwood Terminal 1, (7) Redwood Terminal 2, (8) Green Diamond, and (9) Fairhaven with the area that could potentially be tidally inundated by 2100 by the mean monthly maximum tide of 13.1 feet (NAVD 88).

2015 to 2030

In the City and its PA, no impacts from sea level rise to the bulk cargo dock properties are expected during this period.

2050

In the City, portions of the Chevron bulk fuel dock property could potentially be tidally inundated by 2050, when MMMW rises to 9.6 feet (NAVD 88) and MAMW reaches 10.7 feet (NAVD 88). In the PA, no impacts from sea level rise to the dry bulk cargo dock properties are expected during this period.

2070

In the City, two dry bulk cargo dock properties (Sierra Pacific and Schneider) and the two bulk fuel dock properties (Chevron and Phillips Petroleum) could potentially become tidally inundated when MMMW rises to 11.0 feet (NAVD 88), which is the high projection for 2070 and MAMW reaches 12.0 feet (NAVD 88).

In the PA, the dry bulk cargo dock at Redwood Terminal 1 property on Samoa Peninsula could potentially be tidal inundated when MMMW rises to 11.0 feet (NAVD 88) and MAMW reaches 12.0 feet (NAVD 88). The dry bulk cargo dock property in Fields Landing could also potentially be tidally inundated.

2100

In the City, the City's dry bulk cargo Dock B property could potentially become tidally inundated when projected MMMW rises to 13.1 feet (NAVD 88) and MAMW reaches 14.1 feet (NAVD 88). In the PA, the remaining three industrial dry bulk cargo dock properties on the Samoa Peninsula are greater than 14 feet (NAVD 88) in elevation, and are therefore not expected to be tidally inundated by the high projection for 2100.

Susceptibility

There are seven Coastal Dependent Industrial bulk cargo docks, adjacent lands and developments below 14.0 feet (NAVD 88) in elevation, that if unprotected, are susceptible to a large degree to tidal inundation and flooding as projected by 2100. These sea level rise impacts are expected to begin affecting bulk cargo docks and CDI lands (1) by 2050 but more significantly by 2070 and 2100 (7) based on projected increases in tidal elevations as result of relative sea level rise. The Bulk cargo dock and properties that are vacant or suffering from a lack of maintenance are susceptible to a greater degree than those facilities that being used and maintained. Bulk cargo facilities and their supporting properties may need to be elevated to avoid tidal inundation. The City only owns the Dock B bulk cargo dock and property. The dock is unable to be used in its current condition and the property is vacant. The City could partner with the privately owned bulk cargo docks in its jurisdiction to develop adaptation strategies and secure funding necessary to permit and implement adaptation measures in order to continue to receive benefits from the docks' continued services.

Consequence

In the City, the potential loss of all of its CDI bulk cargo docks and associated developments to sea level rise by 2100 would be significant if its desires to continue to function as a sea port. In the PA, 60% (3) of its bulk cargo docks on the Samoa Peninsula would likely not be impacted by sea level rise projections for 2100. The loss of 40% of the PA's bulk cargo docks would not be as consequential to the Humboldt Bay region as the City losing 100% of its bulk cargo docks would be to the City.

In the City, the potential loss of the port services provided by the bulk cargo docks could be significant to the City and Humboldt Bay region, particularly with the loss of the only operating bulk liquid fuel dock on Humboldt Bay. The Chevron terminal is currently an essential piece of infrastructure to the Humboldt Bay region. The services of the bulk dry cargo docks if lost in the City could be offset if those services were relocated to the three CDI properties with functioning bulk cargo docks on Samoa Peninsula through 2100.

In the PA, the bulk cargo dock in Fields Landing is currently not in operation; however, its potential loss to tidal inundation by 2070 could have a significant impact to the region, as this dock has a Foreign Trade Zone designation. The District's Redwood Terminal 1 bulk cargo dock and property is currently being put back into service; its potential loss by 2070 to tidal inundation could be significant to the region and Port of Humboldt, given the potential loss of the City's bulk cargo facilities.

In the City, tidal inundation of the CDI properties and the consequent loss of the currently active liquid and dry bulk cargo dock facilities potentially by 2070 could be significant. The potential loss of these facilities could greatly impact if not eliminate the City's capacity to function as a port on Humboldt Bay. Regional and local access to and from these bulk cargo facilities will also be significantly impaired from tidal inundation in 2070 through 2100 and beyond.

The City has very little capacity to adapt four of the five bulk cargo docks and properties in its jurisdiction to sea level rise. The City can partner with these bulk cargo property owners and other beneficiaries of these facilities to secure money necessary to implement protective measures to tidal inundation. Ultimately, the long-term strategy for adaptation to sea level rise may be to relocate/consolidate CDI uses and bulk cargo services to the properties and docks on Samoa Peninsula that are not at risk from tidal inundation by 2100.

Priority

By 2050 only one bulk cargo dock in the City could be vulnerable and at risk from tidal inundation by MMMW and MAMW. By 2100 70% (7) of the bulk cargo docks and their adjacent properties could be tidally inundated. All of the bulk cargo docks in the City could potentially be tidally inundated. Cargo docks and their adjacent properties and access streets are all susceptible to being tidally inundated. The potential loss of 70% of the bulk cargo facilities on Humboldt Bay could be significant if it is to continue to be an Industrial port. The priority ranking for the bulk cargo docks and developments for 2050 is 3 and by 2100 a 6.

Bulk cargo docks and their CDI properties should be high priority assets to the City if it is to remain a viable industrial port. If it is not feasible to retain these dock facilities and properties beyond 2070 given the projected sea level rise, then their priority to the City from 2050 to 2100 could be lowered.

5.2.3 Commercial Fishing Fleet

Description

The commercial fishing industry has a long tradition of development and use of the working waterfront in the City and in its PA. In the City, the commercial fishing industry relies on public and private waterfront properties and facilities: District's 214 boat berths at Woodley Island Marina with a boom crane–work/maintenance area (Figure 76); 150 boat berths at City boat basin; the City's Fisherman's Terminal with a 420-foot dock and hoists for unloading; England Marine Supply and fuel dock; Coast Seafood's shell fish processing station, dock and property; old Ice House property; Pacific Choice property and receiving station and processing plant (Figure 77); Caito's property's receiving station, processing plant and dock (Figure 76).

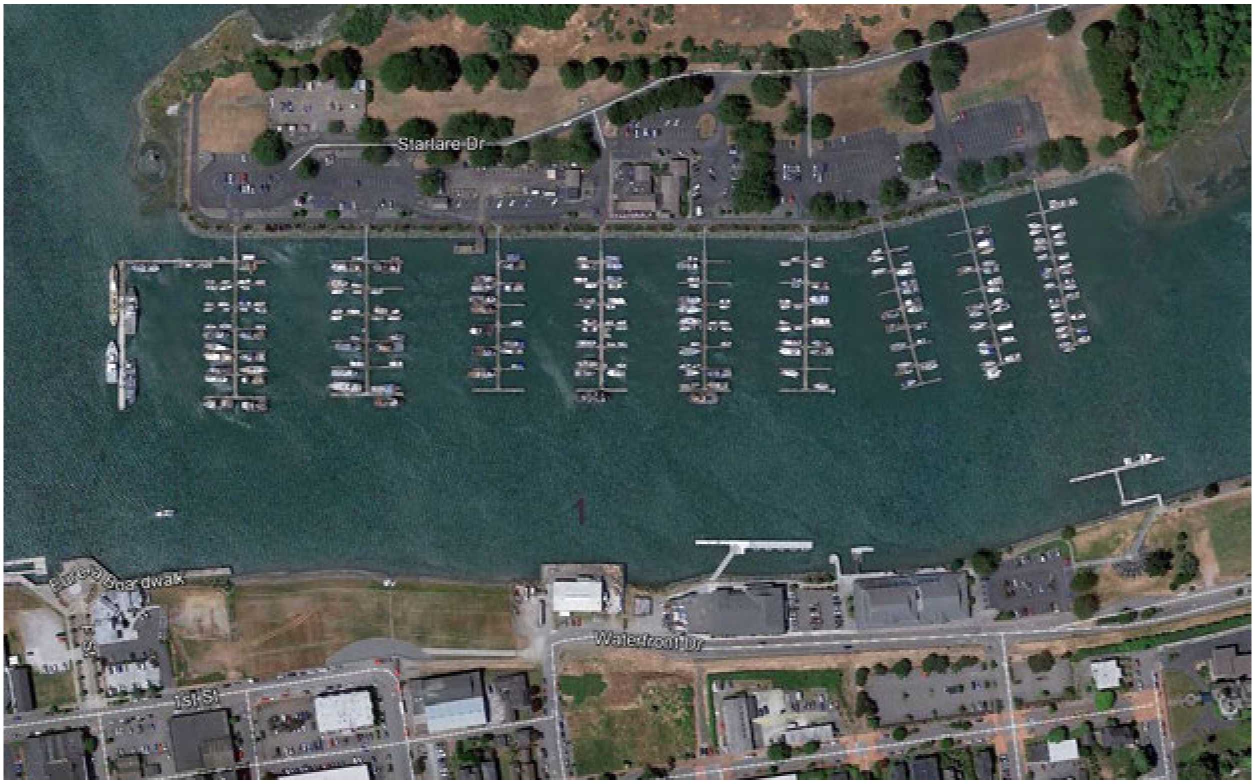

Figure 76. Woodley Island and Humboldt Bay Harbor, Recreation and Conservation District's Marina and (1) Caito fish receiving station.

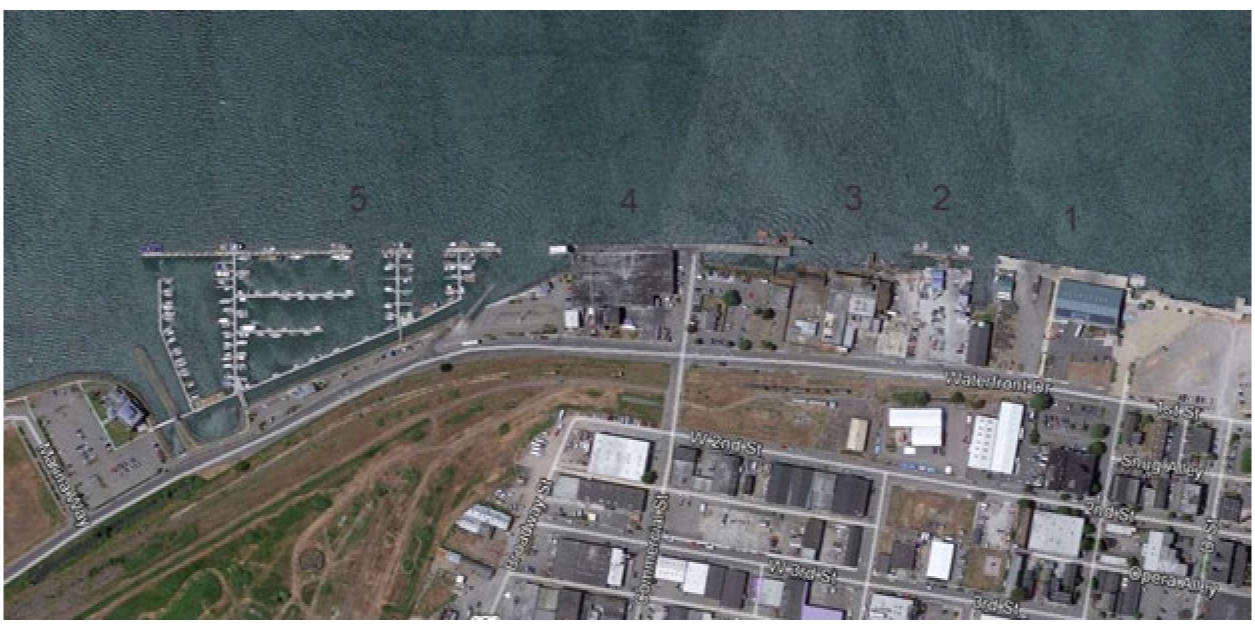

Figure 77. City of Eureka commercial fishing facilities: (1) Fisherman's Terminal, (2) Coast Seafood, (3) Old Ice House, (4) Pacific Choice and Englund Marine, and (5) City of Eureka.

In the PA, there are a several other commercial fishing properties and facilities. On the Samoa Peninsula, the District's property and bulk cargo docks at Redwood Terminal 1 is being developed for commercial fishing fleet use, and Redwood Terminal 2 is now being used by Hog Island Oyster Company to produce oyster spat. Zerlang & Zerlang boatyard in Finn Town, next to Zerlang, is another commercial dock at the end of Comet Street that is being used by Hog Island Oyster Company to raise oysters. A dock in Fields Landing is being used for the commercial crab fishery, and the District's Fields Landing boatyard and property are actively used by commercial and recreational boats (Figure 78).

Figure 78. Fields Landing commercial fishing facilities: (1) Private commercial fishing dock and property, and (2) Humboldt Bay Harbor, Recreation and Conservation District's boatyard property.

Exposure

In the City, by 2030 two of its commercial fishing docks and facilities could potentially be impacted by tidal inundation, and 3 by 2050, by 2100 it is projected that 7 (87%) commercial fishing docks and facilities could be tidally inundated, only one dock and facility is likely to not be affected. In the PA two commercial fishing docks and facilities could be tidally inundated by 2050 and four (80%) by 2100, leaving just one commercial fishing docks and facilities that is not likely to be tidally inundated (Figure 79 and Table 20).

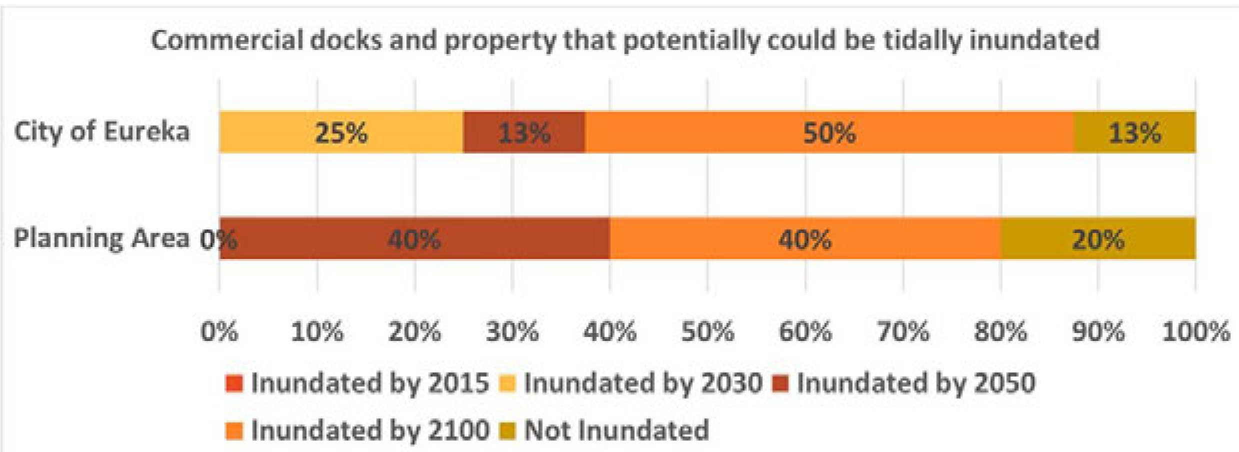

Figure 79. Percentage of commercial docks and property in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the percentage that is not likely to be inundated.

Table 20. Number of commercial docks that are vulnerable and at risk from tidal inundation in the City and its PA.

COMMERCIAL DOCKS-PROPERTY	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	0	2	3	7	1	8
Planning Area	0	0	2	4	1	5

Rising sea levels will eventually cause boat berths and docks to float off their pilings during king tides or storm surges. The high projection for MMMW is to rise 2 feet by 2050, while MAMW could rise that much by 2030, and MAMW may be 3 feet higher in 2050. When sea level rise overtops the shoreline, it would tidally inundate waterfront properties where commercial fishing and recreational boating facilities and docks are located, as well as the streets that access these properties. Most of the properties that support the commercial fishing fleet and recreational boating facilities have fortified shorelines that are not likely to erode, with the exception of the Zerlang & Zerlang property in the PA on Samoa Peninsula.

2015

There are no commercial fishing facilities at risk from tidal inundation in 2015.

2030

In the City, when MMMW rises 0.9 feet to 8.6 feet (NAVD 88), and MAMW reaches 9.7 feet (NAVD 88), Coast Seafood's property could potentially be partially inundated. In the PA, by 2030 no commercial fishing facilities are expected to be tidally inundated.

2050

In the City, when MMMW rises 1.9 feet to 9.6 feet (NAVD 88), and MAMW reaches 10.7 feet (NAVD 88), the jetty at the Eureka Boat Basin could be tidally inundated, and the parking area and adjacent Waterfront Drive could also be partially inundated. Coast Seafood's property and the adjacent reach of Waterfront Drive could be tidally inundated, and Caito's property could potentially be just starting to be tidally inundated.

In the PA, when MMMW rises 1.9 feet to 9.6 feet (NAVD 88), and MAMW reaches 10.7 feet (NAVD 88), the commercial fisheries facility at Fields Landing could be partially inundated, as could the District's Fields Landing boatyard and the Zerlang & Zerlang boatyard on Samoa Peninsula.

2070

In the City, when MMMW rises 3.2 feet to 11.0 feet (NAVD 88), and MAMW reaches 12.0 feet (NAVD 88), the waterfront property between Humboldt Bay and 4^{th} and Summer Streets from West Washington Street to D Street (Eureka Boat Basin, Commercial Street dock, Coast Seafood, and Fisherman's Terminal) could become tidally inundated, with the exception of the CITY's Wharfinger and Dock B properties, and Caito's property. While Woodley Island Marina is not likely to be tidally inundated by 2070, its sole access road could be.

In the PA, when MMMW rises 3.2 feet to 11.0 feet (NAVD 88), and MAMW reaches 12.0 feet (NAVD 88), the waterfront property at the commercial fisheries facility at Fields Landing could be tidally inundated, as could the District's Fields Landing boatyard. On Samoa Peninsula, the Zerlang & Zerlang boatyard and the District's Redwood Terminal 1 properties could be tidally inundated by MMMW of 11.0 feet (NAVD 88) and MAMW of 12.0 feet (NAVD 88).

2100

By 2100, when MMMW rises 5.4 feet to 13.1 feet (NAVD 88), and MAMW reaches 14.1 feet (NAVD 88), all of the waterfront properties in the City and its PA supporting the commercial fishing fleet could potentially be tidally inundated, with the exception of the District's Woodley Island Marina and its Redwood Terminal 2 property on Samoa Peninsula. Access streets to these properties could also be tidally inundated, including access to Woodley Island.

Susceptibility

In the City, rising tidal elevations by 2050 of 2 to 3 feet could require that the pilings at the two marinas be raised to prevent the boat berths and docks from floating off during MAMW and storms, or 100-year floods. The commercial fishing facilities and properties in the City and PA are to a large degree susceptible to tidal inundation by 2070 when the high projection for MMMW and MAMW reaches 10.95 feet and 11.99 feet (NAVD 88). Potential tidal inundation of most of the City's waterfront properties and facilities by 2070 could likely be a significant impact to the commercial fishing fleet, if these are the only receiving, processing, or storage facilities available. The City's Eureka Boat Basin property and access streets are also susceptible to significant degree if they are tidally inundated, by 2070. These commercial fishing facilities and their supporting waterfront properties are very susceptible to tidal inundation in their present condition. The facilities and properties will need to be elevated to avoid tidal inundation. The District's Woodley Island facilities and properties are not expected to be tidally inundated even by 2100.

In the PA, the commercial fishing and boatyard facilities and properties in Fields Landing, the Zerlang & Zerlang boatyard on the Samoa Peninsula, and the District's Redwood Terminal 1 properties are also susceptible to a significant degree as they are likely to be tidally inundated by 2070. The District's Redwood Terminal 1 property and facilities could be elevated to reduce their vulnerability and risk from tidal inundation and protect the commercial fishing fleet's infrastructure if it was relocated there.

Consequence

By 2050, approximately 38% (3 docks) of the City's commercial fishing docks and facilities could be significantly impacted by tidal inundation and in the PA 40% (2 docks). The loss of 80 to 87% of the waterfront facilities and properties in the City and its PA by 2100 that support the commercial fishing fleet to tidal inundation would be significant to the City and the Humboldt Bay region. The District's Woodley Island facilities and properties in the City would likely continue to function through projected sea level rise for 2100. In the PA, the loss of the boatyard at Fields Landing and Zerlang & Zerlang on Samoa Peninsula by 2070 could also be a significant impact to the commercial fishing fleet in the Humboldt Bay region.

Priority

Exposure to the commercial fishing fleet docks, facilities and properties by 2050 is projected to approach 40% and by 2100 80 to 90%. These waterfront facilities and properties are susceptible to tidal inundation. The consequences of 40% of its commercial fishing facilities and properties being tidally inundated by 2050 is significant and only get more so by 2070 and 2100. The commercial fishing fleet and its supportive facilities and properties are priority assets to the City if it is to remain a viable commercial fishing port. The priority rankings for 2050 and 2100 are 5 and 6.

5.2.4 Recreational Boating

Description

Recreational boating also benefits from the safe harbor and port facilities provided by Humboldt Bay. The recreational boating community, in addition to using many of the public and private facilities that the commercial fleet does, also uses facilities specifically for recreational boating in the City and its PA (Figure 80).

Figure 80. City of Eureka recreational boating facilities: (1) Eureka Boardwalk, (2) Humboldt State University's Aquatic Center, (3) Adorni Center, (4) Bonnie Gool dock, (5) Humboldt State University's Crew dock, (6) Samoa boat launch property, and (7) Woodley Island.

In the City, there are two public boat launch ramps, rest rooms, and parking areas: Eureka boat basin (Figure 80) and City's Samoa Bridge boat ramp. The District's Woodley Island Marina. There are also six public recreational boating docks in the City located at: C Street, Eureka Boardwalk on F Street, HSU Aquatic Center/J Street, Adorni Center/K Street, Bonnie Gool/L Street, and HSU Crew in Halverson Park.

In the PA, there are three private recreational boating facilities at King Salmon: fuel dock and bilge & sewage pump-out station, 80 boat berths, and EZ Landing boat launch ramp. There are also two public boat launch ramps, rest rooms, and parking areas at: Humboldt County's Fields Landing boat ramp (Figure 78) and Humboldt County's Samoa Peninsula boat ramp.

Exposure

By 2050, MMMW and MAMW could reach 9.64 feet and 10.68 feet (NAVD 88) may cause most of the City's and in the PA approximately 67%, of boat berths and floating docks to float off their pilings and boat launches to become tidally inundated. By 2100 all but the recreational facilities at Woodley Island could be tidally inundated (Figure 81 and Table 21).

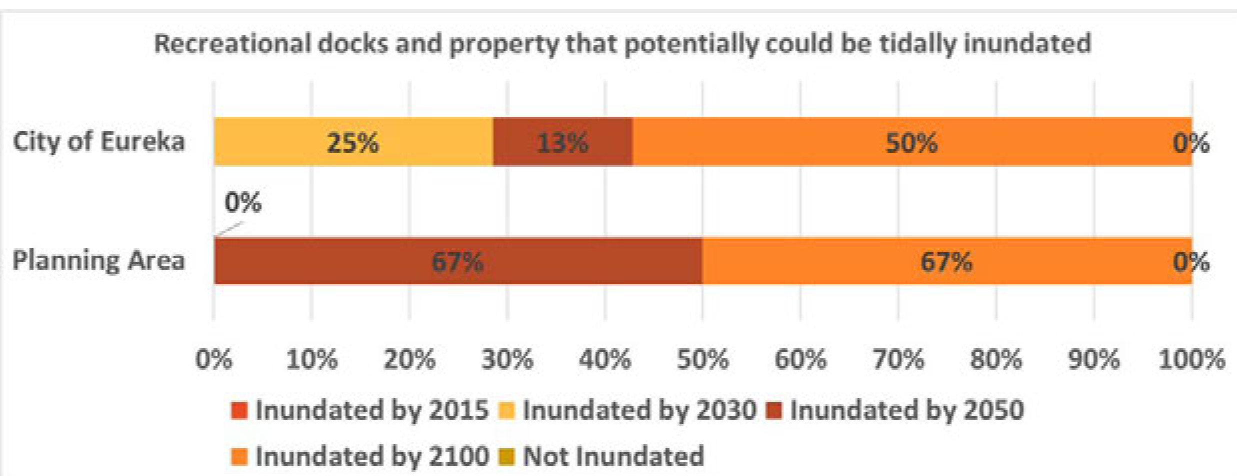

Figure 81. Percentage of Recreational docks in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the percentage that is not likely to be inundated.

Table 21. Number of Recreational docks that are vulnerable and at risk from tidal inundation in the City and its PA.

RECREATIONAL DOCKS-PROPERTY	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	0	7	8	8	0	8
Planning Area	0	2	2	3	0	3

When sea level rise overtops the shoreline, it could tidally inundate waterfront properties where recreational boating facilities and docks are located, as well as the streets that access these properties. Most of the properties that support the recreational boating facilities have fortified shorelines that are not likely to erode.

2015

There are currently two recreational boating facilities (King Salmon and Fields Landing) vulnerable and at risk from tidal inundation during MMMW and MAMW.

2030

In the City, dock pilings in the Eureka Boat Basin and all six recreational floating boat docks may need to be extended when MMMW rises 0.9 feet to 8.6 feet (NAVD 88), and MAMW reaches 2.0 feet higher (9.7 feet NAVD 88). In the PA, the private recreational boating facilities at EZ Landing property in King Salmon and the Humboldt County boat launch at Fields Landing could be tidally inundated when MMMW rises 0.9 feet to 8.6 feet (NAVD 88), and MAMW reaches 9.7 feet (NAVD 88).

2050

In the City, when the MMMW rises 1.9 feet to 9.6 feet (NAVD 88), and MAMW reaches 10.7 feet (NAVD 88), portions of the Eureka Boat Basin (the boat launch ramp and parking area) and adjacent Waterfront Drive could become tidally inundated, as could the City's Samoa Bridge boat launch ramp. In the City, pilings may likely need to be extended at the six public boat docks in the City to accommodate sea level rise.

In the PA, when the MMMW rises 1.9 feet to 9.6 feet (NAVD 88), and MAMW reaches 10.7 feet (NAVD 88), Humboldt County's Fields Landing boat launch ramp could become tidally inundated and the parking lot could partially flood. Recreational boating facilities in King Salmon could be tidally inundated, as would the access streets (Perch Street and Halibut Avenue), except King Salmon Avenue and Buhne Drive.

2070

In the City, when the MMMW rises 3.2 feet to 11.0 feet (NAVD 88), and MAMW reaches 12.0 feet (NAVD 88), the City's Samoa Bridge boat launch and parking lot could be tidally inundated. The parking areas for the J and K Street, Boonie Gool/L Street dock, and HSU Crew dock in Halverson Park could also be tidally inundated. While Woodley Island Marina is not likely be tidally inundated by 2070, its access road could be.

In the PA, when the MMMW rises 3.2 feet to 11.0 feet (NAVD 88), and MAMW tides reaches 12.0 feet (NAVD 88), the County's Fields Landing boat launch ramp and parking lot, Railroad Avenue, and the County's Samoa boat launch ramp and portions of its parking lot potentially could be tidally inundated.

2100

By 2100, with 5.3 feet of sea level rise (13.1 feet NAVD 88), with the exception of the District's Woodley Island Marina, all of the recreational boating facilities and properties in the City and its PA are projected to be tidally inundated. Access streets to these recreational boating properties are also projected to be tidally inundated, including access to Woodley Island.

Susceptibility

The recreational boating facilities could be adversely impacted to a significant degree as early as 2050.

In the City, the marinas contain boat berths and floating docks held in place against the flooding and ebbing tides by concrete pilings that could be impacted significantly by rising tide elevations. Recent tsunami damage of the port in Crescent City illustrates the vulnerability of the pilings to extreme water elevations. Rising tidal elevations by 2050 of 2 feet for MMMW and 3 feet for MAMW could require that the pilings at the two marinas be raised to prevent the boat berths and docks from floating off during MAMW, storms, or 100-year floods. Boat launch facilities and their floating docks could also be adversely impacted by these rising tide elevations. Eventually, parking and restroom facilities at the boat launches will become tidally inundated, leading to the relocation or abandonment of these boat launch facilities. The City's Eureka Boat Basin property, facilities, and access streets could also be tidally inundated by 2070. The District's Woodley Island facilities and properties are not expected to be tidally inundated even by 2100.

In the PA, the three recreational facilities in King Salmon and boat launch in Fields Landing could become tidally inundated by 2050, they are also susceptible to adverse impacts to floating docks, boat launch facilities and access streets from rising tides.

Consequence

In the City and its PA, tidal inundation of most of the recreational boating properties and facilities by 2070 could be a significant impact to the public and recreational boating community, if these are the only boat launch and dock facilities available.

The loss of the recreational boat launches and docking facilities and properties that are vulnerable and at risk from tidal inundation in the City and its PA would be significant to the general public and residents of the City. If these facilities at risk are not adapted to sea level rise or relocated, their loss would result in a significant reduction in coastal access for the general public.

The District's Woodley Island has berths for recreational boats but currently no recreational boat launch or docking facilities. The District could add recreational boating facilities as other such facilities become tidally inundated.

Priority

Recreational boating, associated supportive facilities and properties are likely to be exposed and adversely impacted significantly by 2050. The loss of these facilities would result in a significant reduction in coastal access for the general public. Recreational boating, associated supportive facilities and properties are priority assets to the City if it is to remain a viable port. The priority ranking by 2050 is 6 and 4 by 2100. If it is not feasible to retain the recreational boating facilities and properties beyond 2070 given the projected sea level rise, then their priority to the City from 2050 to 2100 may be lowered.

5.3 Air

5.3.1 Murray Field Airport

Description

The Humboldt County Murray Field Airport is located in the City's jurisdiction, and it is operated by Humboldt County Department of Public Works–Aviation Division. The airport is located on 131 acres of diked former tidelands (elevation 5 to 11 feet NAVD 88). The airport is bound by Eureka and Fay Sloughs to the south and U.S. Highway 101 and North West Pacific Railroad grade to the north, which lie between the airport and Humboldt Bay. Surface elevation of the airport ranges from 5 to 6 feet NAVD 88, while the 3,011-foot-long runway ranges in elevation from 6 to 11 feet (NAVD 88)

(Figure 82). The airport is accessible from U.S. Highway 101 and Jacobs Avenue. This airport is classified as a general aviation airport, rather than a commercial airport. The airport provides public, private, and commercial aviation services, including air freight transport businesses. Commercial airlines have operated at Murray Field for over 40 years and Northern Air is the airport's Fixed Base Operator. They lease two hangars from the County. Their services include fuel, transient aircraft parking, aircraft rental, flight instruction, and engine maintenance repair (HCAOG 20-Year Update-2013 RTP). The original runway is no longer in operation; it was shut-down in 1997. Future plans for the airport include possible expansion of three acres on the south/southwest side of the airport for additional facilities (i.e., aircraft storage and parking), and three acres on the north side of the airport that might be useful for future airport development (County of Humboldt 2007).

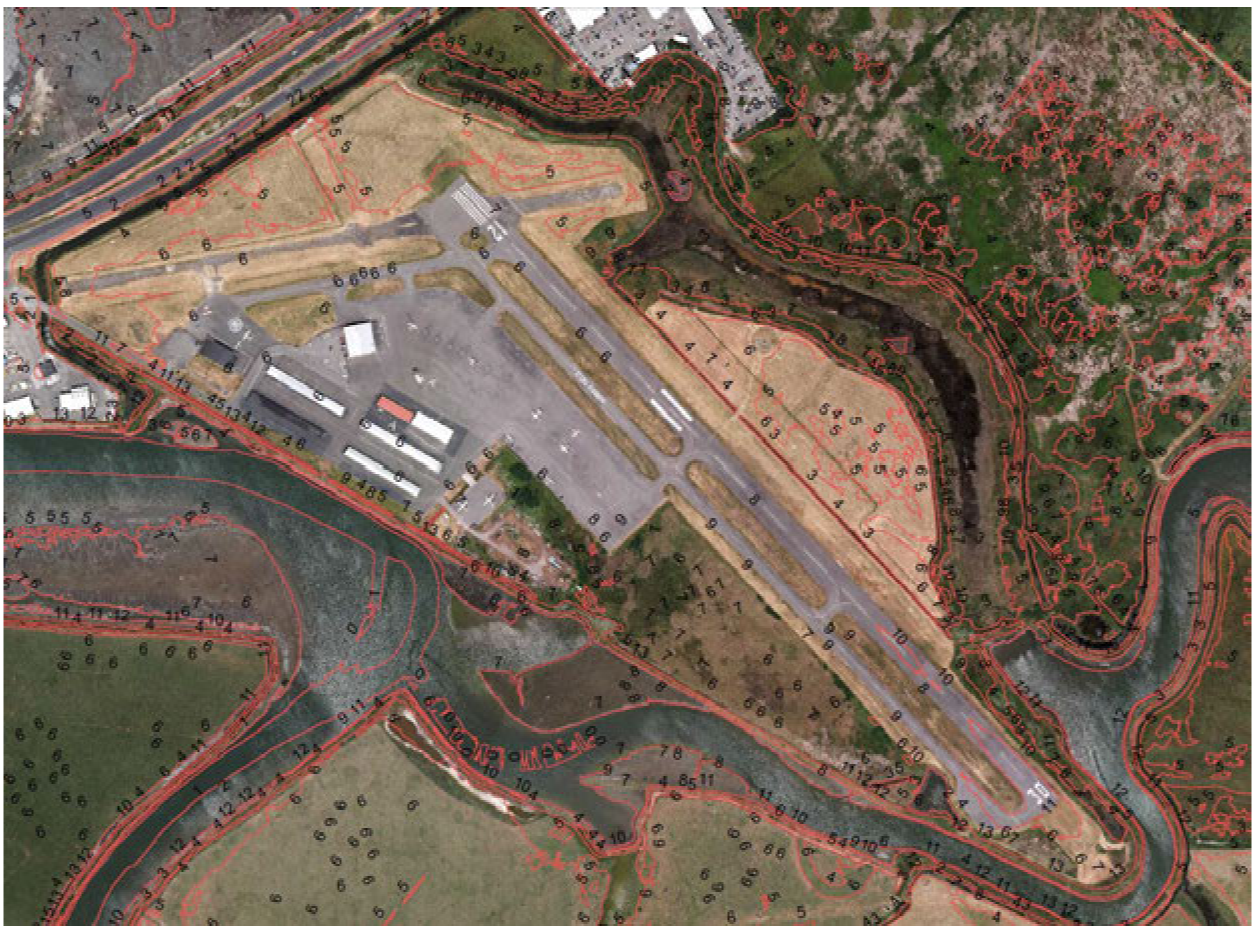

Figure 82. Humboldt County Murray Field Airport surface contours (NAVD 88).

Exposure

The Murray Field Airport is bordered by Eureka and Fay Sloughs. The airport is vulnerable and at risk from tidal inundation should any segment of the 3.3 miles of diked shoreline on Eureka and Fay Sloughs is breached or overtopped. Currently, there are 1.2 miles of shoreline on Eureka and Fay Sloughs that are rated highly vulnerable to breaching or overtopping (Figure 83). Storm water runoff from the area bound by Eureka and Fay Sloughs drains through five tide gates, which would become impaired by rising sea levels that could cause flooding of the airport facilities. Rising ground water in response to sea level rise is also expected to impact existing airport facilities. Indirectly, rising ground water could convert lands adjacent to airport facilities to wetlands and waterfowl habitat, which might pose a hazard to air traffic.

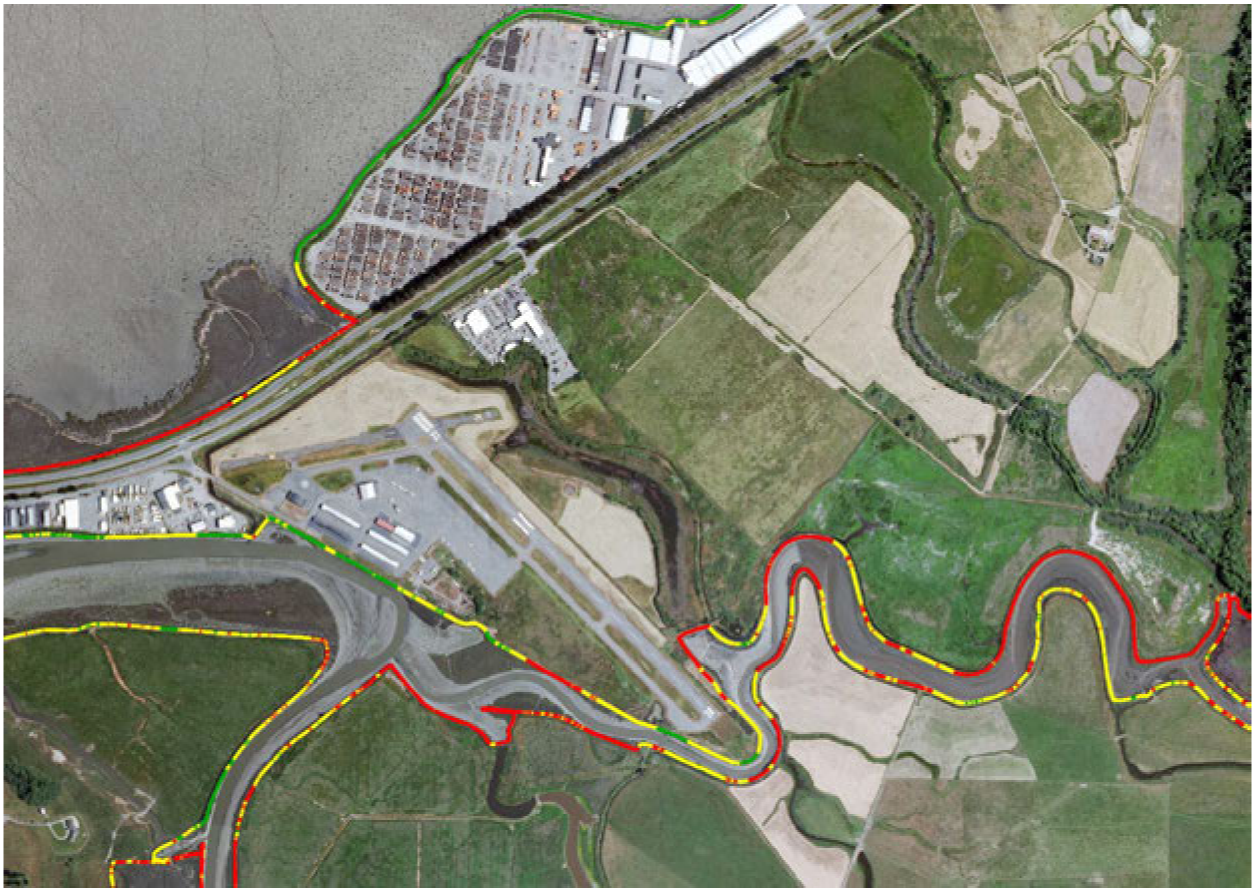

Figure 83. Shoreline vulnerability rating (red = high, yellow = moderate, and green = low) for segments protecting Murray Field Airport from tidal inundation (Laird & Powell 2013).

2015

The shoreline dikes protecting the Murray Field Airport are not overtopped by current MMMW of 7.7 feet. However, protective shoreline dikes on Eureka or Fay Sloughs could be breached during MAMW of 8.8 feet, as there are at least three vulnerable (to erosion and due to low elevation) sections. If the dikes breach, then nearly all of Murray Field's existing airport runway (6 to 11 feet NAVD 88) and facilities (6 feet NAVD 88) could be tidally inundated (Figure 84).

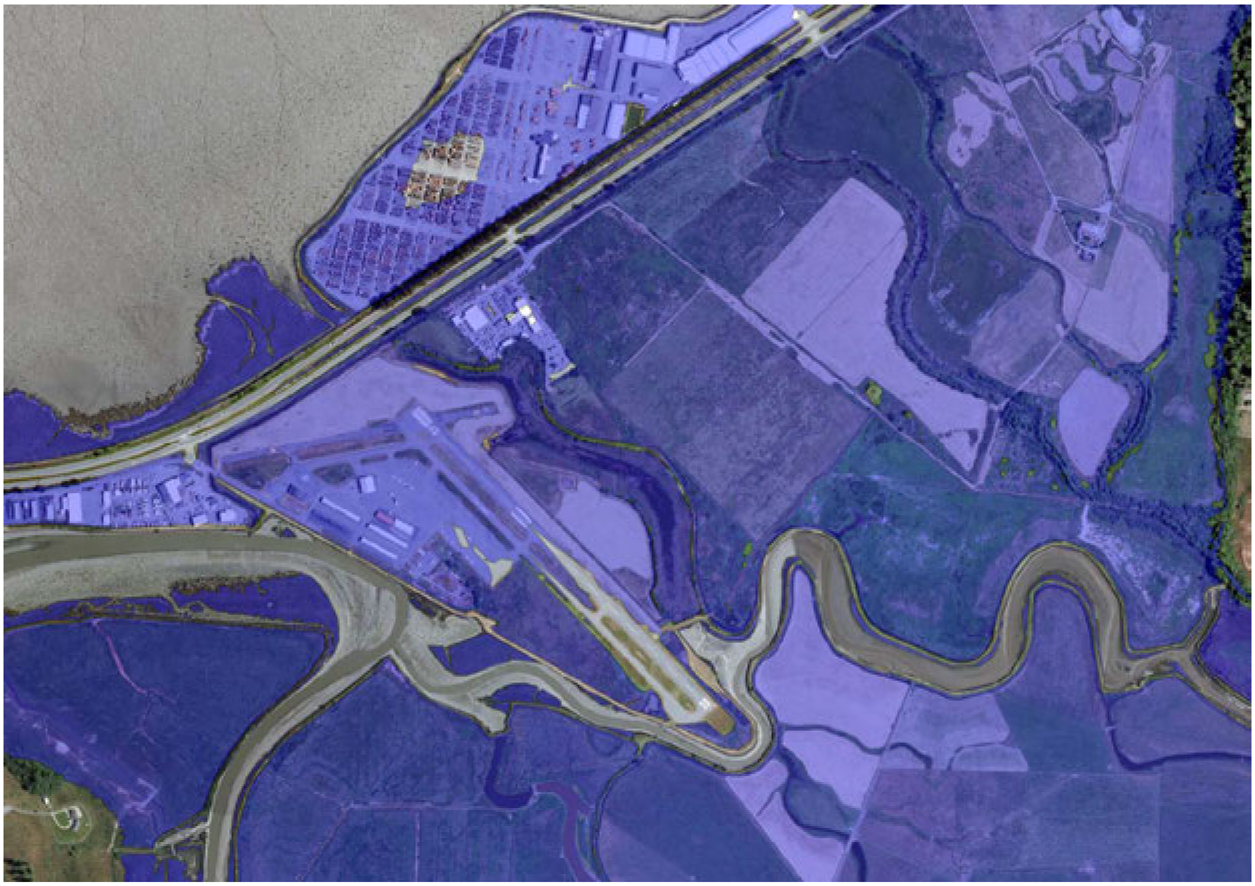

Figure 84. Potential tidal inundation area at Murray Field Airport under existing mean monthly maximum tide elevation (7.7 feet), if shoreline structures fail.

2030

The high projection for MMMW is 8.6 feet (NAVD 88), which could overtop currently vulnerable dike shoreline sections. Average MAMW could rise to 9.7 feet (NAVD 88), and if the 1.2 miles of highly vulnerable dike segments have not been raised in elevation, these segments could also be overtopped. The airport could be tidally inundated to a depth of 2.5 to 3.7 feet.

2050

The high projection for MMMW is expected to be 9.6 feet (NAVD 88), which could frequently overtop the low-lying shoreline segments that have not been raised. The MAMW of 10.7 feet (NAVD 88) could overtop nearly all of the diked shoreline on Fay Slough and much of the diked shoreline on Eureka Slough, tidally inundating the airport to a depth of 4.7 feet.

2070

The MMMW of 11.0 feet (NAVD 88) and MAMW of 12.0 feet (NAVD 88) may exceed the elevation of most of the dikes along Eureka and Fay Sloughs now protecting the airport. If the dikes are increased in elevation sufficient to prevent overtopping, the projected 3.2 feet of relative sea level rise to MLLW elevations could likely prevent the area from draining to the sloughs.

Susceptibility

Tidal inundation would significantly impair the continued use of this or any airport, and is a significant adverse impact. Under current conditions at the airport, if the protective diked shoreline is breached, tidal inundation could reach depths of 1 to 2 feet during MMMW (7.74 feet NAVD 88). Tidal inundation of the tarmac areas of the airport could raise safety concerns, and frequent flooding of the tarmac areas may not be acceptable under current aviation regulations. Frequent flooding and rising ground water of lands adjacent to the runways could convert these lands to wetlands and waterfowl habitat, which might pose a hazard to air traffic. The continued operation of the airport under these conditions may not be possible.

By 2030, if the protective shoreline is breached, tidal inundation at the airport could reach depths of 2 to 3 feet during mean monthly maximum tides, and by 2050, 3 to 4 feet. By 2070, the current dikes protecting the airport will likely be overtopped regularly, leading to breaching and tidal flooding of the low-lying areas behind.

The airport facilities could be raised in elevation to prevent tidal inundation should the protective diked shoreline fail and to mitigate rising ground water inundation. Airport facilities could be protected from tidal inundation with the construction of a protective levee around the perimeter of the airport. Alternatively, the existing protective shoreline structures could be raised in elevation and fortified where necessary to prevent tidal inundation of adjacent property and the airport.

Consequence

While the Murray Field Airport is the only general aviation facility in the City, it is not the only general aviation airport in Humboldt County. The larger commercial Arcata–Eureka Airport 16 miles to the north may be able to accommodate general aviation services that could be displaced with the closure of the Murray Field airport. The loss of the air transport services at Murray Field Airport, if they were maintained at the Arcata–Eureka Airport, could affect the City with a loss of revenue and services.

Priority

The airport property and facilities are vulnerable and at risk from tidal inundation if any portion of protective shoreline dike fails. Airport facilities are very susceptible to tidal inundation or flooding. If the general aviation services provided at the airport could be accommodated at the larger regional airport in McKinleyville then the consequences of losing this airport would be lessened. From now to 2050 the loss of the airport services would be an adverse impact to the City and County. From 2050 to 2100, the airport may be a much lower priority asset to the City. The priority ranking for the airport for 2050 is 6 and 5 for 2100.

5.3.2 Samoa Field Airport

Description

The City owns the Samoa Field Airport, which is located on 359 acres of former dunes (elevation 12.0 feet NAVD 88). Surface elevations of the airport runway range from 11 to 14 feet (NAVD 88) (Figure 85). The airport is operated by the City Department of Public Works. The airport is within the City's PA, located in the unincorporated area of Humboldt County on the Samoa Peninsula. New Navy Base Road is between the airport and Humboldt Bay to the east. To the west the airport is surrounded by coastal dunes and the Humboldt County Samoa Dunes Recreational Area. The airport is accessible from New Navy Base Road. The airport provides services for recreational and personal business. The airport does not operate at night; there are no lights on the runway and no aviation services are provided. Although Samoa Field Airport is classified as a Community General Aviation Airport, it does not meet all the minimum standards of this airport class. The airport's longest runway, 2,700 feet by 60 feet, does not reach the minimum length, width, or weight-bearing standards. Additionally, the airport does not have visual aid equipment, 24-hour on-field weather services, or an instrument approach procedure (HCAOG 2013). The City maintains 15 hangers at the airport.

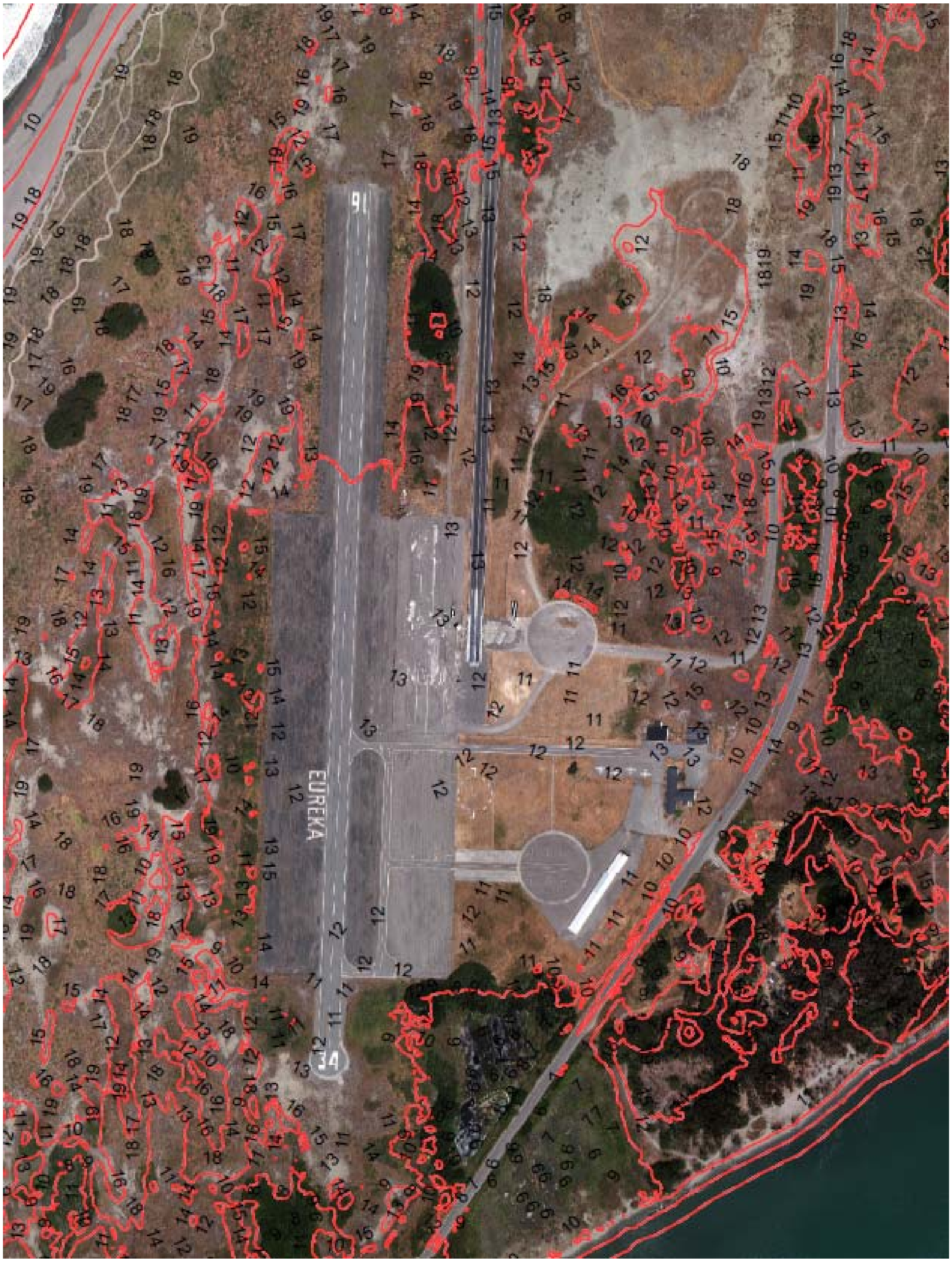

Figure 85. City of Eureka's Samoa Field Airport surface contours (NAVD 88).

Exposure

The Samoa Field Airport is vulnerable and at risk from tidal inundation through a low-lying wetland area southeast of the airport. The low elevation and exposed shoreline on the bay is rated highly vulnerable to overtopping (Figure 86). Old Navy Base Road bisects this wetland area but would afford very little protection, as its elevation ranges from 6 to 8 feet (NAVD 88). Between the road and shore of Humboldt Bay is an inter-tidal wetland. In order for shoreline erosion to affect the airport, Old Navy Base Road would have to be breached. The Samoa Field Airport runway being at an elevation of 11.0 to 14.0 feet (NAVD) is not vulnerable or at risk to tidal inundation until 2070 based on the high projection for MMMW of 10.95 feet (NAVD 88).

Figure 86. Shoreline vulnerability rating (red = high, yellow = moderate, and green = low) for shoreline segment protecting Samoa Field Airport from tidal inundation (Laird & Powell 2013).

2050

Not until 2050 would MMMW (9.6 feet NAVD 88) reach the southeast corner of the airport property by flooding the low-lying area and Old Navy Base Road (less than 9.0 feet elevation NAVD 88).

2070

Even 3.0 feet of relative sea level rise (10.7 feet NAVD 88), which could occur around 2070, would not inundate the airport runway. However, MAMW of 12.0 feet (NAVD 88) could tidally inundate the airport property and portions of the runway. Surface elevations of the Samoa Field Airport and runway range from 11 to 14 feet (NAVD 88).

2100

The high projection for MMMW is expected to reach 13.1 feet (NAVD 88), which could tidally inundate a significant portion of the runway and airport property (Figure 87).

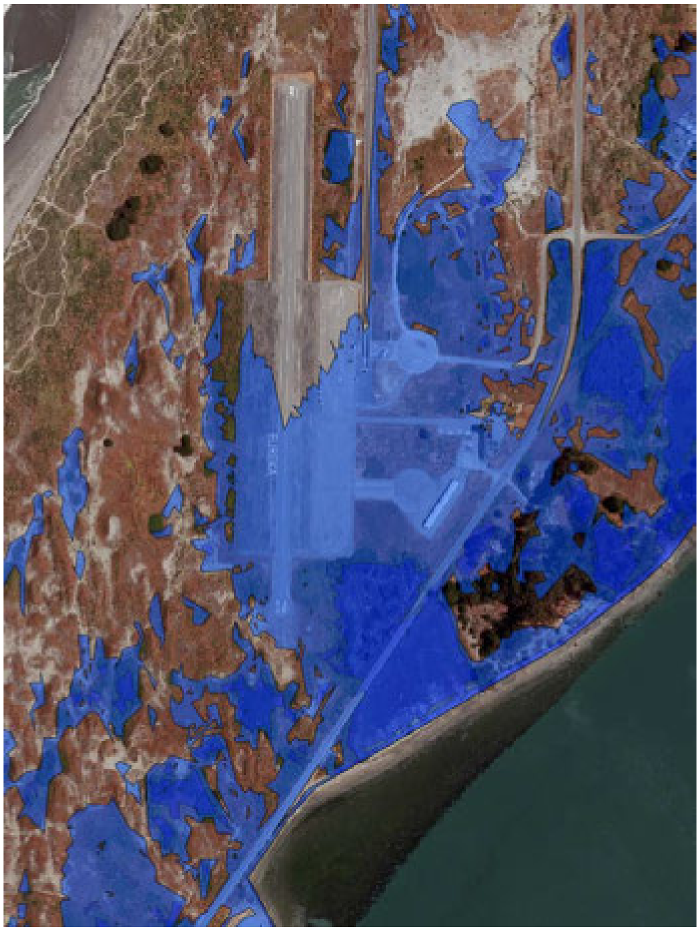

Figure 87. Potential tidal inundation area at Samoa Field Airport by 2050 (dark blue) at 9.6 feet (NAVD 88) and 2100 (light blue) at 13.1 feet (NAVD 88).

Susceptibility

The Samoa Field Airport is not likely to be impacted by shoreline erosion or tidal inundation from now to 2050. Tidal inundation would significantly impair the continued use of this or any airport, and is a significant adverse impact. Tidal inundation of the tarmac areas of the airport would raise safety concerns. However, tidal inundation of the airport is not likely to occur until 2070 during MAMW. Frequent tidal inundation or flooding of the tarmac areas is likely not be acceptable under current aviation regulations. Frequent flooding and rising ground water of lands adjacent to the runways could convert these lands to wetlands and waterfowl habitat, which might pose a hazard to air traffic. The continued operation of the airport under these conditions may not be possible

The airport facilities could be raised in elevation to prevent tidal inundation. Airport facilities could also be protected from tidal inundation with the construction of a protective levee. Although it is not known if rising groundwater would become an issue.

Consequence

The Samoa Field Airport is not the only recreational and personal business airport facility in the County. The larger Arcata–Eureka Airport 16 miles to the north may be able accommodate air services that would be displaced with the closure of the Samoa Field Airport.

The City could partner with the County, who maintains Old Navy Base Road, and the U.S. Coast Guard to secure money necessary to maintain and elevate the road, which could protect the airport from tidal inundation. Ultimately, the long-term strategy for adaptation to sea level rise of 2 to 5 feet by 2100 may be to relocate Samoa Field Airport services to another recreational and personal business airport facility or the Arcata–Eureka Airport.

Priority

By 2050, the City’s Samoa Field Airport is not likely to be exposed or susceptible to sea level rise. By 2100, the airport could be tidally inundated, which would be a significant adverse impact making it susceptible but the importance of this airport could be considered low. The priority ranking for 2050 is 0 and 2100 4.

5.4 Rail

In 1998, the North Coast Railroad Authority (NCRA) and North West Pacific (NWP) Railroad ceased rail transportation operations in the City and PA. In 2007, the NCRA conducted emergency shoreline repairs in the PA on the railroad segment between Elk River Slough and PG&E's HBPP property. In 2008, the NCRA completed additional shoreline repairs of the railroad in this same reach.

5.4.1 Description

In the City, there are 7.3 miles of railroad grade; Two miles of railroad grade form the shoreline of Humboldt Bay, approximately 1.1 miles of which are rated highly vulnerable to sea level rise (Table 22). There are also two railroad bridges: one over Eureka Slough and the other over Elk River Slough. In the PA, there are 5.1 miles of railroad grade; 2.2 miles forming the shoreline of Humboldt Bay, and 0.5 miles of railroad grade is rated highly vulnerable to sea level rise (Figure 88).

Table 22. Cumulative length (miles) of NCRA railroad grade that potentially could be tidally inundated in City of Eureka and its Planning Area at various planning horizons.

Rail Transportation	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	0.1	0.5	1.3	4.7	2.59	7.3
Planning Area	0.0	0.0	2.1	3.7	1.4	5.1

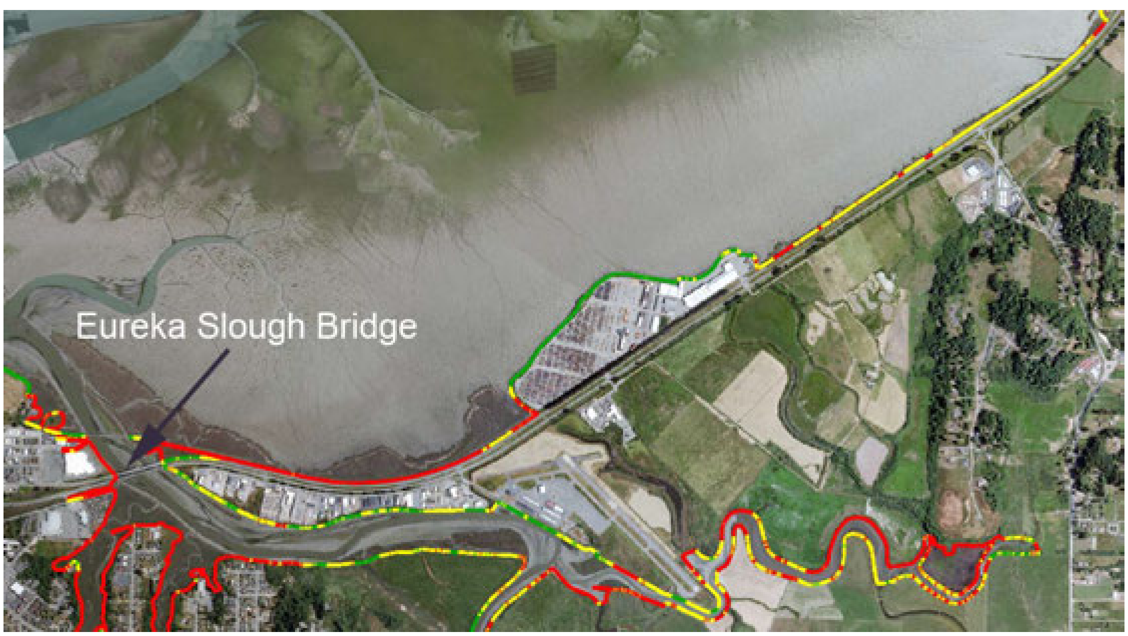

Figure 88. North Coast Railroad Authority railroad grade and Eureka Slough Bridge, shoreline vulnerability rating (red = high, yellow = moderate, and green = low) for segments protecting Murray Field Airport from tidal inundation.

5.4.2 Exposure

The railroad grade across from the entrance to the harbor experiences significant wave energy, and as a result, is heavily fortified; this reach was last re-enforced in 2007 and 2008. In the City, the railroad grade between Eureka Slough and California Redwood Company property and in front of U.S. Highway 101 is exposed to significant wave energy from prevailing winds and is a good example of the value of a living shoreline protective structure that is vulnerable and at risk from sea level rise. However, due to the low elevation of this reach of railroad grade, tidal inundation is likely by 2050 when 1.9 feet of sea level rise is projected. In the City, the low-lying railroad reach between Del Norte and Truesdale Streets is also vulnerable and at risk from tidal inundation between 2030 and 2050. The railroad grade reaches that form the shoreline of Humboldt Bay are vulnerable and at risk of being tidally inundated and from wave induced erosion washing away the railroad ballast.

In the City by 2050, there are 1.3 miles (18%) of the railroad grade that could be tidally inundated and by 2100 4.7 miles (65%), leaving 2.6 miles (35%) that may not be inundated. In the PA by 2050 there are 2.1 miles (45%) of the railroad grade that could be tidally inundated and by 2100 3.7 miles (82%), leaving just 1.4 miles (18%) that may not be inundated (Table 22).

In the PA, the railroad forms a long reach of shoreline in Arcata Bay that protects U.S. Highway 101 that is also exposed to significant fetch from prevailing winds and is vulnerable and at risk from tidal inundation between 2030 and 2050.

2030

In the City, there are two short segments on Arcata Bay that could be tidally inundated by 0.9 feet of sea level rise and on Eureka Bay south of Del Norte Street by MMMW of 8.8 feet (NAVD 88) and MAMW of 9.7 feet (NAVD 88). No railroad reaches in the PA are likely to be exposed to tidal inundation at this time.

2050

In the City, there are 1.3 miles of railroad grade vulnerable and at risk from tidal inundation by the high projection for sea level rise of 1.9 feet (MMMW of 9.6 feet NAVD 88) north of Truesdale Street to Del Norte Street and on Waterfront Drive, as well as the reach north of Eureka Slough Bridge. In the PA, 2.1 miles of railroad grade on Arcata Bay and in Fields Landing are vulnerable and at risk from tidal inundation by MMMW of 9.6 feet and MAMW 10.7 feet (NAVD 88).

2100

In the City, there could be 4.7 miles of railroad grade vulnerable and at risk from tidal inundation by MMMW of 13.1 feet (NAVD 88) from 5.3 feet of sea level rise, north of Elk River Slough and west of Broadway to E Street and east of S Street to north of Eureka

Slough Bridge. In the PA, 3.7 miles of railroad grade could be vulnerable and at risk of tidal inundation, on Arcata Bay north of Eureka Slough Bridge and from King Salmon south.

5.4.3 Susceptibility

The railroad is susceptible to adverse impacts from tidal inundation during MAMW and wave action during storms and 100-year extreme events. The railroad has not been used since 1998, and has only maintained or repaired in one reach of the PA. Without maintenance bridges, on Eureka and Elk River Sloughs, in a marine environment are likely degrading. Likewise railroad ballast is being eroded in areas exposed to wave energy.

5.4.4 Consequence

As the railroad has not been in operation for nearly two decades the loss of this transportation infrastructure may have no impact on current rail transportation needs of the City or the Humboldt Bay region. Erosion of the railroad grade could have significant consequences to U.S. Highway 101 where it is being protected by the railroad grade. Although planning is underway to utilize the railroad grade for alternative pedestrian and non-motorized travel, therefore the loss of this grade and bridges could be of consequence to the City and Humboldt Bay region.

5.4.5 Priority

The railroad is exposed to sea level rise by 2050 and increasingly by 2100. Railroad grades and bridges are susceptible to the adverse impacts from tidal inundation, waves, and flooding. Because the railroad has not been operation for nearly two decades its loss as a form of rail transportation to the City and its PA is no existent. Also the City has access to other transportation facilities such as U.S. Highway 101 the loss of the railroad as a form of transportation is not significant. The priority ranking for 2050 is 3 and for 2100 4. The priority ranking for the railroad to the City could be increased if the railroad were considered as alternative form of pedestrian transportation.

6 Contaminated Sites

Contaminated sites are not so much an asset as a liability in need of remediation to protect public health and water quality. Contaminated sites around Humboldt Bay include leaky storage tanks, a point discharge of hazardous substance, or inadequate hazardous substance storage vessel. Remediation of contaminated sites is regulated by the North Coast Regional Water Quality Control Board (NCRWQCB) and Humboldt County Environmental Health Department (County). Responsibility of the City for contaminated sites is limited to City-owned parcels that have been identified as requiring remediation due to a point discharge of a hazardous substance, or inadequate hazardous substance storage vessels. Based on a listing of regulated sites published by the State Water Resources Control Board (SWRCB), there are currently no contaminated sites owned by the City requiring remediation. This Section focuses on publicly (other than the City) or privately owned untreated or open contaminated sites that have been identified by the SWRCB within the City and surrounding PA.

6.1 Description

The majority of contaminated sites in the City and PA are privately owned and regulated by either the County or NCRWQCB, depending on contamination type. The County is the lead agency for all leaky underground storage tanks (LUST) sites and monitors the transition of leaky UST systems to above ground storage tank systems. The NCRWQCB is responsible for all other contaminated sites.

In the City, there are 231 regulated facility sites reported by the SWRCB Geotracker database (SWRCB 2015). Remediation at many of these sites has been completed, and they are now designated as closed cases. There are 50 open contamination cases in the City that are at various stages of compliance, including sites eligible for closure; undergoing remediation, site assessment, verification monitoring, or interim remedial action; or that are inactive. However, there are only 23 open contaminated sites, ranging in elevation between 4.3 feet to 12.1 feet that are vulnerable to tidal inundation within the 2100 planning horizon (Figure 89). Two sites are located in the Eureka–Fay Slough unit in the Jacobs Avenue commercial area, one is on Duluwat (Indian) Island, one in Old Town on 2nd Street, and the remaining 19 sites are spread out along the waterfront area from H Street to Hawthorne Street, and from the bay to 4th and Broadway.

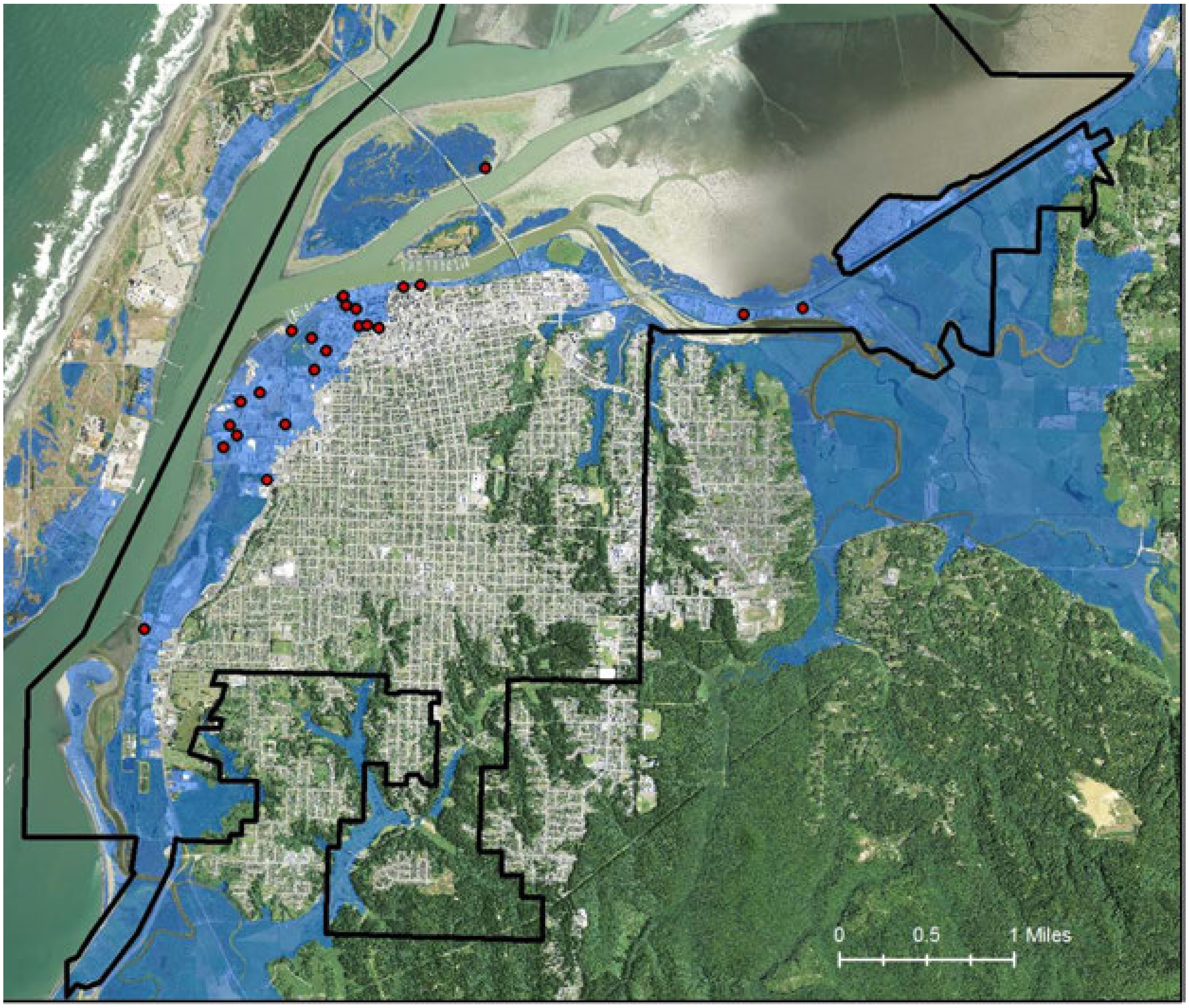

Figure 89. In the City of Eureka, 23 open contaminated sites and the area that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

In the PA, there are an additional 63 regulated facility sites. Remediation at many of these sites has been completed, and they are now designated as closed cases. There are 12 open contaminated sites in the PA, but only six range in elevation from 5.1 to 11.3 feet (NAVD 88), making them vulnerable to tidal inundation within the 2100 planning horizon. There are two sites in King Salmon, two sites in Fields Landing, and 2 sites on the Samoa Peninsula (Figure 90 and Figure 91).

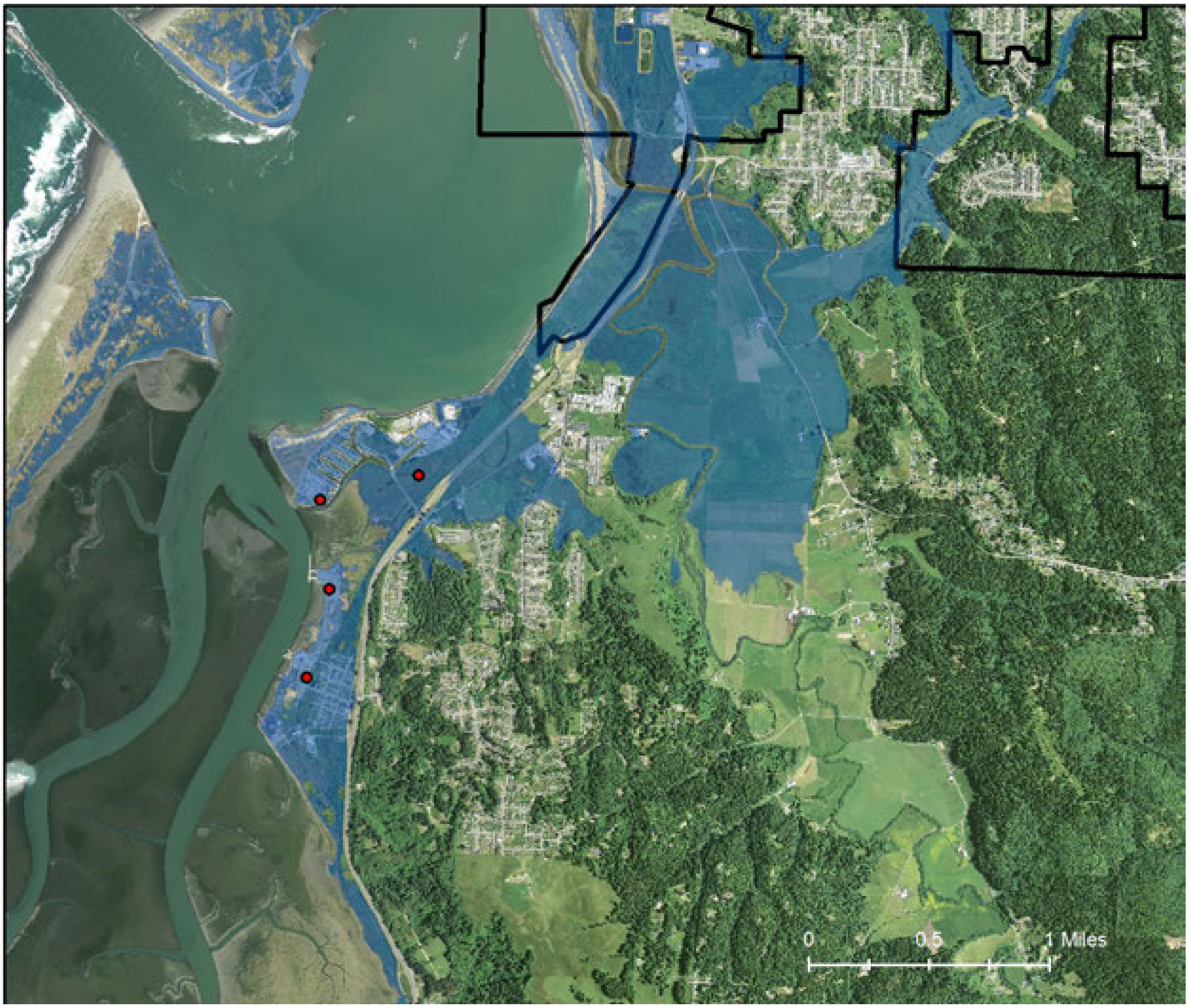

Figure 90. In the Planning Area, four open contaminated sites in King Salmon and Fields Landing and the area that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

Figure 91. In the Planning Area, two open contaminated sites on the Samoa Peninsula and the area that could potentially be tidally inundated by 2100 by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

6.2 Exposure

Open contamination sites are expected to be affected by sea level rise through tidal inundation and rising ground water. Public health and water quality may be affected by contaminated sites that are tidally inundated by sea level rise. Changes in ground water elevation can mobilize constituents trapped in soil layers and result in an increase in the size of the contamination plume. Once a contaminated site is inundated, constituents of concern may pollute drinking water systems like the HCSD's wells, or waters of the state like Humboldt Bay. Tidal inundation of contaminated sites could make monitoring and clean-up activities much more difficult.

Contaminated sites are not graded by regulatory authorities. Instead, the estimated volume of contamination at a site is combined with site-specific geotechnical characteristics and distances to water bodies and aquifers; collectively, this information is used to determine the degree of remediation that will be required to safeguard public health. All of the open contaminated sites that are located along Humboldt Bay have the potential to impact the health and well-being of the public and sensitive ecosystems if remediation is not completed.

It is important to note that a changing regulatory environment and policy greatly impacts the standards for contaminated site closure. The state's low-threat closure policy was changed in 2012, attributed to budgetary constraints, and has led to closure of a number of sites where residual levels of contamination remain. Residual contamination at closed sites susceptible to the impacts of sea level rise may warrant greater scrutiny as they could potentially impact public health, water quality, and the bay ecosystem. Also, as remediation is implemented, contaminated sites that are identified in this document will constitute less of a risk to public health.

In the City, there are a total of 23 open contamination sites and in the PA 12, based on the SWRCB's Geotracker tracking system as of July 2015. These sites are located in areas that are vulnerable and at risk from tidal inundation within the 2100 planning horizon (Table 23). By 2050, there are four (8%) sites that are vulnerable and at risk from tidal inundation by MMMW of 9.6 feet (NAVD 88) located on diked former tidelands, on Duluwat (Indian) Island, and the waterfront. Only one (8%) site in the PA located in the King Salmon Marina is vulnerable and at risk from tidal inundation by 2050. By 2100, MMMW and MAMW could reach 13.1 feet and 14.14 feet (NAVD 88) and in the City 23 (46%) sites could be tidally inundated and 6 (50%) in the PA, 27 (54%) of the open contaminated sites in the City and 6 (50%) in the PA are likely to not be tidally inundated by 2100 (Figure 92 and Table 23).

Table 23. Open contaminated sites that are vulnerable and at risk from tidal inundation in the City and its PA by the high projection for mean monthly maximum tide of 13.1 feet (NAVD 88).

CONTAMINATED SITES	Inundated by 2015	Inundated by 2030	Inundated by 2050	Inundated by 2100	Not Inundated	Total
City of Eureka	2	2	4	23	27	50
Planning Area	0	1	1	6	6	12

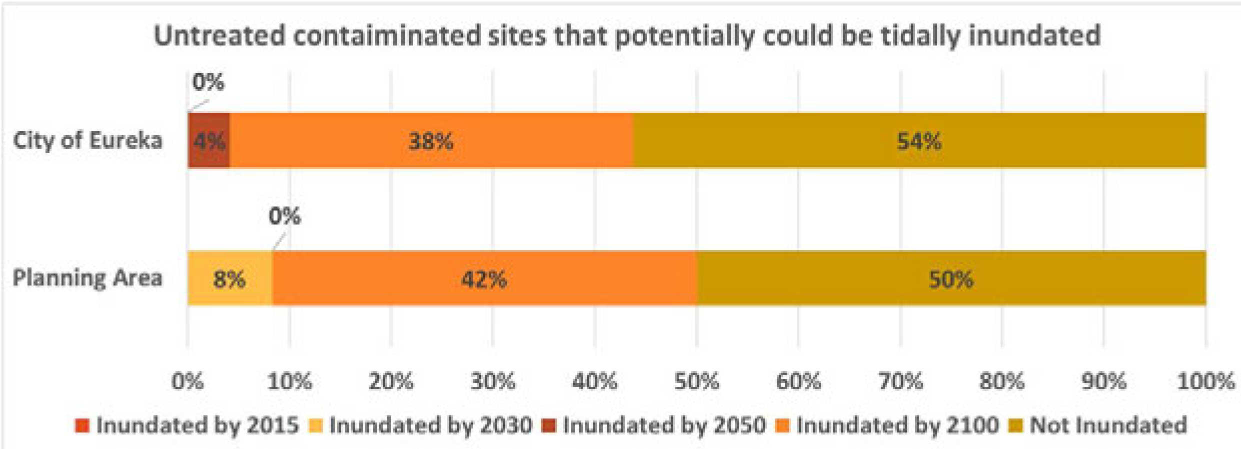

Figure 92. Percentage of open contaminated sites in the City and its Planning Area that potentially could be tidally inundated in 2015 and by 2030, 2050, and 2100 as well as the percentage that is not likely to be inundated.

2015

In the City, there are two open contamination sites in the Eureka–Fay Slough unit near the Jacob's Avenue commercial area. This area is vulnerable and at risk from tidal inundation in 2015 if the protective shoreline dikes are breached. There are no open sites in the PA at risk from tidal inundation in 2015.

2030

There are no additional open contamination sites in the City that are vulnerable to tidal inundation from the MMMW elevation of 8.6 feet (NAVD 88). In the PA, there is one site in King Salmon at the EZ Landing Marina that could be tidally inundated by 2030.

2050

In the City, by 2050, the high projection for MMMW is 9.6 feet (NAVD 88), which is nearly the elevation of a 100-year event in 2015 (9.99 feet NAVD 88). Two open contamination sites could become tidally inundated during this time period, including one site on Duluwat (Indian) Island and one in Old Town on 2nd Street. No additional open contaminated sites in the PA are projected to be tidally inundated.

2100

In the City, the high projection for MMMW is 13.1 feet (NAVD 88). There could be 19 more open contaminated sites that may become tidally inundated, along the waterfront from H Street to Hawthorne Street, and from the bay to 4th and Broadway. In the PA, by 2100, there are an additional five open contaminated sites that could become tidally inundated: two in Field's Landing, two in Samoa, and one in King Salmon.

6.3 Susceptibility

Changes in ground water elevation can mobilize constituents trapped in soil layers and result in an increase in the size of the contamination plume. Once a contaminated site is inundated, constituents of concern may pollute drinking water systems like the HCSD's wells, or waters of the state like Humboldt Bay. Once remediation to acceptable levels has been achieved, these sites should no longer pose a hazard to public health or water quality if they became tidally inundated.

6.4 Consequence

These open contaminated sites either involve a point discharge of hazardous substance(s), or inadequate hazardous substance storage vessels. Public health and water quality may be adversely affected by these open contaminated sites if they are tidally inundated or saturated by rising ground water. Once a contaminated site is inundated, the contamination plume of constituents of concern may expand and pollute drinking water systems, or waters of the state like Humboldt Bay. The magnitude of the impact will depend on the size of the contamination plume and its proximity to water systems or sensitive receptors. The City and County in the PA do not have jurisdiction over these contaminated sites that are regulated by the NCRWQCB, and therefore have little capacity to address the impacts of these sites to public health and water quality. Assuming there will be no new open contaminated sites the consequences of up to 29 open sites becoming tidally inundated could be significant if domestic water systems or sensitive receptors are affected. Pollution of open waters like Humboldt Bay could be significant adverse impact to water quality and possibly to the commercial oyster farms in the Bay.

6.5 Priority

There are 5 open contaminate sites that could be exposed to tidal inundation by 2050 and 29 by 2100. These sites could be impacted significantly if they become tidally inundated as their constituents become mobilized and pollute receiving waters. Some consequences are that when a contaminated site is inundated, the contamination plume of constituents of concern may expand and pollute drinking water systems, or waters of the state like Humboldt Bay. Threats to public health and water quality are significant consequences of open contaminated sites becoming tidally inundated. The priority ranking for 2050 is 4 and 6 for 2100.

CITY OF EUREKA

Potential tidal inundation based on sea level rise projections for 2100: low 2.1 feet and high 5.4 feet.

Sea Level Rise
Adaptation Planning Report

December 2016

Acknowledgements

Funding by: Ocean Protection Council

DISCLAIMER: The following Sea Level Rise Adaptation Planning Report was prepared for the City of Eureka. This Adaptation Planning Report is for City-wide planning purposes, and is not a substitute for site-specific analysis of exposure, vulnerability, or risk from sea level rise.

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EXCUTIVE SUMMARY

The City of Eureka (City) received a grant from the Ocean Protection Council (OPC) to prepare a sea level rise asset vulnerability and risk assessment. The purpose of that assessment is to identify high priority assets which are vulnerable and at risk from sea level rise. Based on the City's assessment, this sea level rise adaptation planning report develops adaptation goals, strategies and measures for high priority assets, planning horizons or targeted water elevations, and specific geographic areas. The recommendations in this adaptation planning report may be used to guide the update of the City's Coastal Land Use Policy to incorporate sea level rise goals, policies, and regulations. It is important to note that the all of the City's Land Use Policies are developed for a 20-year planning horizon.

Between 2013 and 2016, the City actively participated in a regional sea level rise planning effort on Humboldt Bay. The City has been able to use relative sea level rise projections and inundation modeling and maps produced by the Humboldt Bay sea level rise adaptation planning project (NHE 2015). The City's sea level rise adaptation planning effort builds on the adaptation planning work of the regional planning effort. Important reference documents used in the preparation of adaptation goals, strategies, and measures for this report are:

- California Climate Action Team's *State of California's Sea-Level Rise Policy Guidance* (2013); and
- Coastal Commission's *Sea Level Rise Policy Guidance* (2015).

The areas of the City that are vulnerable and at-risk from sea level rise by 2050 and 2100 are presented as Sea Level Rise Planning Areas (SLRPA). Adaptation planning in this report is based on three concepts that address assets, planning horizons/ water elevations, and specific geographic areas of the City most likely to be affected by sea level rise. As the City owns some but not all high priority assets that are critical to the community, this report introduces collaborative stakeholder-based adaptation planning; stakeholders include asset owners, property owners, protective shoreline structure owners, regulatory agencies and interested public.

The City's adaptation planning report utilizes projected rates of sea level rise for Humboldt Bay that incorporate local vertical land motion trends caused by tectonic subsidence (CG 2015 and NHE 2015). Prior hydrodynamic modeling of Humboldt Bay (NHE 2015) generated inundation maps that were used to identify areas adjacent to Humboldt Bay that are vulnerability and risk from sea level rise.

This report explores adaptation planning approaches that focus on: priority assets, planning horizons/water elevations, and geographic areas. This report further presents adaptation goals and strategies for each of these approaches and recommend goals, strategies, and measures that can be incorporated in the City's' Local Coastal Program (LCP) as goals, policies and regulations. It is important to note that the City's LCP is developed for a 20-year planning horizon.

Coastal sea level rise planning involves informational and regulatory components. To date most of the sea level rise planning efforts on Humboldt Bay have been informational. This report is a pathway to exploring pragmatic regulatory and long-range (20 year) planning opportunities for adaptation to sea level rise in the City and disclosing potential private property issues. Several issues associated with developing LCP land use regulations to address sea level rise that consider sea level rise projections and resulting SLRPA are also discussed.

In response to these issues, there are four parameters guiding the direction of this adaptation planning report:

1. The City's emphasis is on the high projection for sea level rise on Humboldt Bay by 2050 and a targeted water elevation of 2 feet (mean monthly maximum water [MMMW] elevation of 9.6 feet NAVD 88);
2. Enhancing or modifying shoreline structures, such as dikes and bulwarks, can protect the City's diked lands and waterfront and other at-risk areas from sea level rise;
3. The City is focused on its most vulnerable geographic areas and the most vulnerable City-owned high priority assets:
    a. Most vulnerable geographic areas
        i. The Eureka-Fay Slough hydrologic unit
        ii. The commercial waterfront
        iii. The industrial waterfront
    b. Most vulnerable high priority assets under its control
        i. Wastewater system
        ii. Stormwater System
        iii. Marina and existing City-owned shoreline protection structures
4. The City's adaptive capacity to address high priority assets is constrained because many of these assets are not owned by the City; therefore, collaboration with asset owners and beneficiaries will be necessary.

When planning for adaptation to sea level rise, it is useful to establish a specific goal(s) that is desired or the threshold that an asset or geographic area needs to achieve or accomplish. <u>Goals</u> have been articulated for:

- Four asset classes (land uses, coastal resources, utilities, and transportation);

- A planning horizon and associated sea level rise prediction (the year 2050 or 2 feet of sea level rise); and
- Two geographic areas (Eureka-Fay Slough and the waterfront).

Strategies to achieve these goals include feasible (physically, legally, and financially) methods, action plans, or approaches. In general, adaptation strategies for existing development are proactive approaches that include: (1) protect, (2) accommodate, (3) retreat, and, for new development, (4) avoid. This report describes adaptation strategies and measures that would help implement the goals of each asset class.

The City's preferred adaptation goal and strategy is to protect people, land uses, development, and the natural environment from an anticipated 2 feet of sea level rise. Sea level rise predictions include uncertainty and a wide range of projections from 2050 to 2100-- 9.8 to 13.1 feet for MMMW elevations. For example, the high projection of 2050 is 1.9 feet and the low projection is 2.1 feet; adopting 2 feet as its planning goal could serve both planning horizons and is more than sufficient to cover the 20-year planning horizon of the City's LCP. There are no "official" state or federal sea level rise projections or tidal inundation maps that the City may rely on to identify SLRPA. The City is undertaking an update to its LCP, which is a regulatory document. Incorporating SLRPA in its LCP will lead to creating a new "Coastal Zone" that will impose new development restrictions in a specific geographic footprint. However, the Coastal Commission retains development jurisdiction over 85% of the SLRPA based upon 2 feet of sea level rise (2050). The Commission relies on Policies in Chapter 3 of the Coastal Act when reviewing and authorizing development.

The development of state and/or federally-directed sea level rise projections and tidal inundations maps for Humboldt Bay would help the City and other municipalities plan for sea level rise without concern for potential claims of takings. The Eureka-Fay Slough area is already vulnerable from tidal inundation if the protective dikes are breached or overtopped. Relying on future projections for sea level rise does not eliminate the risk to land uses and developments in this area. The City's goal and strategies of protecting this vulnerable area, if successfully implemented, would negate the need to adopt a SLRPA for 2 feet.

However, in the waterfront area, there are significant differences in SLRPA based on low versus high projections for the year 2100. The City has elected to utilize the low projection for 2100 of 2 feet and reassess projections based on the best available science when it next updates its LCP in 2040. At this time, the City does not feel it is prudent to consider rezoning or imposing additional siting or developing standards in the SLRPA.

This report also includes Addendum 1, which provides additional analysis, includes draft goals and policies that could potentially be included in the City's Local Coastal Plan, outlines potential strategies that could be utilized to protect priority assets, clarifies how and why the City could selected a specific projected sea level rise elevation, identifies other issues to consider besides "best available science" when making policy decisions, and highlights specific Coastal Act sections that require certain assets to be protected. The Addendum is a good place to start for readers that want to review the City's draft policies and adaptation strategies. The remainder of this report provides the details that were utilized to develop Addendum 1.

1.0 INTRODUCTION

The City is currently updating its General Plan to guide land use through 2040. In 2014, the OPC awarded the City a grant to develop *Coastal Land Use Policy for Sea-Level Rise Adaptation*, as a component of its LCP. The City's adaption planning efforts build on prior and current sea level rise planning within both the greater Humboldt Bay region and the City proper, including the City's 2040 General Plan Background Report. Reference documents consulted in the preparation of the City's sea level rise adaptation planning report include: California's *Adaptation Planning Guide* (CNRA 2012), *State of California Sea-Level Rise Guidance Document* (CA-CAT 2013), and the *Coastal Commission's Sea Level Rise Policy Guidance Document* (2015). Consultation with Coastal Commission staff also helped guide the City in the development of this adaptation planning report.

The City's OPC sea-level rise adaptation planning grant had three tasks:

1. Conduct a sea level rise vulnerability and risk analysis; map assets based on the existing inundation mapping for the Humboldt Bay region. Assets that are vulnerable and at-risk will be prioritized for sea level rise adaptation based on their exposure, susceptibility, and criticality. The results of this analysis are compiled in the *City of Eureka: Sea Level Rise Assets Vulnerability and Risk Assessment Report* (Laird 2016).
2. Prepare an *Adaptation Planning Report* (this report) based on the *Assets Vulnerability and Risk Assessment Report* (Laird 2016). General adaptation strategies fall under several categorical approaches: (1) no action or "business as usual," (2) protect, (3) accommodate, and (4) retreat. This report will describe specific sea level rise adaption strategies and measures for high priority assets. The development of the City's adaptation strategies and measures will be coordinated with Coastal Commission staff and integrated, to the extent feasible,

with efforts of other agencies, including: Humboldt County, Humboldt Community Services District, Humboldt Bay Harbor District, Tribes, North Coast Railroad Authority, California Department of Fish and Wildlife (DFW), and Caltrans.

3. The sea level rise adaptation strategies in the *Adaptation Planning Report* will be incorporated into the City's LCP update as goals, policies and regulations integrated, to the extent feasible, with other LCPs and management plans on Humboldt Bay. Proposed LCP goals, policies and regulations will be presented to the public and submitted to the Coastal Commission for their review and input during the LCP update process.

This sea level rise adaptation planning report utilizes data, tools and findings from several regional and local planning projects: *Tectonic land level changes and their contribution to sea-level rise, Humboldt Bay region, Northern California* (Cascadia GeoSciences 2014), *Humboldt Bay Sea Level Rise Adaptation Planning Project Phase I* (Laird and Powell 2013) and Phase II (NHE 2014a, NHE 2015, Laird 2015), *City of Eureka General Plan Community Background Report's Sea Level Rise Impact Analysis* (ESA 2014), and *City of Eureka Sea Level Rise Assets Vulnerability and Risk Assessment Report* (Laird 2016).

1.1. Humboldt Bay Sea Level Rise Adaptation Planning

The Humboldt Bay Sea Level Rise Adaptation Planning Project (Project) was a multi-phased regional collaboration funded by the California State Coastal Conservancy (2013-2015). The Project conservatively selected the mean monthly maximum water (MMMW) elevation (7.74 feet NAVD 88) based on NOAA's north spit tide gage record as it sea level rise planning datum. The Project's purpose was to inform the public and local agencies of the risk that sea level rise poses to the communities and environment on Humboldt Bay and examine the process of developing adaptation strategies and options for critical regional assets. Critical regional assets provide services necessary for the public's health and safety. Their loss or impairment would affect large numbers of people or properties/business in the Humboldt Bay region. Critical regional asset categories in the Humboldt Bay region are: urban areas, coastal resources (agricultural lands, seasonal freshwater wetlands, and wildlife habitats), utilities, and transportation infrastructure. The adaptation strategies that were developed represented a starting point from which stakeholders may develop plans for dealing with impending sea level rise on Humboldt Bay.

Phase I of the Project involved gathering baseline data on shoreline vulnerability. This included the *Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment* (Laird and Powell 2013), which described current shoreline conditions and identified shoreline segments vulnerable under current conditions to breaching or overtopping. Seventy-five percent (77 miles) of Humboldt Bay's shoreline is artificial, predominately consisting of earthen dikes (41 miles) and railroad beds (11 miles). (Dikes are shoreline structures built to prevent tidal inundation of low-lying areas, often former tide lands.) Approximately 26 miles of artificial shoreline are rated highly vulnerable to breaching or being overtopped (Laird and Powell 2013).

Phase II of the Project included three components: (1) preparation of *Humboldt Bay Sea Level Rise Hydrodynamic Modeling and Inundation Vulnerability Maps* (NHE 2015); (2) formation of a Humboldt Bay Sea Level Rise Adaptation Planning Working Group (APWG), convened by the Humboldt Bay Harbor, Conservation, and Recreation District (HBHCRD) and the Humboldt County Public Works Department as co-lead agencies; and (3) preparation of the *Humboldt Bay Sea Level Rise Adaptation Plan* (Laird 2015).

Relative sea level rise projections have been prepared, for Humboldt Bay's north spit tide gage from 2000 to 2100, including low and high greenhouse gas emission scenarios, by Northern Hydrology and Engineering (NHE) (2015). NHE's projections are based on tectonic research of vertical trends of the Humboldt Bay region (CG 2015). NHE prepared 3-dimensional inundation models in Humboldt Bay and 2-dimensional models adjacent to Humboldt Bay. Model outputs included maps of surrounding areas potentially vulnerable to tidal inundation from existing and future sea levels that are currently protected by the natural shoreline, dikes, and railroad and/or road grades. The goal and purpose of the APWG was to support informed decision-making and encourage unified consistent regional adaptation strategies to address the planning challenges and potential future hazards associated with sea level rise in the Humboldt Bay region.

The *Humboldt Bay Sea Level Rise Adaptation Plan* (Laird 2015) summarizes the APWG's exploration of sea level rise adaption planning on Humboldt Bay. The plan presents in-depth adaptation planning case studies for two critical regional assets that are at-risk from sea level rise: agricultural lands and uses and the U.S. Highway 101 corridor. These assets were evaluated extensively by way of a sea level rise impact risk analysis that assessed the asset's exposure, sensitivity, and significance or consequence if lost or impaired. Regardless of what approach is selected to adapt to sea level rise impacts, funding and regulatory flexibility are two critical issues that will need to be addressed. Developing and implementing adaption strategies for assets at-risk will require decades of planning, design, and implementation, as well as significant financial investments. Determining who owns, is responsible for, is dependent upon or uses the services provided by a critical asset at-risk will likely identify who should be involved in selecting appropriate adaptation strategies, developing feasible adaptation options, and securing funds for implementing these options.

1.2. City of Eureka Sea Level Rise Adaptation Planning

The City is exposed to several types of coastal hazards: tsunamis from a Cascadia subduction event, sea level rise projections of up to 5.4 feet by 2100, and 100-year floods, storm surge, and wave run-up. The City faces a range of exposures to sea level rise by 2050 (0.7 to 1.9 feet) and 2100 (2.1 to 5.4 feet) based on low versus high emission scenarios. While the State of California and the Federal Emergency Management Agency (FEMA) have mapped the tsunami and 100-year flood hazard areas on Humboldt Bay, modeling and mapping of potential tidal inundation of lands adjacent to Humboldt Bay was prepared by NHE in 2015 pursuant to a grant from the State Coastal Conservancy. The City has selected to focus its present adaptation planning efforts on approximately 2 feet of sea level rise, the high projection for 2050, which for MMMW could rise to 9.6 feet (NAVD 88) at the north spit tide gage (NHE 2015).

To support addressing sea level rise in the City's current LCP update pursuant to OPC's grant, an assessment of asset (land uses, developments, and coastal resources) vulnerability and risk to sea level rise was prepared for the City. The broad classes of assets in the City and its PA that are vulnerable and at-risk from sea level rise by 2100 include land uses (Coastal Dependent Industrial [CDI], Industrial, Commercial, Public, and Residential), coastal resources (agricultural lands, environmentally sensitive habitat areas, such as marine and freshwater wetlands and dunes, public access and recreation opportunities/facilities, and cultural sites), utilities (waste water, drinking water, storm water, energy, communications, and solid waste), transportation (surface, marine, air, and rail), and open contaminated sites. The assessment describes the location and characteristics of these assets, how they might be exposed to sea level rise impacts, when they may be impacted (present-day, 2030, 2050, and 2100), how susceptible they are to tidal inundation or salt water intrusion and flooding, and the consequences to the community if these assets are impaired or lost.

The assessment assigned a priority ranking to each asset for 2050 and 2100 to facilitate the City and community in developing adaptation strategies and measures for select high-priorities assets: waste and stormwater systems, and marina. This *Sea Level Rise Adaptation Planning Report* describes adaptation goals, strategies, and measures for the City's high priority assets. This report also describes adaptation goals, strategies, and measures for 2 feet of sea level rise to 9.6 feet (NAVD 88) (MMMW by 2050) and specifically for Eureka-Fay Slough a geographically vulnerable area. This report is based on findings described in the City's *Sea Level Rise Assets Vulnerability and Risk Assessment Report* (Laird 2016).

1.3. State Sea Level Rise Adaptation Planning Guidance

The sea level rise adaptation planning process used to produce the City's Assets Vulnerability and Risk Assessment and Adaptation Planning Reports was informed by the three State reference documents mentioned earlier and consultations with Coastal Commission staff. These reference documents present a multi-step adaptation planning process to address sea level rise (Figure 1). The City's 2016 *Sea Level Rise Assets Vulnerability and Risk Assessment Report* addressed the first three steps: choose a range of sea level rise projections relevant to Humboldt Bay, identify potential sea level rise impacts in the City and its PA, and assess vulnerability and risk to coastal resources and development in the City and its PA. This Adaptation Planning Report focuses on Step 4 to identify adaptation goals, strategies and measures.

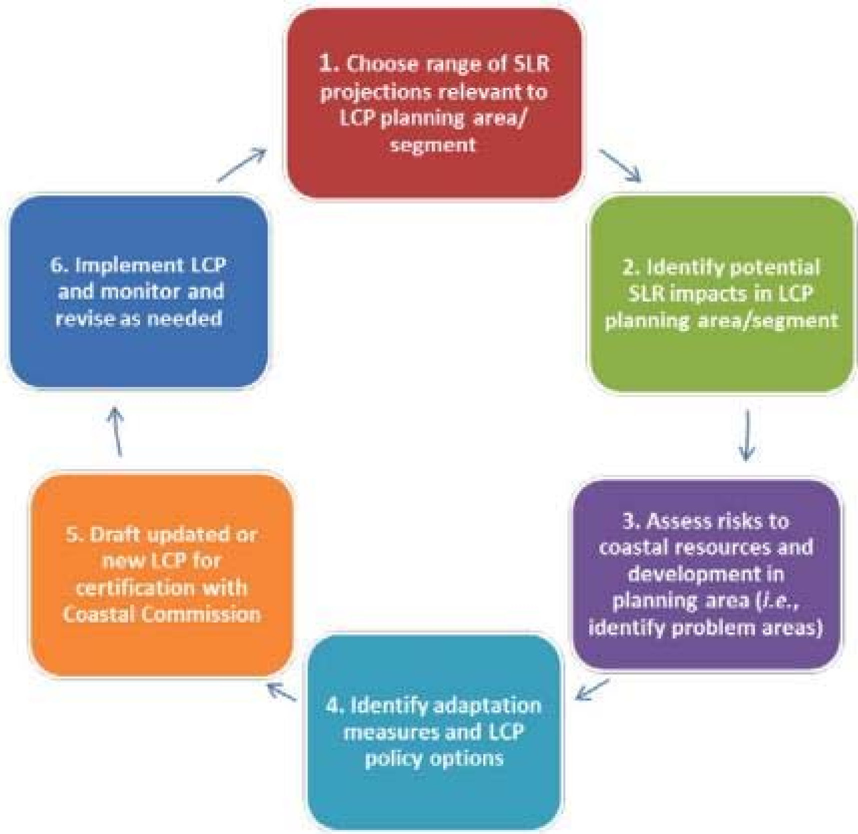

Figure 1. Sea level rise adaptation planning process for Local Coastal Programs (CCC 2015).

To the extent possible, preparation of this report has been integrated with efforts made by other agencies. A Public meeting was held to share the results of the City's adaptation planning effort and solicit public input that has been incorporated in the final Adaptation Planning Report. The City intends to publicly release a single document that will present its sea level rise assets vulnerability and risk assessment and adaptation plan. The sea level rise adaptation goals, strategies, measures, and recommendations described in this report may be incorporated into the City's LCP update as goals, policies and regulations, completing Step 5 of the sea level rise adaptation planning process (Figure 1).

2.0 ADAPTATION PLANNING

The City's adaptation planning for sea level rise began by utilizing projected rates of sea level rise for Humboldt Bay (NHE 2015) that incorporate local vertical land motion trends (CG 2014), which are caused by tectonic subsidence. Hydrodynamic modeling of Humboldt Bay generated tidal inundation maps for areas adjacent to Humboldt Bay (NHE 2015). The vulnerability and risk of assets to sea level rise was assessed for four time steps (present-day, 2030, 2050, and 2100) (Laird 2016). These activities completed Steps 1-3 of the Coastal Commission policy guidance (Figure 1). This report explores adaptation planning concepts that focus on priority assets, planning horizons/water elevations, and geographic areas (Figure 2). This report further presents adaptation goals and strategies (Step 4) for each of these approaches and recommend goals, strategies, and measures that can be incorporated in the City's' LCP as goals, policies and regulations (Step 5).

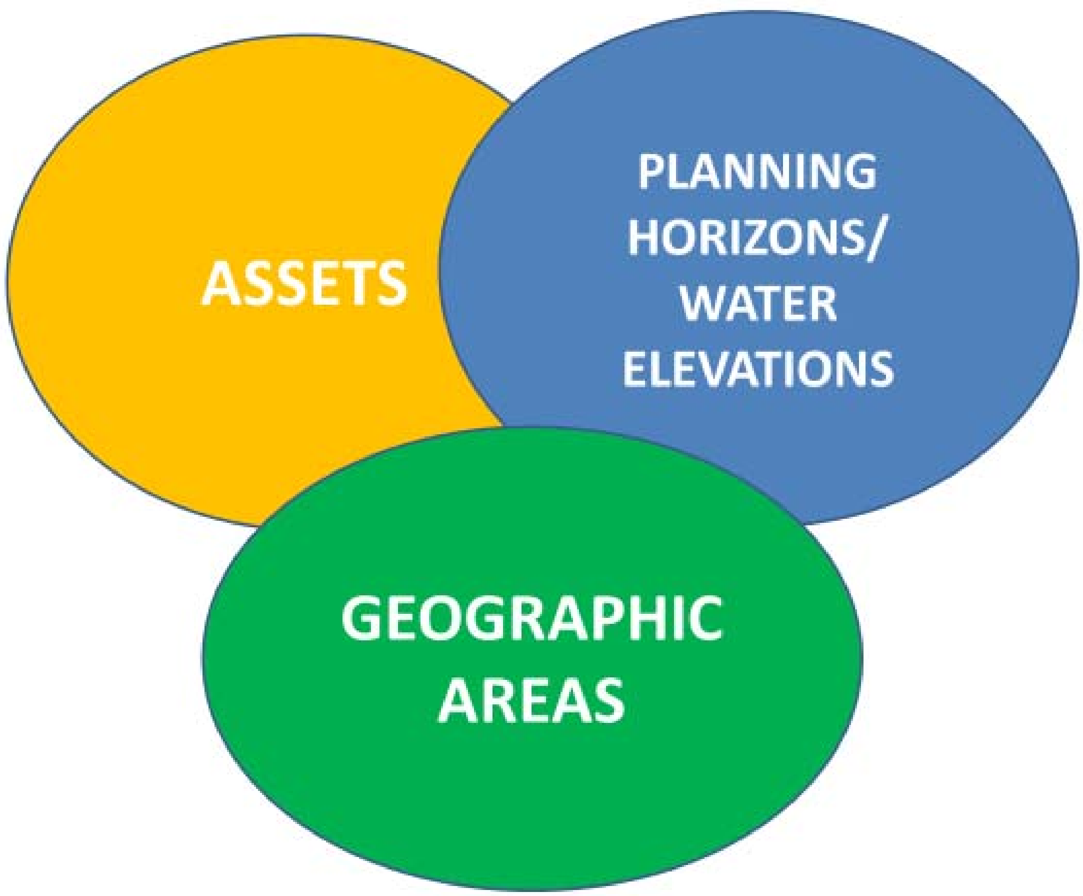

Figure 2. Adaptation Approaches: focus on assets, planning horizons/water elevations, or geographic areas, and, more likely, various combinations thereof.

Coastal planning for sea level rise involves informational and regulatory components. To date most of the sea level rise planning efforts on Humboldt Bay have been informational (vulnerability assessments and adaptation planning). Local governments such as the City are beginning to develop regulatory policies and regulations (LCP amendments). The City finds that there are several practical issues associated with developing LCP land use regulations to address sea level rise, including:

- Lack of “official” state or federal sea level rise planning or hazard maps for LCP authorities to base their land use policies and regulations without fear of litigation;
- Adopting sea level rise planning areas (SLRPA) for 2100 based on high versus low sea level rise projections, given the wide range of projections varying 3.3 feet;
- Deferring adopting SLRPA maps and siting/development standards to the next update of their LCP near 2050 because FEMA’s Flood Insurance Rate Map (FIRM) flood hazard zones and regulations cover the same area as the high projection (2 feet) for sea level rise by 2050;
- Accounting for successful implementation of adaptation strategies that could protect land uses and developments from projected sea level rise through 2050, thus negating the need to adopt a SLRPA for 2050;
- Revising current zoning ordinances based on high projection for sea level rise by 2100 is overly restrictive of existing land uses and developments that would not need protection from sea level rise through 2050;
- Adopting siting and development standards based on structural longevity and projected exposure to sea level rise through 2100;
- Limitations of a LCP, as a regulatory tool to protect existing (particularly assets not owned by the City) or vested land uses and developments versus future land uses and developments;
- Limitations of an individual LCP versus a regional or multi-agency LCP to develop and implement regional adaptation goals and strategies;

This report will attempt to put these issues in context and convey how the City has elected to respond.

To summarize, three key aspects of this sea level rise adaptation planning report include the:

- City’s emphasis is on adapting to the high projection of 2 feet for sea level rise on Humboldt Bay by 2050 and a targeted MMMW elevation of 9.6 feet (NAVD 88);

- City’s focus is on its most vulnerable and at risk geographic areas
    - The geographic area that is vulnerable to sea level rise most immediately is the Eureka-Fay Slough hydrologic unit
    - The commercial and industrial waterfronts are critical to the future of the City; and,
    - City’s adaptive capacity to address high priority assets is constrained because many vulnerable and at risk priority assets are not owned by the City. Key infrastructure related to energy, bulk fuel, communications, and transportation are owned by other public and private entities. The most vulnerable high priority assets under the City’s control are:
        - Wastewater system
        - Stormwater System
        - Marina and existing City-owned shoreline protection structures

2.1 Assets

In the City and its PA, there are four classes of assets (utilities, transportation, land uses, and coastal resources) (Table 1). All four classes contain high priority assets that are vulnerable and at-risk from sea level rise for 2050 and 2100 (Table 2). While contaminated sites are not an asset they are vulnerable to sea level rise and their remediation is a high priority.

Table 1. Summary of asset classes.

ASSET CLASS	ASSET TYPES
UTILITIES	Waste water, Municipal water, Storm water, Energy, and Communications
TRANSPORTATION	Surface, Marine, Air, and Rail
LAND USES	Coastal Dependent Industrial, Industrial, Commercial, Residential, Public, and Agricultural
COASTAL RESOURCES	Public Access, Environmental sensitive habitat areas: Marine and freshwater wetlands and dunes, Public access, Recreational sites, and Cultural sites
CONTAMINATED SITES	Open-untreated sites

Each asset has been prioritized for the 2050 and 2100 planning horizon based on its exposure to sea level rise impacts, susceptibility (the degree to which an asset is affected adversely) to expected impacts, and the consequence (result or effect of impact) of the loss or impairment of the asset to the City, its criticality. Assets have been given a priority ranking to facilitate the selection of priority assets for development of adaptation strategies and measures (Table 2).

To assign a priority ranking for an asset, each of the elements (exposure, susceptibility, and consequence for 2050 and 2100) was assigned a value of 0, 1, or 2. For example, with exposure, an asset is attributed 0 if there is no exposure, 1 if less than 50% of an asset is exposed, and 2 if greater than 50% of an asset could be exposed, based on the results summarized in Tables 2 and 3. These values are summed for both 2050 and 2100, forming a cumulative value total which can then be ranked and prioritized. Cumulative value totals for an asset of 0 through 2 are be considered a low priority. Cumulative values of 3 or 4 are considered a medium priority. High priority assets have a cumulative value of 5 or 6.

The highest priority assets to protect by 2050 are utilities (waste water, municipal water, storm water) transportation (Highway 101 Murray Field Airport), residential communities located in the County's LCP jurisdiction (King Salmon and Fields Landing), commercial fishing facilities and property, public access and recreation, agricultural lands, and Environmentally Sensitive Habitat Areas (ESHAs). By 2100, all assets except recreational boating (pilings would have been extended by 2050), agricultural lands (existing dikes are projected to be overtopped and diked lands would be drainage impaired by 2070 with approximately 3 feet of sea level rise), and ESHA (most are located on diked lands that are projected to be overtopped or flooded due to impaired drainage by 2070) are all high priority assets.

To best plan for adaptation to sea level rise, it is helpful to establish a specific goal(s) that is desired or the threshold that an asset or geographic area needs to achieve or accomplish. Goals have been articulated for the four asset classes, planning horizons or water elevations for the year 2050 (2 feet) and the year 2100 (5 feet), and for specific geographic areas (Eureka-Fay Slough and the waterfront).

Strategies include feasible (physically, legally, and financially) methods, action plans, or approaches to attain an asset's goal(s). In general, adaptation strategies are proactive approaches that, for existing development, include: (1) protect, (2) accommodate, (3) retreat, and for new development (4) avoid. Various combination of these approaches are also likely. While no action or "business as usual" might be considered an adaptation strategy, and may be appropriate in some situations, it is not a proactive approach to adaptation planning. Adaptation measures are individual actions that, if implemented successfully, will assist in implementing a strategy and achieve the asset's adaptation goal.

Table 2. High priority assets based on their exposure, susceptibility, consequence ranking for 2050 and 2100 in the City and its Planning Area. Values for exposure, susceptibility, and consequence are summed to generate their ranking for both 2050 and 2100.

HIGH PRIORITY ASSETS	Exposure	Susceptibility	Consequence	2050	Exposure	Susceptibility	Consequence	2100
Waste Water-Collection System	1	2	2	5	2	2	2	6
Municipal Water-Transmission System	1	2	2	5	2	2	2	6
Residential Zoned Property & Communities-PA	1	2	2	5	1	2	2	5
US Highway 101	1	2	2	5	2	2	2	6
Storm Water System	2	1	2	5	2	2	2	6
Commercial Fishing Facilities-Property	1	2	2	5	2	2	2	6
Recreational Boating	2	2	2	6	1	2	1	4
Murray Field Airport	2	2	2	6	2	2	1	5
Agricultural Zoned Lands	2	2	2	6	1	2	0	3
Freshwater ESHA	2	2	2	6	0	2	0	2
Electric System	1	1	0	2	2	2	1	5
Natural Gas System	1	0	2	3	2	1	2	5
Optical Fiber Transmission	1	1	1	3	2	2	2	6
Jetty-Channels	0	0	0	0	2	2	2	6
State Highway 255	1	2	0	3	2	2	2	6
Coastal Dependent Industrial Zoned Property-City	1	2	1	4	2	2	2	6
Industrial Zoned Property-City	1	2	1	4	2	2	2	6
Bulk Cargo Docks-City	1	1	1	3	2	2	2	6
Contaminated Sites	1	2	1	4	2	2	2	6
Bulk Fuel Terminal	0	0	0	0	2	2	1	5
Streets	1	2	1	4	1	2	2	5

Education should be an integral part of the adaptation planning process and could also be considered an adaptation strategy that is common to all other strategies and should be the first strategy to be employed. At a minimum, sea level rise education needs to convey which areas are currently vulnerable to tidal inundation under existing tidal conditions, and should ideally include SLRPA predicted to be vulnerable to extreme flood events and future sea level rise. The properties, infrastructures, and services at-risk in these areas are also important to identify and share with the public, agencies, and property owners. The goals, strategies, and measures available to address sea level rise should also be shared with these constituencies.

The State recommends sea level rise planning horizons of 2050 and 2100 for LCP update purposes, particularly for new and future assets. When developing adaptation strategies for developments, it is important to consider the design life or longevity of the structure when assessing their exposure to sea level rise impacts such as tidal inundation. The expected or actual life of a structure may span the planning horizons being used today.

2.1.1 Asset Adaptation Goals

Most municipalities, like Eureka, have general land use goals to maximize development for the benefit of the community, while maintaining infrastructure and other assets, in accordance with Municipal Codes, including participation in the National Flood Insurance Program, and State policy guidance as well as regulatory constraints. Much of Eureka's undeveloped and under-developed areas are within the potential zone of inundation for 2100, adaptation planning has the potential to limit development and is therefore in tension with the City's goals (ESA 2016). Several of the Coastal Commission's policy guidance principles for adaptation planning have the potential to limit development and therefore, if adopted by the City, may limit attainment of the City's land use goal of maximizing development, at least in SLRPAs.

Many individual utility and transportation assets are linear and traverse multiple geographic regions of City and its PA. Several goals are being recommended for each of the asset classes to help guide the development of adaptation strategies and measures (Table 3). These are further clarified in Addendum 1.

Table 3. Asset classes and proposed sea level rise adaptation goals.

ASSET CLASS	GOAL(S)
UTILITIES	**Maintain reliable and economical delivery of all utilitiy services.**
	Accommodate and support future growth.
TRANSPORTATION	**Retain local, regional, and inter-state transportation capabilities.**
	Accommodate and support future growth.
LAND USES	**Land uses in a SLRHZ can accommodate projected sea level rise impacts without need for protection.**
	Development/structures in a SLRHZ can accommodate projected sea level rise impacts for the estimated design life of development/structures without need for protection.
	Relocation of land uses and developments in current tidal hazard zones in need of protection from tidal inundation should shoreline structures fail.
	Assure priority for coastal-dependent and coastal-related development.
COASTAL RESOURCES	**Protect, prepetuate, and maximize public coastal access and recreational opportunities.**
	Protect and prepetuate existing environmental sensitive habitats.
	Protect and where feasible restore natural shorelines and beaches.
	Retain cultural resources.

Utilities

Utility services are critical to any municipality. A common mission statement and suitable adaptation planning goal for utility entities is to reliably deliver their service as economically as possible to their customers. Utilities, even those located in SLRPA s must be able to provide their services uninterrupted to their customers at all times. Allowing utilities to remain in SLRPA s cannot compromise these goals of reliability and economy. As utilities support nearly all land uses and developments, the City's planned future growth, outside of the SLRPA s, will need to be served by these utilities even if they remain in a SLRPA.

Transportation

The City is built around transportation infrastructure, particularly surface modes of transportation. Highway 101 is perhaps the most critical transportation infrastructure to the sustainability of the City and the Humboldt Bay region. While local streets and Murray Field Airport are high priority assets, they do not rise to the same level of criticality as does Highway 101. The marine transport capabilities that the Port of Humboldt and Eureka provide are high priority assets to the Humboldt Bay region. However, their utilization has been in serious decline for decades. Only three of the five bulk cargo docks in the City are still functioning. Retaining the capabilities of local, regional, and inter-state surface transportation is critical to the sustainability of the City and the Humboldt Bay region. The retention and potential revival of marine transport capabilities of the Port of Humboldt and Eureka is also desirable goal for the City and Humboldt Bay region. Air transport capabilities, if they are feasible to retain in the SLRPA, will help diversify and support the City's industry and commerce. It may not be feasible to retain the current rail transport facilities in the City and its PA, beyond 2050 or with more than 2 feet of sea level rise if the North Coast Railroad Authority (NCRA) does not invest in the reconstruction of their rail infrastructure. However, the capability of the railroad right-of-way to support non-motorized transport is being actively developed by the City and Humboldt County Association of Governments and certainly desirable to support in the City and its PA if it is feasible to retain in this location.

Land Uses

With land use, the State recommends a goal that would be to not have assets (land use, developments/structures, and resources) in a SLRPA that need to be protected from sea level rise impacts, during the life a structure/development, such as tidal inundation or saltwater inflow/intrusion. For those land uses that need to be in SLRPA s, priority should be given to coastal-dependent and coastal-related developments.

Coastal Resources

Two primary coastal resource goals are to maximize public access and recreational opportunities to and along the coast (CCC 2015). Another shared goal of the Coastal Act and the City's LCP is to provide for maximum protection of coastal resources (public access, recreation, ESHAs, beaches, natural shorelines, and cultural sites). The retention of cultural resources, where and when feasible, is also a goal of the City and tribal governments.

2.1.2 Asset Adaptation Strategies and Measures

Three general adaptation strategies (protect, accommodate, and retreat) are predicated on deciding whether an existing asset should remain at its present location.

- Protect: Protection strategies employ an engineered structure or other measure to defend an asset in its current location without changes to the asset itself.
- Accommodate: Accommodation strategies employ methods that modify existing assets to decrease their vulnerability and risk and thus increase their resiliency to impacts of sea level rise.
- Retreat: Retreat strategies relocate or remove an asset out of SLRPA and limit new development in a SLRPA.

Pragmatically, a hybrid strategy may provide the maximum amount of flexibility for an existing asset over time (Figure 3).

An alternative adaptation strategy to sea level rise, while not proactive, is to do nothing. The high projection for sea level rise by 2050 is 2 feet (MMMW elevation of 9.6 feet NAVD 88), which is less than FEMA's new base flood elevation (BFE), or 100-year stillwater event (10.2 feet NAVD 88 at the north spit tide gage) for lands adjacent to Humboldt Bay. FEMA's FIRM delineate which areas are in flood hazard zones. FEMA and the City have siting and development standards that allow structures and development to occupy flood hazard zones; flood insurance is also generally required in these zones. If the new federal FIRM are incorporated in the City's LCP Safety Element to delineate flood hazard zones (BFE 10.2 feet), there may not be a need for a separate SLRPA map for the high projection of sea level rise by 2050 (MMMW of 9.6 feet).

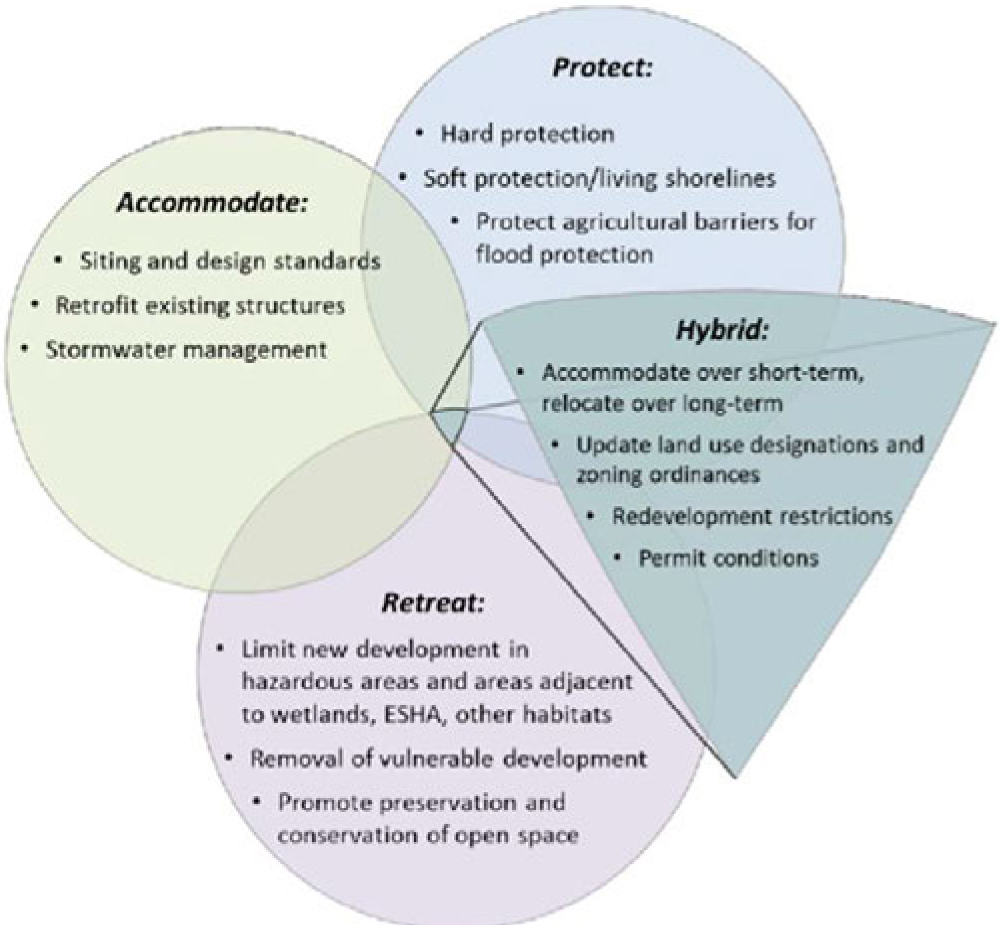

Figure 3. Examples of general adaptation approaches (CCC 2015).

A fourth general strategy, applicable to new assets, seeks to avoid sea level rise hazards. Protection strategies usually involve hard engineering to defend a structure from sea level rise impacts. However, there can be negative consequences from engineered solutions such as shoreline armoring to coastal resources. Accommodation strategies seek to retain an asset's location in a SLRPA. Both strategies attempt to modify or design a structure <u>in-place</u> to increase its resiliency to sea level rise impacts. For example, rebuilding a highway as an elevated causeway on pilings would be a form of accommodating sea level rise. Retreat and avoidance strategies would remove an asset from a SLRPA and from sea level rise impacts.

Potential adaptation strategies and measures for utilities, transportation, land use, and coastal resources would help to implement the goals of each asset class are summarized below. The following potential strategies are a summary of what is possible and do not necessarily represent the City's planned approach for each category. Addendum 1 outlines the potential strategies that the City is currently evaluating as means to protect priority assets. As is shown in Addendum 1, the City's primary strategy is "Protect."

Utilities

Utilities, are high priority assets that include both City (municipal water, wastewater, and stormwater) and other agencies and private (natural gas, electricity, bulk fuel, solid waste, and communications) infrastructure. Most utility systems are composed of linear assets, many of which are underground, and therefore vulnerable to salt water intrusion. Utility systems also include buildings, pump stations, towers, and poles. These utilities traverse multiple land use jurisdictions and properties often in a right-of-way located on low-lying lands behind protective shoreline structures that are not owned or maintained by the utility. Regardless of which adaption strategy is considered, a collaborative stakeholder process to address sea level rise impacts to utilities will need to be led by the City or by utility owners. The adaptation planning process would need to include property owners of protective shoreline structures, potentially affected property owners, public, and local and state agencies.

Protect

Protecting utilities in place is a pragmatic adaptation strategy until funds can be secured to ultimately relocate utility infrastructure out of the SLRPA. Protection measures may also become necessary to maintain access to utilities located in low-lying areas, underground, or behind shoreline structures.

Maintenance or enhancement of the shoreline structure may be appropriate for utilities located behind shoreline structures that prevent tidal inundation of utility infrastructure now or in the future. Protection of these shoreline structures with either hard or green engineering measures may be needed. Eventually, rising groundwater behind the shoreline structure may necessitate pursuing accommodation and/or retreat strategies for utility infrastructure. Underground facilities, electrical pumps, or other electrical infrastructure components will need to be sealed or otherwise made flood proof to salt water intrusion or tidal inundation.

Accommodate

Accommodating sea level rise is another strategy that allows an asset like utilities to remain in its present location within a SLRPA. Raising the elevation of utility facilities to accommodate higher water elevations would be an alternative to holding back tide waters. Elevating the surface elevation of the utility right-of-way may also be an appropriate accommodation in some situations to retain access to utility infrastructure.

Retreat

Utilities could be relocated to a future utility/transportation corridor centered on Highway 101 or elsewhere that is protected by fortified dikes. Relocating utility infrastructure that is vulnerable and at-risk from sea level rise inland from the SLRPA s may be the most appropriate response particularly whenever feasible financially.

Decentralizing the wastewater collection and treatment facility may increase the number of suitable sites available beyond the SLRPA s. Conversely, considering a regional wastewater treatment facility at the former Pulp Mill site on Samoa peninsula could utilize the ocean outfall facility as well as eliminate redundancy of maintaining several wastewater treatment facilities on Humboldt Bay.

Avoid

An avoidance adaptation strategy would prohibit future developments requiring utilities that should not be sited in SLRPA s. Utilities should not be extended into SLRPA s if they will need to be protected from sea level rise. Utility infrastructure and facilities should not be in SLRPA s if at all feasible.

<u>Transportation</u>

In the City, there are both state and local surface transportation facilities that are vulnerable and at-risk from tidal inundation on Humboldt Bay. Like many utilities, surface transportation infrastructure is by its nature linear. On Humboldt Bay, these surface transportation facilities traverse multiple land use jurisdictions and are located on low-lying lands behind protective shoreline structures (dikes and railroad grades), that are not owned or maintained by the transportation authority. A collaborative stakeholder group and process to address sea level rise adaptation strategies and measures for surface transportation facilities on Humboldt Bay may be appropriate for the Humboldt County Association of Governments to lead, given the organization serves as the regional transportation planning agency. The process would need to include Caltrans, the agency responsible for Highway 101, and potentially property owners of protective shoreline structures (dikes and railroad), federal, state, and local agencies.

Humboldt County's Murray Field Airport facility is in the City. The airport was situated on diked former tidelands, which today are lower in elevation than adjacent salt marsh on Humboldt Bay. Adaptation strategies that are suitable for Highway 101, as it traverses these same diked former tidelands, will likely be applicable for adaptation of this airport facility.

Marine transportation facilities in the City and its PA occupy waterfront areas on Humboldt Bay. In the City, these facilities are in the Waterfront-Bayshore shoreline areas and on Woodley Island. The Woodley Island facilities are owned and managed by the HBHRCD. As a state granted lands entity, the HBHRCD will likely be addressing sea level rise vulnerability of its Port facilities pursuant to a sea level rise adaptation program administered by the State Lands Commission. The U.S. Army Corps of Engineers (USACE) are responsible for the maintenance of the harbor jetties, and in cooperation with the HBHRCD, the entrance and navigation channels. The City and HBHRCD also cooperate in the maintenance of the City's marina berth and channels.

Protect

Protecting surface transportation infrastructure in place is a preferred adaptation strategy when considering Highway 101 and the Murray Field Airport, which represent large local and state investments that are located behind dike shoreline structures. These dike structures are critical to preventing tidal inundation of transportation infrastructure. Between now and 2050, protecting these shoreline structures with either hard or green engineering measures will likely become necessary to protect these transportation facilities. Enhancement of these dikes, particularly by increasing their elevations, may be desirable compared to the impacts of relocating transportation infrastructure behind the dikes. Eventually, rising groundwater behind the dikes may necessitate pursuing accommodation and/or retreat strategies for the surface transportation infrastructure and for Murray Field Airport.

Additional adaptation measures to protect transportation infrastructure include:

- Construction of new protective dikes parallel to Highway 101 on Caltrans' property or right-of-way may become an option if enhancing existing diked shorelines or railroad grade is not feasible. Highway and street road prisms could be modified to prevent slumping or erosion. As groundwater rises behind diked shorelines or when stormwater runoff becomes impounded behind the highway or streets, pumping may become necessary to protect road prisms from over-saturation.
- Fortification of the waterfront shoreline would protect marine facilities and properties from erosion and tidal inundation if the shoreline elevation is increased.
- Enhancement of the jetty structures may become necessary to protect vulnerable infrastructure from sea level rise and increased wave energy caused by extreme storm events. Protecting these structures will also be necessary to maintain the entrance channel to Humboldt Bay. Protective structures built to mitigate the

impacts from construction of the jetties will also need protection from sea level rise including HBHRCD's jetties and beach dune system at King Salmon and the sea wall fronting the NCRA railroad between King Salmon and Elk River Spit.

Accommodate

Accommodating sea level rise is a strategy that not only allows an asset like transportation infrastructure to remain in its present location but is likely much less expensive that relocating, given the huge investments of public funds in infrastructure. As Highway 101 and streets are scheduled for resurfacing, there may be opportunities to incrementally raise their elevation. Reconstruction of Highway 101, streets, and roads would provide an opportunity to import fill and raise the elevation of the road base and surface.

Additional adaptation measures to accommodate transportation infrastructure include:

- Increasing the capacity and number of water control structures draining the diked lands could enable these areas to accommodate increasing sea level rise as it affects the efficiency of these water control structures. Increasing drainage from these lands could help protect surface transportation infrastructure that traverses these lands like Highway 101.
- Replacing low-lying sections of Highway 101 and critical local streets and roads with an elevated viaduct on pilings may be a preferred long-term solution to accommodate sea level rise.
- Increasing the surface elevation of marine facility property would protect it from tidal inundation. Increasing the elevation of access streets servicing these properties will likely be necessary to accommodate higher sea levels and tidal inundation.
- Replacing or increasing the height of pilings that anchor floating docking would help keep these marine facilities in place as sea level rises.

Retreat

Adaptation measures to support the retreat of transportation infrastructure include:

- Relocating or abandoning surface streets that serve specific properties and developments would only be feasible if those developments are also relocated.
- Relocating Highway 101 would be a significant undertaking in time, money, and environmental impacts. Alternative routes for Highway 101 in the City or its PA are located to the east of the Bay and would also have to traverse low-lying diked former tidelands in Salmon Creek, Elk River, Freshwater Creek, and Bayside-Jacoby Creek. Relocating Highway 101, as opposed to accommodating sea level

rise, is likely not a feasible adaptation measure before 2100 with less than 6 feet of sea level rise predicted.
- Relocating the County's Murray Field Airport facilities and/or services to another existing local airport other than the City's Samoa Airport is feasible and could possibly be phased over time.
- Relocating Coast Dependent Industrial (CDI) bulk cargo docks to new locations in the City, rather than increasing the elevation of the docks and supporting property, is likely not feasible. There are a sufficient number (based on current use trends) of bulk cargo docks on Humboldt Bay in the PA on Samoa peninsula that could still be operational by 2100, at least based on being above the high projection for sea level rise. In the City, the Chevron bulk fuel facility versus its bulk fuel dock, does not need to be located on the shoreline of Humboldt Bay. It could be relocated inland with a pipeline(s) extending inland from its dock.
- Relocating the commercial fishing facilities and marina in the Waterfront Shoreline area. Commercial fishing facilities could be relocated inland as the shoreline moves, to Woodley Island, and to CDI property in the PA on Samoa peninsula. These areas are above the high sea level rise projections for 2100 for MMMW and 100-year event water elevations (Laird 2016).

Avoid

Additional adaptation measures to help avoid impacts transportation infrastructure include:

- Avoiding impacts Highway 101 would only be possible if it were to be relocated. Disallowing new development in SLRPA s would negate the need to locate new streets in these areas.
- New airport facilities are not currently planned; nor should they be in SLRPA s in the future.
- While new marine facilities have no choice but to be sited in SLRPA s, they could be built on areas that have been raised with imported fill.

<u>Land Uses</u>

The Waterfront-Bayshore Shoreline areas of the SLRPA include CDI, Industrial and Commercial, Public, and Natural Resource zoned property. There are many acres that are undeveloped or under-developed CDI property in the City's SLRPA. There is no residential zoned property in the City's SLRPA through 2100; however, there is residential zoned property in its PA within the SLRPA for 2050. These urban areas are in low-lying areas adjacent to Humboldt Bay. The combination of the high projection for sea level rise by 2100 and a 100-year event could potentially expose a limited residential area in the City along Third Slough off Bay Street. There may also be contaminated sites in these low-lying areas. Inundation of contaminated areas prior to remediation could impact water quality in Humboldt Bay (Laird 2016). Agricultural zoned property dominates the Eureka and Elk River Slough areas, except for the public zoned Murray Field Airport and the municipal golf course. Note, agricultural zoned property located in SLRPA s is included under Land Uses rather than under the Coastal Resource section.

Sea level rise potentially could tidally inundate most of the urban waterfront areas and existing development between 2050 and 2100. However, urban waterfront land uses and development in the 2100 SLRPA may be affected before 2050 if underground utilities that support existing development become impaired by sea level rise. The ability of a wastewater treatment facility to maintain existing capacity or accommodate future growth may be impaired by tidal inundation and infiltration/inflow of underground sewer lines, reducing the facility's capacity. This type of impact serves to illustrate the vulnerability of urban areas—tidal inundation of surface land uses may be preceded by tidal inundation impacts to critical underground utilities.

If adaptation strategies and measures are not implemented, sea level rise is likely to tidally inundate diked agricultural lands in the City and its PA by 2050. Adaptation strategies and measures can help make diked agricultural lands more resilient to sea level rise, possibly through to 2070. After approximately 2070, based on the high projection for sea level rise, these lands may no longer drain sufficiently due to rising groundwater during low tides or tidal inundation and will be unable support pasture grasses and grazing.

A future collaborative stakeholder group and process to address sea level rise impacts to land uses would likely be led by the City the LCP authority and include private utility owners, potentially affected property owners, public, and local and state agencies. In Eureka and Elk River Sloughs, the two LCP authorities (City and County) could consider a collaboration to integrate their respective LCP sea level rise adaptation strategies and measures to uniformly address future impacts within discrete hydrologic units.

Protect

Diked tidelands on Humboldt Bay provide a rather unique situation when planning for sea level rise, particularly in the near term such as 2050. Tidal inundation maps and FEMA's FIRM assume that there are no shoreline structures present, and the inundation areas delineated are a result of what is characterized as a bathtub model. If pursuant to a protection strategy, shoreline structures are increased in elevation to prevent overtopping by sea level rise projections for 2050, SLRPA s would not need to be applied to these areas through 2050 (or the effective life the shoreline structure).

The City may protect existing land uses that are currently located in SLRPA through 2050 with its current LCP update. Land uses in the City would be protected by strategies and measures also implemented to protect utilities, diked or fortified shorelines, or transportation infrastructure, as discussed above.

Land uses specifically on Eureka and Elk River Sloughs could be protected with green and hard engineering measures, including constructing salt marsh plains (living shorelines) to protect dikes, and/or constructing a tidal dam at the mouth of these sloughs at existing bridges to mute the tide cycle and potentially protect all the diked lands (urban and rural) on these sloughs.

Accommodate

Accommodating sea level rise is a strategy that allows an asset like buildings to remain in their present location within a SLRPA rather than retreating. However, the City should adopt siting and development standards based on site specific topographic and hydrologic studies that would determine the minimum surface elevation for lots and livable structures that are in SLRPA s. Future CDI and Coastal related developments should not need protection from sea level rise they should be designed to accommodate high projections for sea level rise through 2100.

Utilizing pile foundations would help raise buildings above projected sea levels. Raising the surface elevation of individual low-lying lots and surface streets in adaptation a SLRPA for specific geographic areas such as Jacobs Avenue on Eureka Slough could help accommodate higher water elevations. Importing fill to increase the surface elevation of individually owned diked former tidelands or for all undeveloped tidelands in a hydrologic sub-unit that have compacted over the last century as organic material oxidized from the former salt marsh soils may reduce impacts from rising groundwater in response to sea level rise. Increasing the capacity and number of water control structures or installing pumps to drain diked and urban lands could enable these areas to accommodate increasing sea level rise as it affects water control structure efficiency.

Retreat

Retreating from a SLRPA is an adaptation strategy that will provide long-term certainty. Relocating urban land uses and developments, other than CDI and coastal-related development, that are vulnerable and at-risk from sea level rise inland may be the most appropriate response whenever feasible. Retreat of urban land uses and developments would also facilitate habitat restoration which can serve as “natural or green infrastructure” to increase protection of assets farther inland.

Relocating agricultural uses inland is not a feasible adaptation measure as most if not all suitable land that could support agricultural uses are already in use for agricultural purposes or have been developed for other uses. Existing agricultural lands on diked former tidelands will slowly convert to freshwater or brackish or salt marsh wetlands (ESHA) as drainage is reduced with rising tides and groundwater.

Avoid

Avoidance as an adaptation strategy would prohibit future land uses and development, with the exception perhaps of CDI and coastal related development, sited in SLRPA s if they will need to be protected from sea level rise during the life of any structures. The Commission's policy guidance recommends that shoreline protection should not be allowed to site new development in undeveloped areas.

Coastal Resources

In the City and its PA, public access to Humboldt Bay and ESHAs is limited mostly to public lands and facilities, except for King Salmon. There are several boat launching facilities including the Eureka Marina in the Waterfront Shoreline area and three in the PA. There are also several floating docks in the Waterfront Shoreline area and on Woodley Island open to the public, and the Del Norte Street pier. The City's Waterfront Trail now reaches from Elk River Slough and soon up to Del Norte Street pier and will extend beyond to the Boardwalk and eventually to Eureka Slough east of Highway 101. The Hikshari Trail, and its possible extension south to King Salmon, provides public access to Elk River Slough and Elk River Spit with its dune ecosystem, salt marsh, beach, and unique artesian freshwater pond, wetlands, and riparian ecosystem. DFW provides public access and recreation to its Fay Slough and Elk River Wildlife Refuges where Aleutian geese graze in the winter and spring. In the PA, public access to Humboldt Bay and recreation is provided by the HBHRCD and PG&E at King Salmon, and by Humboldt County on the Samoa peninsula.

Coastal terrestrial resources on Humboldt Bay that are most at-risk from tidal inundation or flooding are the diked former tidelands (Eureka and Elk River Slough areas) that support agricultural uses, seasonal freshwater wetlands and riparian areas (ESHA), and wildlife habitats and populations. Based on current shoreline conditions, extreme high tides and storm surges or El Niño events can result in 2 feet of sea level rise that can overtop low elevation dikes. During these events, wind waves can erode unfortified dikes, causing them to breach. The resulting flooding of former tidelands, presently agricultural lands, with salt water will convert existing terrestrial freshwater resources. Elk River Spit, with its terrestrial and aquatic ecosystems, are also vulnerable and at-risk from sea level rise impact such as shoreline erosion and tidal inundation.

These diked former tidelands are both privately and publicly owned, with much of the public lands located in Eureka Slough (DFW's Fay Slough Wildlife Refuge) and Elk River (City of Eureka's Elk River Estuary Enhancement Project and DFW's Elk River

Wildlife Refuge). These wildlife refuges are managed for wildlife, open space, and recreation. The collaborative stakeholder group and process to address sea level rise impacts to diked former tideland agricultural areas would likely include dike owners, potentially affected public and private property owners, the public, Humboldt County Resource Conservation District, LCP authorities, Coastal Commission, and National Resources Conservation Service.

Sea level rise will also impact coastal aquatic and terrestrial resources on Humboldt Bay. Aquatic resources include eel grass, salt marsh, estuaries, brackish water wetlands, and low gradient fish habitats. Riparian areas are both aquatic and terrestrial in nature. To adapt to increasing water depths or expanding tidal influences, these habitats will need to migrate if they are to survive.

Protect

Protecting public access will be a limited adaptation strategy, one that when combined with accommodation and ultimately retreat can maintain access to Humboldt Bay. Hard and/or green engineered shoreline protection may be used to prevent erosion of the shoreline along waterfront trails and dikes.

Any measures implemented to protect diked lands or the Bay Trail would also be protecting ESHAs behind this infrastructure. Dikes could be raised in elevation to reduce overtopping by extreme tides, stormwater, or sea level rise.

Accommodate

Accommodation may become an on-going adaptation strategy for public access facilities through 2050 on the shoreline of Humboldt Bay. Replacing or increasing the height of pilings that anchor floating docking would help keep these recreational facilities in place as sea level rises.

Additional adaptation measures to accommodate coastal resources include:

- Raising the surface elevation of low-lying surface streets in the SLRPA could help accommodate higher water elevations and maintain public access to Humboldt Bay.
- As the Bay Trail is scheduled for resurfacing, there may be an opportunity to incrementally raise its elevation.
- Increasing the capacity and number of water control structures draining diked lands could enable these areas to accommodate increasing sea level rise.
- Maintaining undeveloped areas as open space to allow natural areas such as coastal wetlands to migrate inland with sea level rise.

- Relocating dikes inland, even 50 to 100 feet, could allow for restoration of salt marsh habitat and provide a wave attenuating buffer to protect dikes from erosion and breaching.
- Building new dikes farther up Eureka Slough on Freshwater Creek and on Elk River could prevent tidal inundation because of sea level rise of agricultural lands and ESHAs current not affected by saltwater.

Retreat

Retreat is the one adaptation strategy that can maintain public access. Public access to Humboldt Bay can be relocated inland as the shoreline retreats in response to sea level rise. However, most ESHA in the City will not be able to retreat with rising sea level as they are backed by shoreline structures such as dikes, railroad grade, and streets; unless these structures are moved landward and allow the ESHAs to migrate inland.

Avoid

Siting public access to Humboldt Bay and coastal recreation, by its very nature, will not be able to avoid SLRPA s.

2.1.3 Adaptive Capacity

Like most municipalities, the City only owns and controls some high priority assets: waste water treatment facility, sewer lines and lift stations, municipal water lines and pump stations, storm water infrastructure, surface streets, trails, some waterfront and adjacent properties with commercial fishing facilities, recreational docks and marina, and coastal resources (public access, recreation, and ESHA) that are vulnerable and at-risk from sea level rise. Many other high priority assets that are vulnerable and at-risk from sea level rise are owned by other agencies or private parties, such as Highway 101 and the dikes that protect the commercial property in the Eureka-Fay Slough area. The Humboldt County Flood Control District could provide an institutional umbrella to facilitate adaptation planning for sea level rise across a land scape of multi-agencies and property owners. The District could serve as a vehicle to secure funds for planning, engineering, and permitting adaptation efforts in areas that are vulnerable to sea level rise and flooding. For high priority assets that the City does not own but are within its LCP jurisdiction and critical to the City, it may be advantageous for the City and/or District to form partnerships with asset owners (land use/development, coastal resources, utilities and transportation) and collaborate with owners of shoreline structures that protect (dikes and railroad grade) these assets, and others who benefit from these high priority assets to develop and implement adaptation measures.

2.2 Planning Horizons (Target Sea Levels)

An alternative approach to, or in combination with developing adaptation strategies for high priority assets or geographic areas, exposure can be assessed based on a specific planning horizon or date. The City of Eureka is generally leaning away from this approach because there is a significant range in sea level rise projections for 2050 (8.4 to 22.9 inches) and 2100 (24.1 to 63.2 inches). Accordingly, there will be uncertainty regarding the use of any projections for sea level rise 84 years into the future. This is especially true since these time horizons are well beyond the 2040 term of the City's proposed Local Coastal Program amendments. While this section of the report presents a method of thinking about sea level rise from a "horizon" perspective, the City is more focused on the "geographic areas" and "critical assets" approach.

The years 2050 and 2100 are two planning horizons most often recommended in California. However, with this approach, there is increasing uncertainty over time in predicting the exposure level from sea level rise by a specific date in any location (Figure 4). There is a 1.2-foot range in projections for 2050 and up to a 3.3-foot range by 2100 on Humboldt Bay (NHE 2014).

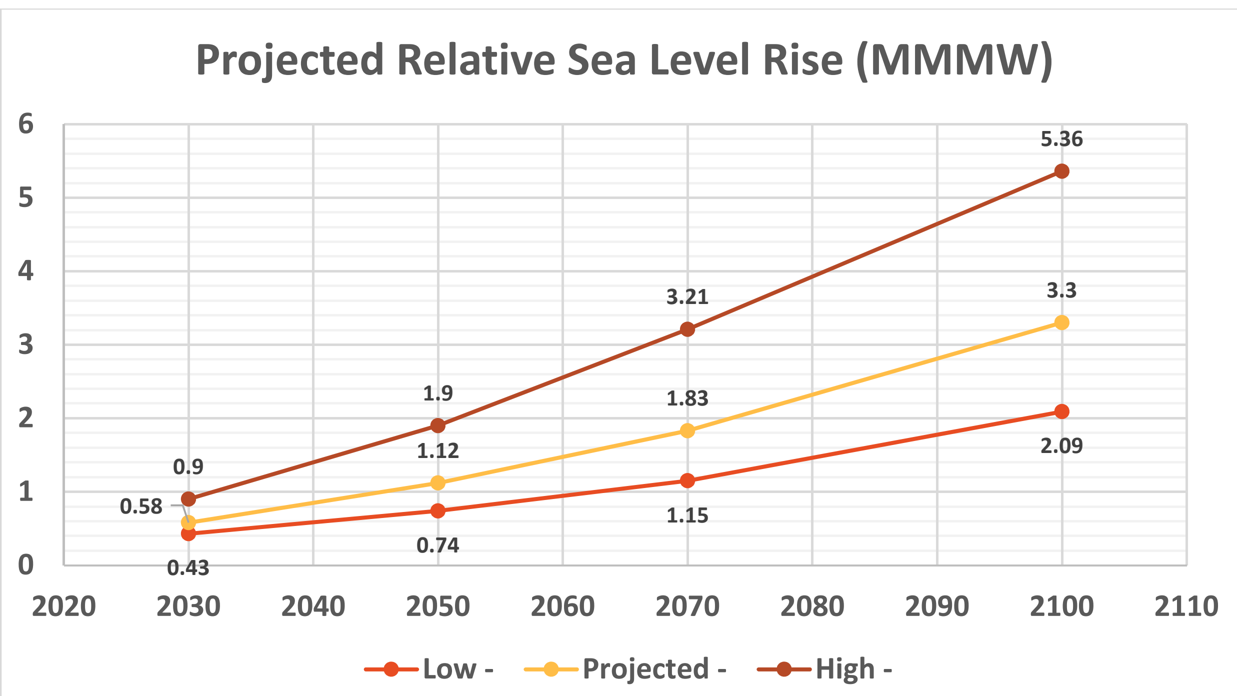

Figure 4. Relative sea level rise projections for four planning horizons (2030, 2050, 2070, and 2100), including low and high greenhouse gas emission scenarios (NHE 2014).

It may be more appropriate to target a specific benchmark for sea level rise, such as 2 feet and a specific elevation of 9.74 feet NAVD 88 for MMMW as measured at the north spit tide gage, regardless of whether it might be realized by 2050 as the high projection, or 2100 as the low projection. Either method would be useful for adaptation planning based on assets or geographic areas in the City's LCP jurisdiction. Currently, the state recommends utilizing the 2050 and 2100 planning horizons. Regionally on Humboldt Bay, MMMW has been selected as the datum for use in sea level rise adaptation planning.

Compounding adaptation planning based on a near-term planning horizon such as 2050 is the need to account for an asset's expected design life, or likely longevity and the projected sea level rise exposure it is may face. The design life/longevity of most existing utility and transportation infrastructure is greater than 50 years and would transcend the 2050 planning horizon. In fact, many existing facilities could exceed the 2100 planning horizon.

It is important to note that there is lengthy lead time for modifying or building utility and transportation infrastructure, often measured in decades. It is imperative that adaptation strategies, for utility and transportation facilities, and the measures to implement them, are initiated early to accommodate project funding, planning, engineering, permitting and construction. It is not too early to begin the adaptation planning process now for assets in SLRPA, preparing for increases in sea level rise greater than the proposed 2 feet benchmark.

By 2050, projections for relative sea level rise through 2100 will likely be updated. Shoreline conditions may have changed, and adaptation measures implemented could affect asset vulnerability and risk from sea level rise. Regularly revising the City's sea level rise asset vulnerability and risk assessment would be a sensible approach to keeping pace with changed conditions. It is important to identify and disseminate information today about potential SLRPA s for more than 2 feet, along with the corresponding assets that would be vulnerable and at-risk from these projected sea levels. It may be prudent for the City to plan on developing sea level rise adaptation goals, strategies and measures during its 2040 General Plan/LCP update for SLRPA beyond 2050.

Hazard Maps

The only "official" hazard flood elevations and maps that cover the lands surrounding Humboldt Bay are FEMA's FIRM. These FIRM depict special flood hazard areas

(SFHA), inundated by the 1% annual chance flood (Seemann 2016). New FIRM maps for Humboldt Bay were approved in November 2016. SFHA are composed of two zones, one where the ground elevation is lower than the base flood elevation (BFE) (100-year event stillwater) Zone AE (inundated by 1% annual chance flood, lower than BFE 10.2), and Zone VE (inundated by 1% annual chance flood, with additional wave-induced hazards) a combination of a BFE and waves. The new AE Zone BFE on Humboldt Bay is 10.2 feet NAVD 88. There are several VE zones in the City on Humboldt Bay that range in elevation from 13 to 18 feet NAVD 88. The City utilizes the FIRM to depict flood hazard areas in its General Plan and LCP.

However, there are no "official" state or federal sea level rise tidal inundation maps that the City may rely on to identify SLRPA. The City is undertaking an update to its LCP, which is a regulatory document. Incorporating SLRPA in its LCP will lead to creating a new "Coastal Zone" as the SLRPA that will impose new development restrictions. The City is concerned that property owners may attempt to hold the City responsible for using tidal inundation maps to depict SLRPA to encumber existing and future developments.

The development of state and/or federally-directed sea level rise tidal inundations maps for Humboldt Bay would help the City and other municipalities better plan for sea level rise. In lieu of official sea level rise tidal inundation maps, SLRPA based on low to high projections could be identified in the City by utilizing inundation maps that were produced from hydrodynamic modeling prepared for the Humboldt Bay Sea Level Rise Adaptation Planning Project (NHE 2015) (Table 4).

Table 4. Existing tidal inundation mapping projections that can be used to depict sea level rise planning areas for 2050 and 2100 projected sea level rise (NHE 2014, NHE 2015).

Projected Water Elevation	Projected Elevation in feet	Existing Mapping Resource
2050 **Low** Projected Water Elevation	0.74 (**8.48** feet NAVD 88)	2012 MAMW* (8.78 feet NAVD 88)
2050 **High** Projected Water Elevation	1.9 (**9.64** feet NAVD 88)	2000 plus 0.5 meters (9.38 feet NAVD 88)
2100 **Low** Projected Water Elevation	2.09 (**9.83** feet NAVD 88)	2000 plus 0.5 meters (9.38 feet NAVD 88)
2100 **High** Projected Water Elevation	5.36 (**13.1** feet NAVD 88)	2000 plus 1.5 meters (12.66 feet NAVD 88)

*Mean Annual Maximum Water

Both FEMA's FIRM and NHE's tidal inundation maps assume that non-certified shoreline structures (levees or dikes) do not protect the lands behind the shoreline from flooding or tidal inundation. The City could use FEMA's new official 2016 FIRM of Humboldt Bay (AE Zone BFE of 10.2 feet NAVD 88) as a surrogate SLRPA map for 2050 based on the high projection of 1.9 feet (MMMW of 9.6 feet NAVD 88), and as a surrogate SLRPA map for 2100 based on the low projection of 2.1 feet (9.8 feet NAVD 88). The City can also rely on the 0.5-meter (1.6 feet) tidal inundation maps prepared for Humboldt Bay by NHE to depict the high sea level rise projection for 2050 of 1.9 feet and low projection for 2100 of 2.1 feet, and the 1.5-meter (4.9 feet) map for the high projection of 5.4 feet by 2100. However, in the diked former tide lands areas of Eureka and Fay Slough, maps for 2050 and 2100 depict virtually the same area being tidally inundated (Figure 5); only the depth of inundation would vary by different sea level rise projections.

Figure 5. Eureka-Fay Slough potential sea level rise planning area for the high projection of 1.9 feet for 2050 (MMMW elevation of 9.64 feet NAVD 88). Based on 2000 plus 0.5 meter map layer (NHE 2015).

On Humboldt Bay, shoreline structures such as dikes are presently protecting thousands of acres from tidal inundation, independent of sea level rise. In the City and its PA, adaptation strategies and measures that can make shoreline structures more resilient to sea level rise could protect most of these lands and developments that are currently vulnerable and at risk from 2 feet or more of sea level rise. Successfully implementing a shoreline protection strategy in diked areas like Eureka and Elk River Sloughs could maintain the current tidal inundation area even with 2 feet of sea level rise or 2050 based on the high projection (Figure 6).

Figure 6. Current tidal inundation area and potential sea level rise planning area for the high projection of 1.9 feet by 2050 (MMMW elevation of 9.6 feet NAVD 88) if shoreline structures are enhanced in the Eureka-Fay Slough diked former tideland area, which is mostly in the City limits (black line).

The SLRPA maps that depict the high projection for 2100 will prove valuable as an educational tool to convey the magnitude of potential future vulnerability from sea level rise as they depict that landscape scale changes are possible, such as the tidal inundation of thousands of acres of diked former tidelands. It may be difficult for LCP authorities accustomed to 20-year planning cycles to contemplate now imposing land use restrictions based on projected conditions 84 years into the future, particularly relying on such a wide range of sea level estimates for 2100. Minimizing exposure of people and development to sea level rise, is a suitable goal for any planning horizon. However, adopting SLRPA maps, which is a regulatory function of updating a LCP, for 2100 given the wide range of sea level rise projections, could be considered speculative (Figure 7). The significant difference in SLRPA based on low versus high projections for 2100 may confound property owners from accepting justifications on why land uses and development should be encumbered with restrictions now based on just the high projection. Discounting the opportunity to adopt protective adaptation strategies or the effects of successfully implementing adaptation measures will also undermine confidence in the need for land use and development restrictions based on projections for 2100.

Figure 7. Potential sea level rise planning areas based on low projection of 2.1 feet (left, modified to eliminate isolated polygons not connected to shoreline) and high projection of 5.4 foot (right based on 2000 plus 1.5 meter map layer, NHE 2015) for 2100 along the City's waterfront.

2050-2.0 Feet of Sea Level Rise

In the City and its PA, there are several low-lying SLRPA s for 2050, based on the high sea level rise projection of 1.9 feet elevation, 9.6 feet (NAVD 88) for MMMW (Figures 8-11).

Figure 8. Potential sea level rise planning area from tidal inundation by MMMW elevation of 9.6 feet (NAVD 88) projected for 2050 of the Eureka-Fay Slough diked former tideland area and the City's boundary. At-risk assets include underground utilities, Jacobs Avenue commercial developments, Humboldt County's Murray Field airport, U.S. Highway 101, Harper Motors commercial property, California Redwood Company commercial property, a State wildlife refuge, Indianola commercial property, ESHA, coastal access, and agricultural zoned areas. Based on 2000 plus 0.5 meter map layer (NHE 2015).

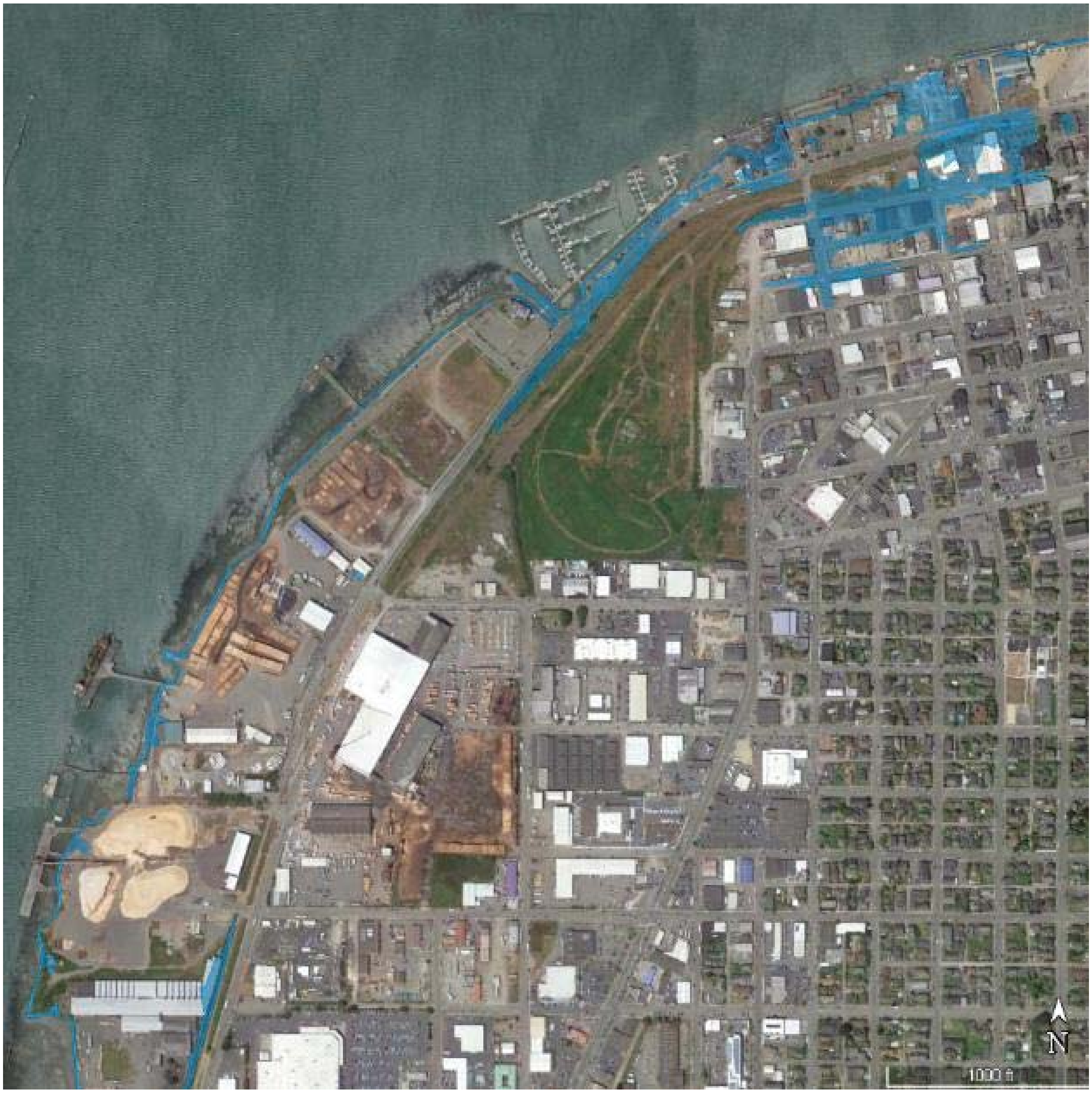

Figure 9. Potential sea level rise planning area from tidal inundation by MMMW elevation of 9.6 feet (NAVD 88) projected for 2050 for the City's waterfront area (isolated inundation polygons without pathways for inundation resulting from the bathtub modeling effect have been removed). At-risk assets include underground utilities, commercial fishing property/facilities, coastal access-public marina, public facilities, industrial property and commercial zoned areas south of Waterfront Drive. Based on 2000 plus 0.5 meter map layer (NHE 2015).

Figure 10. Potential sea level rise planning area from tidal inundation by MMMW elevation of 9.6 feet (NAVD 88) projected for 2050 for the waterfront area (isolated inundation polygons without pathways for inundation resulting from the bathtub modeling effect have been removed). At-risk assets include underground utilities, public recreational facilities, CDI property, ESHAs and the Humboldt Waste Management Authority's solid waste facilities west of Broadway Avenue. Based on 2000 plus 0.5 meter map layer (NHE 2015).

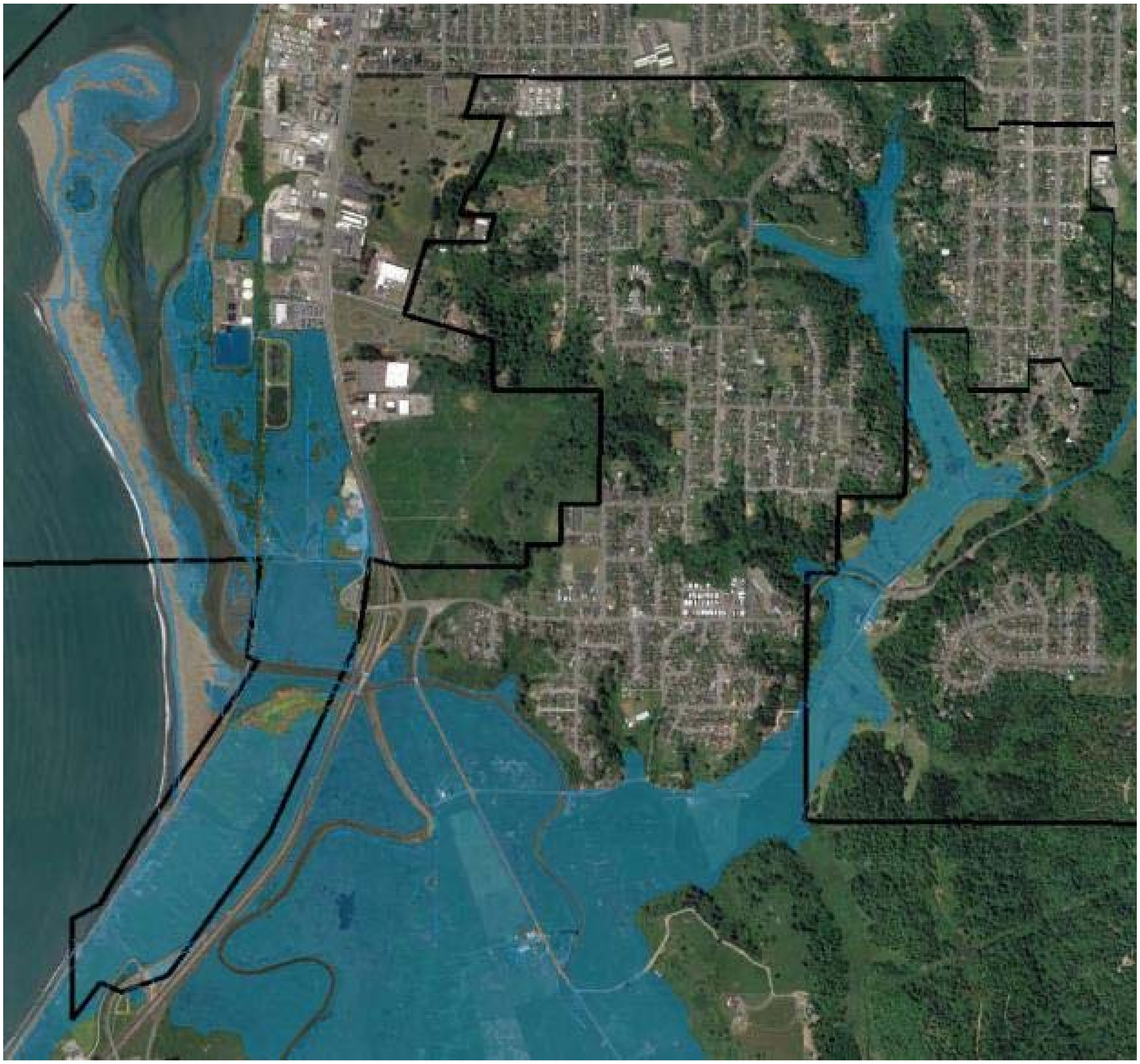

Figure 11. Potential sea level rise planning area from tidal inundation by MMMW elevation of 9.6 feet (NAVD 88) projected for 2050 for the waterfront, Elk River, Swain and Martin Slough diked areas with City's boundary (isolated inundation polygons without pathways for inundation resulting from the bathtub modeling effect have been removed). At-risk assets include CDI, commercial, public, and agricultural zoned areas, Highway 101, ESHAs (Elk River Spit and Slough), Hikshari Coastal Access Trail, and Elk River Regional Wastewater Treatment Facility, U.S. Highway 101 and local streets and roads. Based on 2000 plus 0.5 meter map layer (NHE 2015).

2100-5.4 Feet of Sea Level Rise

There is also a 2100 SLRPA located in the City, based on a high projection (5.4 feet) elevation of 13.1 feet (NAVD 88) for MMMW (Figure 12). Due to the confining topography, inland of the low-lying diked lands of Eureka Slough and Elk River Slough, the 2050 and 2100 SLRPA s occupy near-identical footprints (Figures 8 and 11).

Figure 12. Potential sea level rise planning area from tidal inundation by MMMW elevation of 13.1 feet (NAVD 88) a high projection of 5.4 feet for 2100 along the City's waterfront from the wastewater treatment facility north to U.S. Highway 101 at the Eureka Slough Bridge. Based on 2000 plus 1.5 meter map layer, NHE 2015.

2.2.1 Planning Horizon Adaptation Goals

Protecting people, development, and the environment from coastal hazards is a principle goal of the City, for any planning horizon or sea level rise elevation. Adaptation planning time horizons based on sea level rise projections could be linked to the City's current and future LCP updates. Between now and 2040 (the current LCP update's time frame), development could be designed for conditions expected to occur by 2050 (0.7 to 1.9 feet of sea level rise). While the next LCP update in 2040 could consider conditions expected to occur between 2050 and 2100 (2.1 to 5.4 feet of sea level rise) (ESA 2016).

2050

In general, an adaptation goal for the 2050 planning horizon or for approximately 2 feet of sea level rise (MMMW of 9.6 feet NAVD 88) would be to plan for and mitigate vulnerability and risk from sea level rise to current and future land uses and developments. The goals described in section 2.1.1 for high priority assets: utility, transportation, and coastal resource assets are also applicable to support adaptation planning in the City based on the 2050 planning horizon, or for when 2+ feet of sea level rise may occur. These goals include:

- Maintain reliable and economical delivery of all utility services;
- Retain local, regional, and inter-state transportation capabilities;
- Accommodate and support future growth; and
- Protect public access, recreational opportunities, environmentally sensitive habitats, natural shorelines and beaches, and cultural resources.

However, the land use asset goals based on the state's recommendations described in section 2.1.1 may not be consistent with the City's overall general plan goal to accommodate and support future growth if applied to the 2050 planning horizon, or for locations where 2+ feet of sea level rise may occur. Shoreline structures currently protect land uses and development that are vulnerable to 2 feet of sea level rise. Adopting a protection strategy to enhance these shoreline structures could enable these structures to continue to protect land uses and developments from 2+ feet of sea level rise. A more appropriate land use goal for these vulnerable areas would be to protect land uses and development from sea level rise of 2+ feet, where feasible. In the City and its PA, protective adaptation strategies and measures can sustain existing land uses through 2050 or 2+ feet of sea level rise.

2100

A suitable means to address land use goals for 2050 to 2100 could be to reassess sea level rise projections in the next LCP update of 2040, and then consider appropriate land use goals if projections confirm that 3+ feet of sea level rise is likely between 2050 and 2100. Independent of the level of sea level rise projection for 2050 to 2100, the goal of protecting land uses and development from sea level rise, where feasible, will be preferred by the City. If that goal is no longer appropriate in 2040, then a goal that relocates existing land uses and developments would have to be considered. A goal that would disallow land uses or developments in the SLRPA projected for 2100 that will need to be protected from sea level rise would also be needed.

2.2.2 Planning Horizon Adaptation Strategies and Measures

To summarize, the City's overarching goal for 2050 is to protect land uses and developments from tidal inundation now and from sea level rise of up to 2 feet. The City would defer adopting goals for sea level rise greater than 2 feet (i.e. 2100) to its 2040 LCP update.

The adaptation strategies most applicable through 2050 or for 2 feet of sea level rise would first be protection and later accommodation. Both enable land uses and development to remain where they are presently located. These strategies are particularly appropriate for existing assets: land uses and developments, utilities and transportation infrastructure, and coastal resources. Adaptation strategies post 2050 or for more than 2 feet of sea level rise would likely transition from protection and accommodation to retreat for existing assets and avoidance for new assets.

Protection Strategies

Protection strategies include:

- Addressing shoreline vulnerability and risk for entire discrete hydrologic units (Figure 13).
- Making vulnerable shoreline reaches that have been rated high (Figure 14) more resilient to sea level rise to protect land uses and developments within a hydrologic unit from tidal inundation.
- Enhancing the resiliency or vulnerability rating of all shoreline reaches to protect land uses and developments from 2 to 3 feet of sea level rise.

- Creating muted tide cycles on Eureka and/or Elk River Sloughs to reduce vulnerability and risk from tidal inundation.

Figure 13. Eureka-Fay Slough hydrologic area (white boundary) has 3.1 miles of diked shoreline that need to be elevated, and potential tidal inundation area (blue shading). Based on 2000 plus 0.5 meter map layer (NHE 2015).

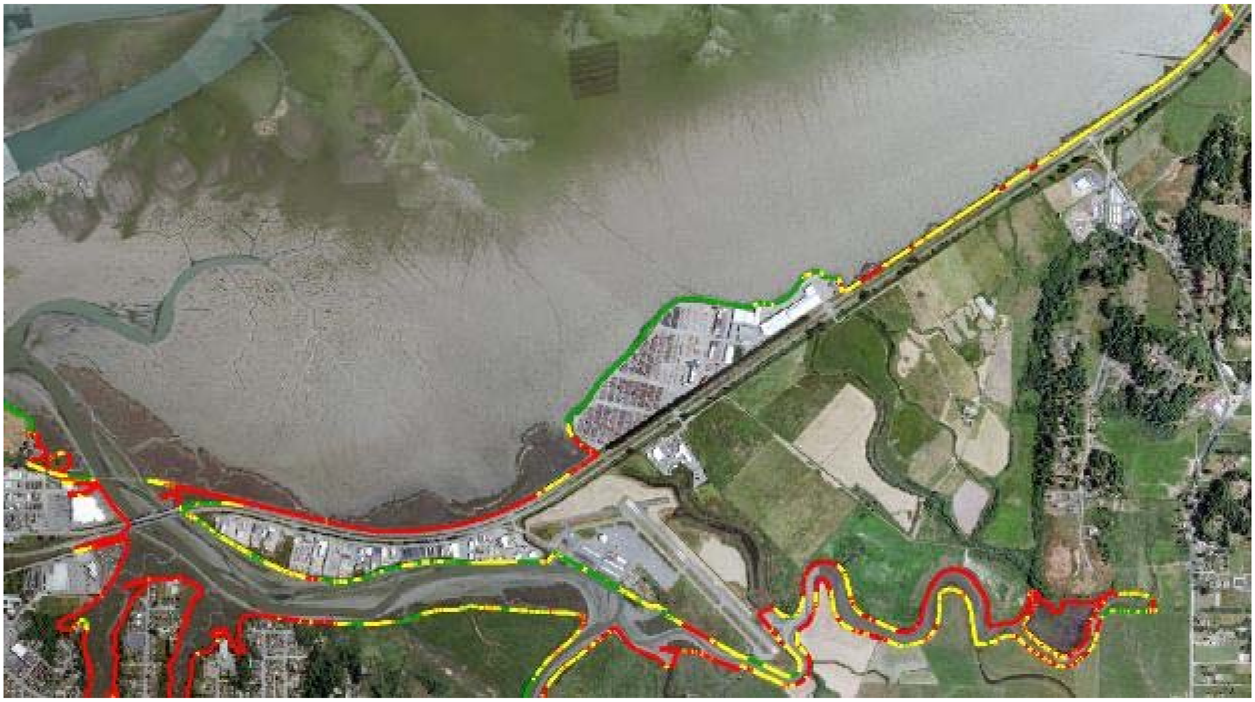

Figure 14. Shoreline vulnerability assessment rating of Eureka-Fay Slough hydrologic unit: high (red), moderate (yellow), and low (green) (Laird 2013). Most the vulnerable shorelines on Eureka-Fay slough that are rated high are on public lands.

Protection Measures

Protection measures include:

- Increasing the height of shoreline structures for the entire length of a hydrologic unit to approximately 11 feet (NAVD 88) or more to protect lands behind shoreline structures that are lower than FEMA's BFE of 10.2 feet with 1 foot of free board and from up to 3.2 feet of sea level rise, the high projection for 2070.
- Relocating shoreline structures landward to create a living shoreline of salt marsh to afford protection from wave induced erosion and overtopping.
- Adopting a SLRPA for 2 feet of predicted sea level rise (MMMW of 9.6 feet NAVD 88), referenced to FEMA's FIRM AE flood zone and BFE of 10.2 feet.
- Utilizing FEMA siting and building standards to mitigate vulnerability and risk to land uses and developments from approximately 2.5 feet of sea level rise (10.2 feet NAVD 88) in AE zones.
- Utilizing Humboldt County Flood Control District to secure funds to design, permit, elevate and maintain shoreline structures or a certified levee system.

- Creating a federally certified coastal levee system (minimum of ~11 feet (10.2 foot BFE plus 1.0 freeboard) (NAVD 88) on vulnerable hydrologic units with high priority assets, such as Eureka-Fay Slough could offer protection for people and property through 2070 based on a high sea level rise projection of 3.2 feet.

Accommodation Strategies

Increasing the elevation of shoreline structures, such as dikes, can protect land uses and development behind these structures from sea level rise of 2 to 3 feet. As sea levels rise, so to do mean low tide elevations. Tide gates associated with shoreline dikes, levees, and stormwater outlets will experience reduced capacity to drain stormwater runoff. Impounding stormwater runoff or elevated groundwater behind protective shoreline structures like dikes or tide gates may result in flooding of land uses and developments. Rising sea levels will impede stormwater runoff likely causing backwater flooding upstream of outlet structures on the shoreline of Humboldt Bay. Additional accommodation strategies include:

- Enhancing drainage capacity of lands vulnerable and at risk from tidal inundation due to sea level rise to reduce their flooding.
- Increasing the elevation of lands vulnerable and at risk from tidal inundation due to sea level rise to reduce their flooding.

Accommodation Measures

Accommodation measures include:

- Increasing drainage capacity of dikes and levees and stormwater outlets to accommodate 2 to 3 feet of sea level rise (2050 to 2070 based on high projections) by upgrading existing and installing more water control structures to increase the volume and extend duration of drainage.
- Installing pumps to accelerate drainage of stormwater behind shoreline structures.
- Creating stormwater runoff detention basins to attenuate backwater flooding upstream of stormwater outlets.
- Import fill to increase the elevation of land vulnerable and at risk from tidal inundation and flooding.
- Constructing a tidal dam at the entrance to Eureka and/or Elk River Sloughs to mute tide cycles and reduce vulnerability and risk from tidal inundation.

2.3 Geographic Areas

A third, and the City's preferred adaptation planning approach, focuses on uniform geographic areas, or landscapes that are similarly vulnerable and at-risk under present conditions as well as from future sea level rise, such as diked former tide lands and the urban waterfront that is vulnerable and at-risk from seal level rise. In the City and adjacent PA, there are three separate geographic areas with similar topography, hydrology, and development that are conducive to developing adaptation goals and strategies to address common aspects of their vulnerability and risk from sea level rise: Eureka Slough, the waterfront, and Elk River Slough (Figure 15). Section III of the Addendum outlines additional potential adaptation strategies in sub-areas of these three geographic areas.

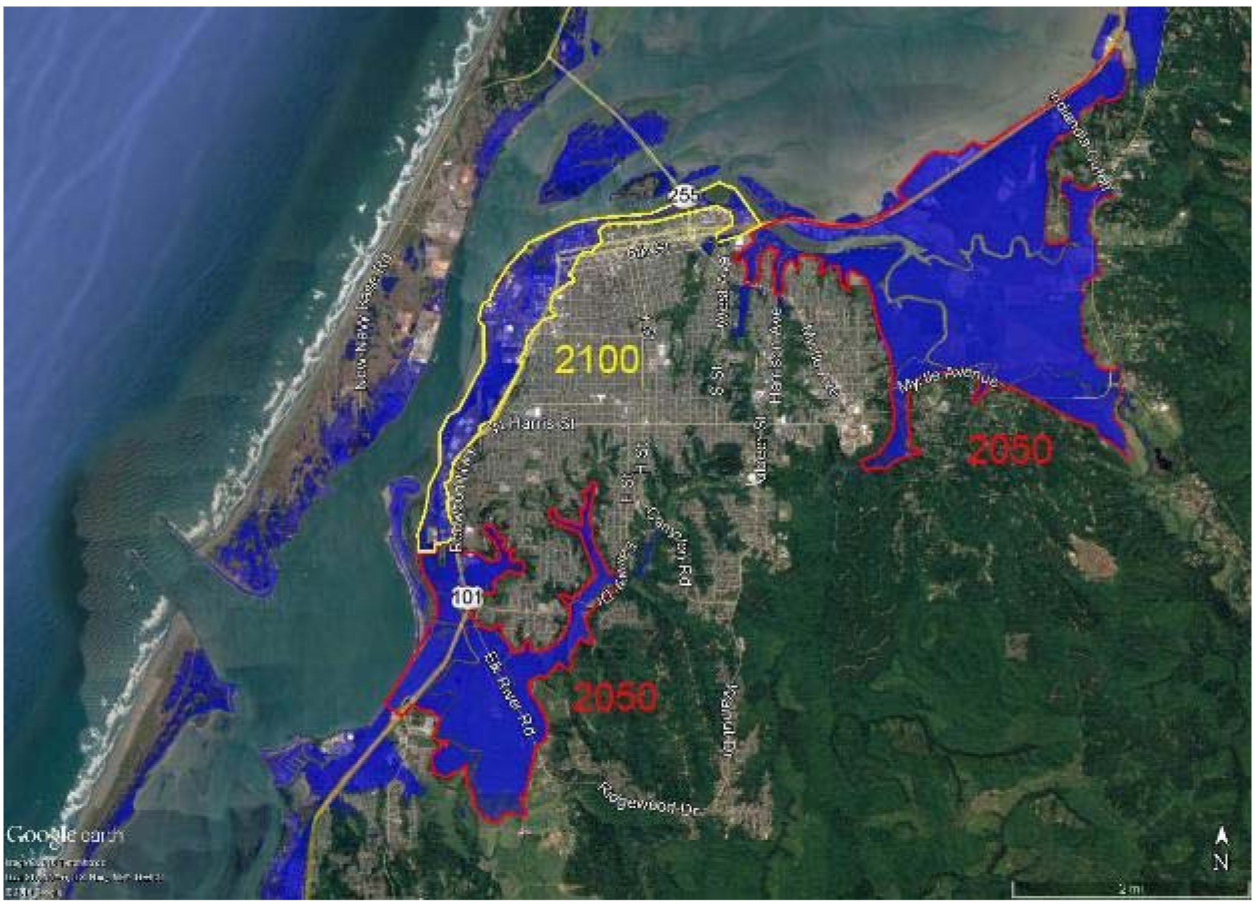

Figure 15. City of Eureka and Planning Area geographic units, Eureka and Elk River Sloughs (red boundary), and Waterfront (yellow boundary), depicting the SLRPA for 2050 and 2100. Based on 2000 plus 0.5 and 1.5 meter map layers (NHE 2015).

Both Eureka Slough and Elk River Slough hydrologic areas are vulnerable and at risk now if dikes are breached or from 2 feet of sea level rise that would overtop a significant length of the dikes (2050). Most of the waterfront area is vulnerable and at risk from 3 to 5 feet sea level rise that is projected to occur between 2050 and 2100.

While outside the City's LCP jurisdiction but within its PA, there are also several geographically discrete communities that are vulnerable and at-risk from sea level rise: King Salmon (by 1 foot of sea level rise based on the high projection for 2030), Fields Landing (by 1 to 2 feet of sea level rise based on the high projections between 2030 to 2050), and Fairhaven (by 3 to 5 feet of sea level rise based on the high projections between 2070 to 2100). These residential communities reside in the unincorporated area of Humboldt County and are subject to the County's HBAP and are mostly under the State's retained jurisdiction.

When addressing vulnerable geographic areas, adaptation planning could benefit from a collaborative stakeholder group consisting of direct asset/property owners, asset/property owners who are affected or derive benefits from the asset, LCP and regulatory authorities, and, if possible, funding agencies. Successful implementation of adaptation strategies and measures will likely require partnerships among affected stakeholders.

2.3.1 Diked Lands

As discussed previously, dikes on Humboldt Bay are protecting thousands of acres of former tidelands and many high priority assets (utilities, transportation, and coastal resources) now from tidal inundation. However, these diked former tide lands and priority assets are particularly vulnerable and currently at-risk from tidal inundation if existing shoreline dike structures were to fail. Successfully implementing a shoreline protection strategy in these diked areas could maintain the current tidal inundation area through 2050 based on the high projection of 2 feet of sea level rise. If not these diked areas and priority assets that are protected by dikes would become tidally inundated when the dikes are breached or overtopped (Figure 16).

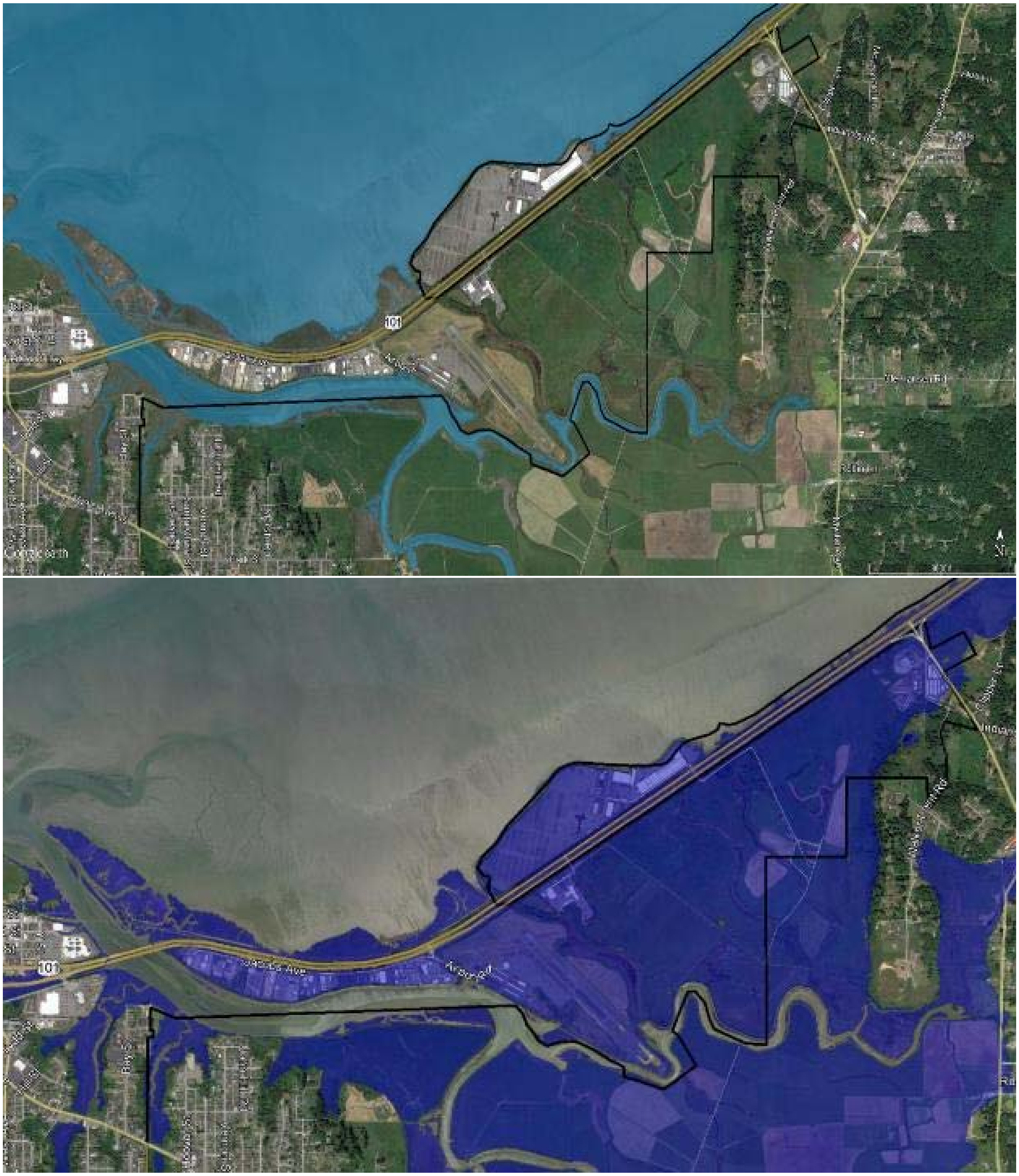

Figure 16. Areas that would be tidally inundated with shoreline dikes intact (above, MHW) versus potentially tidally inundated areas if shoreline dikes are breached or overtopped (below based on 2000 plus 0.5 meter map layer, NHE 2015).

In the City and its PA, there are two low-lying SLRPA s for 2050 or 2 feet of sea level rise, if the shoreline structures are breached/overtopped that are discrete hydrologic areas: Eureka Slough (composed of the Eureka-Fay Slough sub-unit, Fay-Freshwater Slough sub-unit and Ryan Slough sub-unit) (Figure 17), and Elk River (composed of the Elk-Swain Slough sub-unit and Swain-Martin Slough sub-unit) (Figure 18).

Figure 17. Eureka Slough (Eureka-Fay-Freshwater-Ryan Sloughs) diked former tidelands area (white line) that could become tidally inundated now and through 2050 or from 2 feet of sea level rise, unless existing dikes elevations are increased. Based on 2000 plus 0.5 meter map layer (NHE 2015).

Figure 18. Elk River Slough (Elk-Swain-Martin Sloughs) diked former tidelands area (white line) that could become tidally inundated now and through 2050 or from 2 feet of sea level rise, unless existing dikes elevations are increase. Based on 2000 plus 0.5 meter map layer (NHE 2015).

These diked former tide land areas protect several high priority assets such as utilities owned by both the City and the Humboldt Community Services District (HCSD) including waste water collection systems, municipal water transmission pipelines, pump station, and wells. Additional utility assets in these areas include natural gas transmission lines, electrical transmission towers and distribution poles, optical fiber lines. There is also infrastructure for multiple modes of transportation including local streets and roads, Murray Field Airport, Highway 101, NCRA railway, and extensions of the City’s Waterfront Trail and the County’s Bay Trail. Priority land uses and coastal resources in these areas include: commercial developments, agricultural lands, ESHAs (Aleutian goose grazing habitat, seasonal freshwater and brackish wetlands, and riparian habitat) and DFW’s Fay and Elk River Wildlife Refuges.

The City's asset vulnerability and risk assessment found on Eureka and Elk River Sloughs that there is a tipping point when the effects of 2+ feet of sea level rise may quickly become dramatic if dikes are overtopped. This tipping point could occur by 2050 when the high projection of 1.9 feet may reach 9.6 (MMMW) to 10.7 feet (MAMW) or any year that an extreme 100-year event of 10.2 (NAVD 88) were to occur. The highest water level recorded on Humboldt Bay was 9.55 feet (NAVD 88) in 2005, and the Governor declared a state of disaster on Humboldt Bay. In approximately 30+ years, the future MMMW (9.64 feet NAVD 88) is projected to exceed the current extreme tide of record (Figure 19). However, reaching the tipping point could be delayed until as late as 2100 based on the low projection of 2.1 feet of sea level rise.

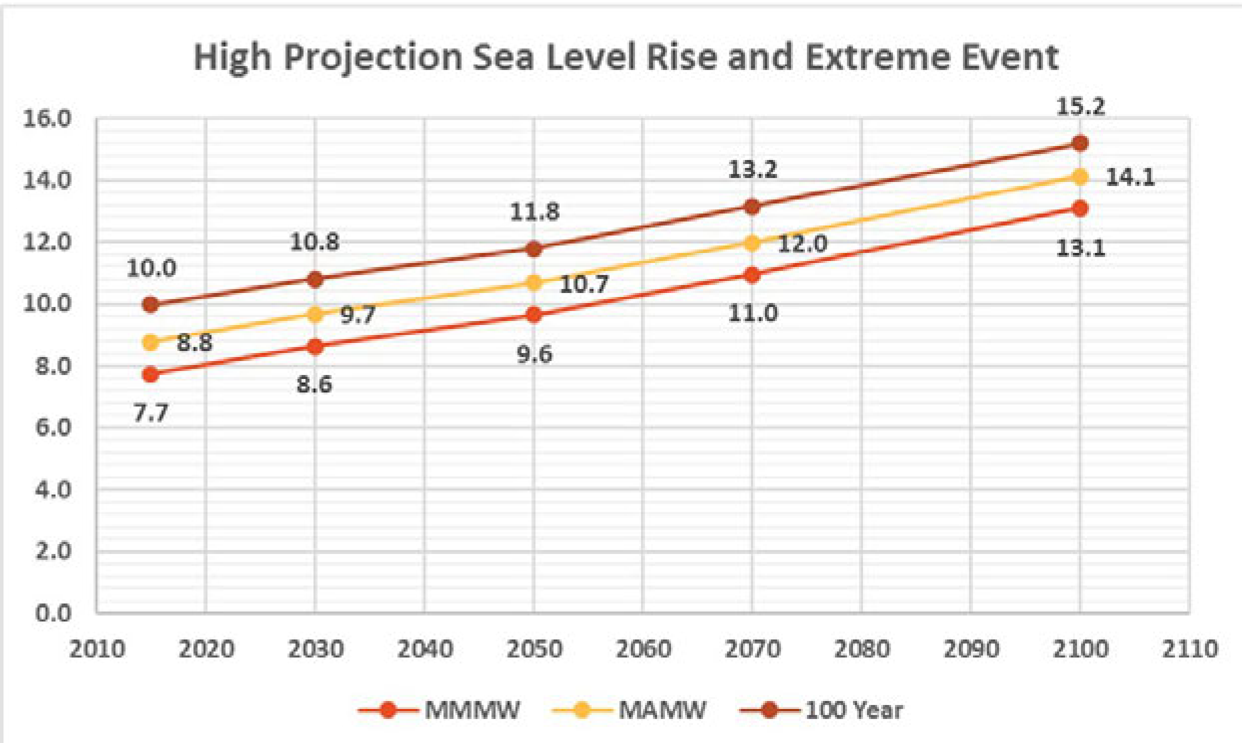

Figure 19. Relative sea level rise estimations for high greenhouse gas emission scenario for mean monthly maximum water (spring tides), mean annual maximum water (king tides), and 100-year extreme storm events (NHE 2014).

A less dramatic tipping point on diked former tidelands would result from the rising elevations of low tides. As low tides rise 2 to 3 feet, existing water control structures will become impaired with reduced drainage capacity and increased duration necessary to drain stormwater runoff, and eventually will likely result in permanent ponding behind dikes. Groundwater behind dikes will also rise in response to rising sea levels and contribute to saturated conditions and flooding that will adversely affect vegetation, land uses and developments.

In the Eureka Slough, hydrologic area, there is a Eureka-Fay Slough sub-unit, which is primarily within the City's jurisdiction (Figure 13) that is vulnerable and at-risk now and from sea level rise (Figure 14). This sub-unit has a diverse assemblage of high priority asset interests and property owners (30+). The most vulnerable reaches of shoreline rated high are located on lands owned by the State and County, which should facilitate developing and implementing a unified adaptation strategy and protection measures. There is a need for a unified and collaborative stakeholder driven planning effort to understand property/asset management goals, adaptation strategies and measures and to develop adaptation projects to increase the resiliency of shoreline structures and extend the sustainability of these critical assets and land uses in the face of sea level rise. The adaptation plan for the Eureka-Fay slough sub-unit could lead to developing greater awareness of the community's vulnerability and risk to sea level rise as well as gaining an understanding of potential adaptation strategies and measures. The remainder of Eureka Slough resides in Humboldt County's HBAP jurisdiction. The adaptation goals, strategies and measures that the City proposes for diked lands in its LCP would be equally applicable on the diked lands in the County's HBAP jurisdiction. Again, all the diked lands on Humboldt Bay are under the State's retained jurisdiction with land uses and development subject to the policies in Chapter 3 of the Coastal Act.

On Elk River Slough, in the City's LCP jurisdiction, there are essentially no dikes. In fact, the few existing dikes along the banks of the lower Elk River in the City are currently slated for removal to enhance the estuary of Elk River. There are diked former tidelands in the City's LCP on Martin Slough, but the diked shoreline protecting this area is on Swain Slough in the County's HBAP jurisdiction. Therefore, the City proposes to defer to Humboldt County and the Coastal Commission to address adaptation for diked shorelines and lands that are vulnerable and at risk from sea level rise on Elk River.

Determining who owns, is responsible for, is dependent upon or uses the services provided by a critical asset at-risk in each geographic area will likely identify who should be involved in selecting appropriate adaptation strategies, developing feasible adaptation options, and securing funds for implementing these options. For example, with diked former tidelands, forming an adaptation planning group solely based on property ownership of the protective shoreline structures would be insufficient to identify all the stakeholders associated with and benefiting from the protection that the diked shoreline structures provide. These diked lands highlight a situation common to Humboldt Bay where property, structures, or resources are being protected from sea level rise by shoreline structures located on property not owned or controlled by the beneficiary of these protective structures. The diked shoreline on Eureka and Elk River

Sloughs traverse and protect both private and publicly owned property, assets, utilities, and transportation corridors.

Diked Lands Adaptation Goals

The goals described in section 2.1.1 for the high priority assets that are located on diked lands (utility, transportation, and coastal resource assets) are also applicable to support adaptation planning on diked lands for 2 feet of sea level rise, including:

- Maintaining reliable and economical delivery of all utility services;
- Retaining local, regional, and inter-state transportation capabilities;
- Accommodating and support future growth; and
- Protecting public access, recreational opportunities, environmentally sensitive habitats, natural shorelines and beaches, and cultural resources.

The City's goals specifically for its diked lands is to:

- Protect people, land uses and development by enhancing the diked shoreline and mitigating existing vulnerability and risk from tidal inundation.
- Protect people, land uses, development and the environment from 2 feet of sea level rise (MMMW of 9.6 feet NAVD 88) where feasible given the physical limitations of these former tidelands.

The land use asset goals based on state recommendations described in section 2.1.1 are restrictive and potentially unnecessary if applied to diked lands before 2 feet of sea level rise may occur. Shoreline structures currently protect land uses and development that are vulnerable now and from any sea level rise. Adopting protective strategies that enhance these shoreline structures could enable these structures to continue to protect land uses and developments from 2 feet of sea level rise. As mentioned earlier under planning horizons, these restrictive land use goals also conflict with the City's overall general plan goal to accommodate and support future growth.

When the diked lands protection goal is no longer appropriate, based on revised and hopefully more certain sea level rise projection of more than 2 feet, an updated goal that addresses relocating existing land uses and developments could be considered.

Diked Lands Adaptation Strategies and Measures

To restate, the City's current overarching goal is to protect land uses and developments from tidal inundation now and from sea level rise of up to 2 feet. The City would defer adopting a goal for sea level rise greater than 2 feet until its 2040 LCP update when projections for sea level rise by 2100 will be reassessed based on the best available science for Humboldt Bay at that time.

The adaptation strategies most applicable for diked lands for 2 feet of sea level rise would be protection and accommodation. These strategies are particularly appropriate for existing assets: land uses and developments, utilities and transportation infrastructure, and coastal resources.

Adaptation strategies for more than 2 feet of sea level rise would likely transition from protection and accommodation to retreat for existing assets and avoidance for new assets. The protection strategies, protection measures, accommodation strategies, and accommodation measures for diked lands are the same as those presented in Section 2.2.2 for planning horizon adaptation strategies.

2.3.2 Waterfront

The SLRPA for 2100 covers the City's waterfront, another discrete geographic area (composed of the waterfront and Bayshore shoreline reaches). The SLRPA for 2100 is based on the high projection of 5.4 feet of sea level rise with MMMW elevation of 13.1 feet (NAVD 88) (Figure 22).

Figure 22. Waterfront (red line) and Bayshore Shoreline (gold line) areas that could become tidally inundated by 5.4 feet of sea level rise during MMMW, which is predicted to occur by 2100 based on the high projection. Based on 2000 plus 1.5 meter map layer (NHE 2015).

The City's waterfront SLRPA is vulnerable to sea level rise that is greater than 2 feet, which is predicted to occur as the high projection by 2050 and possibly not until 2100 based on the current low projection. The City's urban waterfront area does contain several high priority assets, Historic Old Town District, coastal dependent industrial properties and dock facilities, industrial, and commercial lands, utilities (waste water treatment plant, waste water collection system, municipal water transmission pipeline and pump station, bulk fuel terminal, stormwater collection and discharge system, electrical sub-station and distribution system, optical fiber lines, and solid waste transfer facilities) transportation infrastructure (local streets, Highway 101, Port facilities, NCRA railway, and the soon to be completed Waterfront Trail) and commercial/recreational fishing marina and processing facilities, land uses (CDI property and bulk cargo docks, industrial and commercial property), and coastal resources (ESHA, public access, recreational dock and waterfront facilities). The adaptation strategies for these assets are discussed further in Section 2.1.

2050, or 2 feet of Sea Level Rise

Historically, much of the waterfront was created by placing fill in the Bay and fortifying the shoreline (Figure 23). Existing shoreline vulnerability, based on elevation and susceptibility to overtopping by 2 feet increase in water elevation, above MMMW (7.7 feet) and/or an eroding shoreline, has been recently mapped (Figure 24). The built-up shoreline of the waterfront area could be elevated, and eroded and unfortified segments fortified to protect landward developments from sea level rise.

Figure 23. Much of the waterfront area was created by placing fill in the Bay and fortifying its shoreline (blue), there a few shoreline segments that were not fortified and are eroding (red) and other shoreline segments that are unfortified but not eroding (green) (Laird 2013).

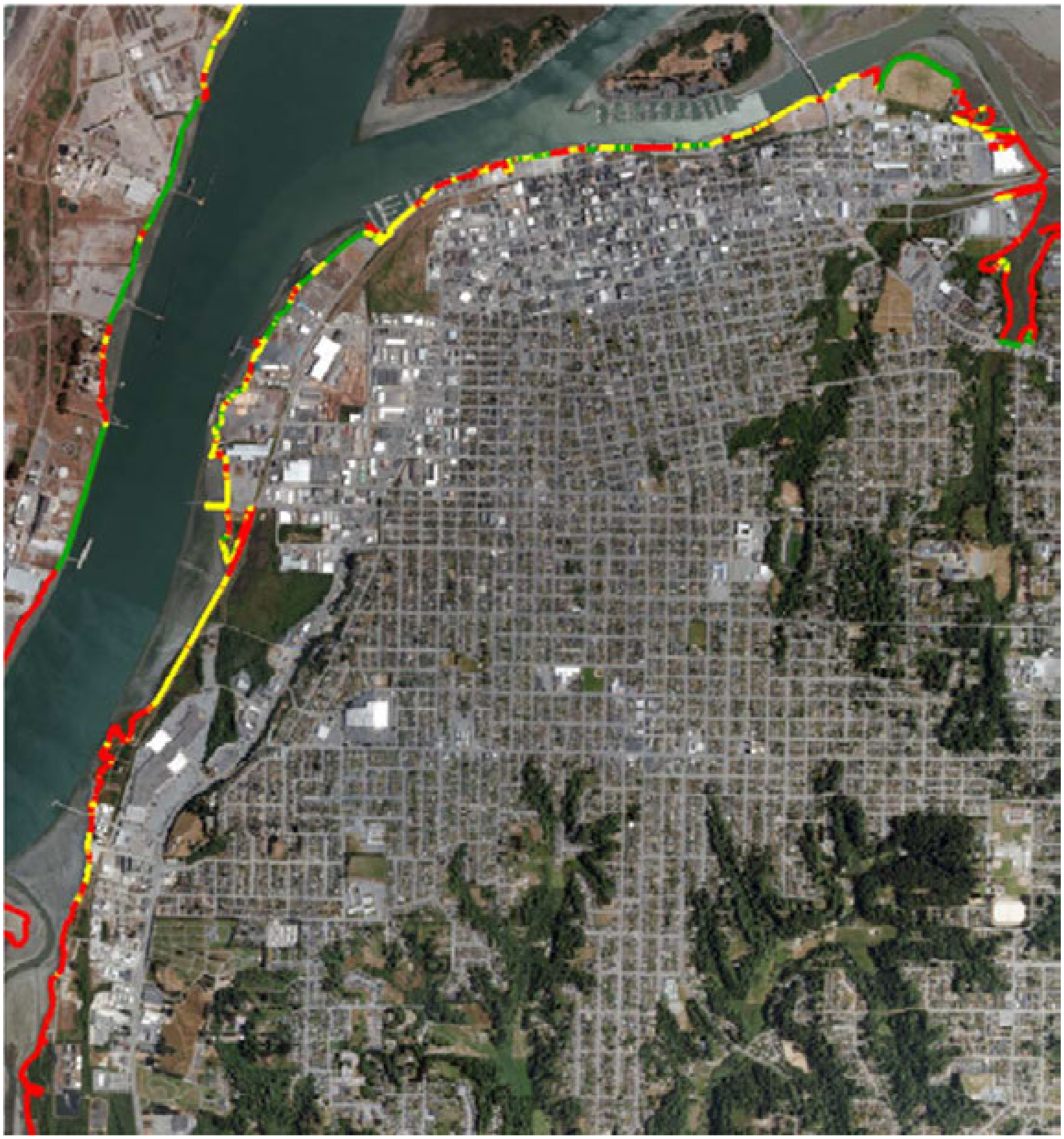

Figure 24. Shoreline vulnerability assessment rating of waterfront area: high (red), moderate (yellow), and low (green) (Laird 2013).

By 2050 or from 2 feet of sea level rise, only a few areas in the waterfront area will be tidally inundated (PALCO marsh) interior of the NCRA railroad and Waterfront Trail, which forms the Bay's shoreline. With 2 feet of sea level rise, a portion of the Chevron bulk fuel terminal property, the City's marina property and Waterfront Drive, short segments of the shoreline on Commercial fishing property, adjacent City streets are likely to become tidally inundated if adaptation measures are not implemented (Figure 25).

Figure 25. Existing tidally inundated waterfront undeveloped areas (left) and potentially inundated developed areas with 2 feet of sea level rise (right), (isolated inundation polygons without pathways for inundation resulting from the bathtub modeling effect have been removed), the high projection for 2050. Based on 2000 plus 0.5 meter map layer (NHE 2015).

As Eureka's Waterfront Trail is completed it will form a new shoreline in many locations and help protect interior areas from 2 feet of sea level rise from Elk River to Eureka Slough.

The results of the vulnerability and risk assessment for the high projection of sea level rise by 2050 indicate that the extent of tidal inundation of urban land use zones in the City's waterfront is not significant. Urban land use developments are supported by a multitude of utilities and infrastructure that are in turn themselves vulnerable and at risk from sea level rise. With 2 feet of sea level rise the regional waste water collection system and therefore the waste water treatment facility that supports urban land uses could start experiencing inflow/salt water intrusion impacts when lift stations (6 of 51) and sewer lines in the Waterfront area may become tidally inundated. Any impairment of the wastewater collection system and/or the wastewater treatment facility could potentially affect nearly all development in the City and in HCSD, which shares use of the treatment plant. With the storm water system, in the waterfront area there are 12 storm water basins with 20 outfalls and 4 tide gates that unless modified may not be fully functioning with 2 feet of sea level rise, potentially resulting in backwater flooding of the waterfront and inland urban areas during high tides. The only operating bulk fuel terminal for the Humboldt Bay region is located on the City's waterfront and may need additional protection by 2050 when MMMW could reach 9.6 feet and MAMW 10.7 feet (NAVD 88).

With 2 feet of sea level rise, 2 commercial fishing properties and the City's marina on the waterfront could become tidally inundated. The piers anchoring commercial and recreational boating docks on the waterfront may also need to be extended to mitigate 2 feet of sea level rise or the docks could float off during MAMW, king tides.

2100, or 2 to 5.4 feet of Sea Level Rise

As described earlier, in the City's waterfront area there are significant differences in SLRPA based on low versus high projections for 2100 (Figure 26). While not part of the City's urban waterfront, most of the developed portion of Woodley Island and marina are not vulnerable or at risk from the high sea level rise projection for 2100.

Figure 26. Potential sea level rise planning areas based on low projection of 2.1 feet (left, modified to eliminate isolated polygons not connected to shoreline) and high projection of 5.4 foot (right based on 2000 plus 1.5 meter map layer, NHE 2015) for 2100 along the City's waterfront.

Compared to the potential effects of 2 feet of sea level rise on the waterfront, the number of high priority assets and urban property that are potentially vulnerable and at risk to the high projection for sea level rise of 5.4 feet increases significantly. For example, if adaptation strategies and measures are not employed as much as 93% of the Coastal Dependent Industrial lands and developments as well as local streets servicing these waterfront properties are projected to be tidally inundated, along with 7 of 8 commercial fishery docks, facilities, and properties are projected to be tidally inundated. If left untreated 20 of the currently open contaminated sites may become tidally inundated (Laird 2016). The potential magnitude of change from 3 to 6 feet of sea level rise on Humboldt Bay is of sufficient significance that a regional LCP adaptation planning effort by the Cities of Eureka, Arcata, and Humboldt County and others on Humboldt Bay may be needed.

Waterfront Adaptation Goals

The successful achievement of the City's goals is particularly important for the future of the City's waterfront.

- Protect people, land uses, and development by enhancing the shoreline and mitigating existing vulnerability and risk from tidal inundation where feasible.
- Protect people, development, and the environment from 2 feet of sea level rise (MMMW of 9.6 feet NAVD 88).

Protection Strategies

Protection strategies for the waterfront include the following actions:

- Make vulnerable artificial shoreline reaches more resilient to sea level rise to protect land uses and developments from tidal inundation;
- Enhance the resiliency of all shoreline structures to protect land uses and developments from 2 feet of sea level rise;
- Recognize the uncertainty of sea level rise projections for 2050 to 2100.
- Update the City's LCP Safety Element as necessary to incorporate the best available science of sea level rise projections;
- Utilize Humboldt County's Hazard Mitigation Plan to help reduce the level of risk to people, development, and the environment from tidal inundation;
- Re-assess sea level rise projections in the next LCP update of 2040; and consider appropriate land use goals if projections confirm that 3 or more feet of sea level rise is likely between 2050 and 2100.

Protection Measures

Protection measures for the waterfront include the following actions:

- Increase the height of shoreline structures for the entire length of the waterfront to approximately 11 feet (NAVD 88) or more to protect lands behind shoreline structures that are lower than FEMA's BFE of 10.2 feet with 1 foot of free board and from up to 3.2 feet of sea level rise, the high projection for 2070.
- Utilize FEMA siting and building standards to mitigate vulnerability and risk to land uses and developments in the FIRM AE zones and City's SLRPA; and
- Disclose in real estate transactions whether properties are in a SLRPA and that they are potentially vulnerable and at risk from tidal inundation.

Accommodation Strategies

Accommodation strategies for the waterfront include:

- Increasing the elevation of waterfront lands vulnerable and at risk from tidal inundation due to 2 feet of sea level rise; and
- Enhancing stormwater runoff capacity to protect land uses and developments from backwater flooding.

Accommodation Measures

Accommodation measures for the waterfront include the following actions:

- Import fill to increase the elevation of land vulnerable and at risk form tidal inundation and flooding;
- Increase drainage capacity of stormwater outlets to accommodate 2 to 3 feet of sea level rise (2050 to 2070 based on high projections) by upgrading existing and installing more water control structures to increase the volume and extend duration of drainage;
- Install pumps to accelerate drainage of stormwater behind shoreline structures; and
- Create stormwater runoff detention basins to attenuate backwater flooding upstream of stormwater outlets.

3 CONCLUSIONS

The City's sea level rise adaptation planning report is a culmination of a regional planning effort that began in 2010 on Humboldt Bay. The regional effort inventoried, mapped, and assessed the vulnerability of the shoreline on Humboldt Bay and found that the diked shoreline comprises much of the artificial shoreline and is already vulnerable to breaching and to overtopping during MAMW or king tides. The relative sea level rise projections (CG 2014 and NHE 2014) and tidal inundation maps (NHE 2015) prepared for the lands around Humboldt Bay have been invaluable to the City in its efforts to assess the vulnerability and risk of assets in its jurisdiction and in its PA. The City's sea level rise asset vulnerability and risk assessment (Laird 2016) identified high priority assets in its LCP jurisdiction and in the PA.

The City's sea level rise adaptation planning report explores three adaptation approaches that focus on: (1) assets, (2) planning horizons of 2050 based on high projection of 2 feet of sea level rise and 2100 based on low projection of 2, and (3) two specific geographic areas in the City—Eureka-Fay Slough and its waterfront. This report presents adaptation goals, strategies and measures for each of these approaches that can be incorporated in the City's LCP update. Addendum 1 includes draft goals and policies and outlines potential strategies that could be utilized to protect priority assets.

The City’s sea level rise adaptation planning emphasis is on a high projection of 2 feet on Humboldt Bay, predicted to occur by 2050. The City and this plan use this projection to establish a target water elevation of 9.6 feet NAVD 88 for MMMW to guide its adaptation planning.

Planning for sea level rise involves informational and regulatory components. To date most of the sea level rise planning efforts on Humboldt Bay have been informational (vulnerability assessments and adaptation planning). This report is a bridge from the informational to regulatory component, as the City of Eureka’s next step is to draft regulatory policies and regulations that address sea level rise in its LCP update. The City finds that there are several problematic issues associated with developing LCP land use regulations to address sea level rise, including:

- A lack of “official” state or federal sea level rise hazard or planning maps for LCP authorities to base their land use policies and regulations;
- Adopting sea level rise planning areas (SLRPA) for 2100 based on high versus low sea level rise projections, given the wide range of projections from 2050 to 2100;
- Adopting SLRPA based on future sea level rise that does not account for successful adaptation strategies that could protect land uses and developments from projected sea level rise through 2050;
- FEMA FIRM flood hazard zones and regulations provide similar protection as adopting a SLRPA for 2050 or even 2100 under the low projection for sea level rise, thereby providing an opportunity for the City to defer adopting adaptation regulations until its next LCP in 2040;
- Revising current zoning ordinances based on high projection for sea level rise by 2100 may present conflicts for land uses and developments currently established (vested) in the City’s General Plan that would not need protection from sea level rise through 2050;
- Limitations of a LCP, a regulatory tool, to protect existing (particularly assets not owned by the City) or vested land uses and development versus future land uses and developments; and
- Limitations of an individual LCP versus a regional or multi-agency LCP to develop and implement regional adaptation goals and strategies.

Lastly, the City’s adaptive capacity to address high priority assets is constrained because many of these assets are not owned by the City. Key infrastructure related to energy, bulk fuel, communications, and transportation are owned by other public and private entities. The City’s LCP jurisdiction also does not encompass, the Highway 101 corridor and Humboldt Bay Power Plant which are critical assets essential to the City’s long term sustainability, they are the respective responsibility of Caltrans and PG&E in

Humboldt County's HBAP jurisdiction. Clearly, adaptation to sea level rise on Humboldt Bay needs to be a collaborative and regional effort. For instance, a single shoreline protection measure in some areas could protect any number of critical assets regardless of who owns or maintains them.

3.1 Adaptation Plan Summary

The Sea Level Rise Adaptation Plan findings can be summarized as follows:

- The City has elected to take a pragmatic approach to plan for and adapt to hazards from sea level rise.
- The City's adaptation plan focuses on specific geographic areas that are vulnerable now or at risk from sea level rise— Eureka-Fay Slough diked former tidelands and its waterfront area.
- The City concurs with the state's recommendations to assess vulnerability and plan for adaptation to sea level rise through 2050.
- The City's adaptation goal for diked lands is to protect land uses and development now as well as mitigate vulnerability from 2 feet of sea level rise, where feasible, given the physical limitations of these former tidelands.
- The City will consider the effects of successful adaptation strategies that could protect diked land uses and developments from projected sea level rise through 2050, thus negating the need to adopt a SLRPA for 2050.
- The City's adaptation goal for 2050 in its waterfront area is to protect people, development, and the environment from 2 feet of sea level rise.
- The City's waterfront area is mostly vulnerable to sea level rise that is greater than 2 feet, which is predicted to occur as the high projection by 2050 and possibly not until 2100 based on a low projection, thus negating the need to adopt a SLRPA in this area for 2050.
- Because there is a significant range in sea level rise projections for 2100 (2 to 5.4 feet), the City believes there is sufficient uncertainty regarding the use of any projections for sea level rise 84 years into the future. The City believes that creating a SLRPA now based on the existing high projection for sea level rise (> 5 feet) by 2100 would undermine its land decisions/regulations and unnecessarily encumber land uses and development.
- When the City updates its LCP in 2040, it will reassess the projections for sea level rise by 2100 based on the best available science for Humboldt Bay at that time.

- While the City's LCP will control zoning in SLRPA, it is the Coastal Commission's administration of policies in Chapter 3 of the Coastal Act that will regulate development because most of the SLRPA for 2050 and 2100 in the City are under the state's retained jurisdiction.
- Planning for sea level rise raises LCP policies and regulations in the Coastal Zone to a new level of constraint and impact to land use and development, essentially creating a new *defacto* regulatory zone.
- Individual LCPs are a limited vehicle to plan for sea level rise on Humboldt Bay. A regionally integrated LCP would be more appropriate as LCP jurisdictions traverse multiple hydrologic units.

Regardless of the strategy or approach selected to adapt to sea level rise impacts, funding and regulatory flexibility are two critical issues that will need to be addressed. Normal capital funding mechanisms are currently unable to accommodate the huge backlog of necessary infrastructure improvements, and it is unrealistic to expect that baseline capital funding might also fund new adaptation projects. Developing and implementing adaption strategies and measures for assets that are vulnerable and at-risk will require decades of planning, design, and implementation, as well as significant financial investments. New state and federal funding sources will be needed to address sea level rise impacts. Implementing adaptation measures will require permits. Regulatory constraints to potential adaptation measures could be reduced with the integration of local, state and federal statutes into flexible programmatic authorizations. Jurisdictional integration/collaboration among LCP authorities (Humboldt County, City of Eureka, and City of Arcata) and resource management authorities (Coastal Commission and HBHRCD) could also facilitate the development and implementation of adaptation strategies and measures.

3.1.1 High Priority Assets:

The highest priority assets to protect by 2050 are utilities (waste water, municipal water, storm water) transportation (Highway 101 Murray Field Airport), commercial fishing facilities and property, public access and recreation, agricultural lands, and Environmentally Sensitive Habitat Areas (ESHAs). By 2100, all assets except recreational boating (pilings would have been extended by 2050), agricultural lands (existing dikes are projected to be overtopped and diked lands would be drainage impaired by 2070 with approximately 3 feet of sea level rise), and ESHA (most are located on diked lands that are projected to be overtopped or flooded by 2070) are all high priority assets.

Adaptation Goals

Adaptation goals for high priority assets by 2050 include**:**

- Utilities: to reliably deliver public services as economically as possible to all customers.
- Transportation: retain local, regional, and inter-state transportation infrastructure.
- Commercial Land Uses: assure priority for coastal-dependent and related development.
- Coastal Resources: protect, and perpetuate public access and recreational opportunities, and environmentally sensitive habitats, agricultural lands and cultural resources.

Protection Strategies

Protection strategies for high priority assets include**:**

- Protecting utilities in place is a pragmatic adaptation strategy until funds can be secured to ultimately relocate utility infrastructure out of the SLRPA.
- Protecting, enhancing, and maintaining shoreline structures may be appropriate for utilities located behind shoreline structures that prevent tidal inundation of utility infrastructure now or in the future.
- Protecting Highway 101 and Murray Field Airport can best be achieved by protecting, enhancing, and maintaining shoreline structures on Eureka-Fay Slough hydrologic unit.

Accommodation Strategies

Accommodation strategies for high priority assets include**:**

- Raising the elevation of utility facilities and right-of-way to retain access to utility infrastructure;
- Raise the elevation Highway 101 and streets when resurfacing;
- Reconstruction of Highway 101, streets, and roads would provide an opportunity to import fill and raise the elevation of the road base and surface;
- Increasing drainage from diked lands could help protect surface transportation infrastructure that traverses diked lands like Highway 101;
- Replacing low-lying sections of Highway 101 and critical local streets and roads with an elevated viaduct on pilings may be a preferred long-term solution to accommodate sea level rise;
- Increasing the surface elevation of marine facility property and access streets servicing these properties;

- Replacing or increasing the height of pilings that anchor floating docking would help keep these marine facilities in place as sea level rises;
- Utilizing pile foundations would help raise buildings above projected sea levels;
- Raising the surface elevation of individual low-lying lots and surface streets in specific geographic areas such as Jacobs Avenue on Eureka Slough;
- Importing fill to increase the surface elevation of individually owned diked former tidelands or for all undeveloped tidelands in a hydrologic sub-unit that have compacted over the last century;
- Increasing the capacity and number of water control structures or installing pumps to drain diked and urban lands could enable these areas to accommodate increasing sea level rise as it affects water control structure efficiency.
- Raising the surface elevation of low-lying surface streets in the SLRPA could help accommodate higher water elevations and maintain public access to Humboldt Bay.
- As the Bay Trail is scheduled for resurfacing, there may be an opportunity to incrementally raise its elevation.
- Maintaining undeveloped areas as open space to allow natural areas such as coastal wetlands to migrate inland with sea level rise.
- Relocating dikes inland, even 50 to 100 feet, could allow for restoration of salt marsh habitat and provide a wave attenuating buffer to protect dikes from erosion and breaching.

Protection Measures

Protection measuring for the Eureka-Fay Slough diked lands area include the following actions**:**

- Protect dike structures with either hard or green engineering measures.
- Increase dike elevations, may be desirable compared to the impacts of relocating transportation infrastructure behind the dikes.
- Construction of new protective dikes parallel to Highway 101 on Caltrans' property or right-of-way may become an option if enhancing existing diked shorelines or railroad grade is not feasible.
- Highway and street road prisms could be modified to prevent slumping or erosion.
- As groundwater rises behind diked shorelines or when stormwater runoff becomes impounded behind the highway or streets, pumping may become necessary to protect road prisms from over-saturation.

3.1.1 Diked Lands, Eureka-Fay Slough Area:

As discussed previously, dikes on Humboldt Bay are presently protecting thousands of acres of former tidelands and many high priority assets (utilities, transportation, and coastal resources) from tidal inundation. However, these diked former tide lands and priority assets are particularly vulnerable and currently at-risk from tidal inundation if existing shoreline dike structures were to fail. Successfully implementing a shoreline protection strategy in these diked areas could maintain the current tidal inundation area through 2050 based on the high projection of 2 feet of sea level rise. If not, these diked areas and priority assets that are protected by dikes would become tidally inundated when the dikes are breached or overtopped.

Adaptation Goals

Adaptation goals for the Eureka-Fay Slough diked lands area include the following actions**:**

- Protect people, land uses and development by enhancing the diked shoreline and mitigating existing vulnerability and risk from tidal inundation.
- Protect people, land uses, development and the environment from 2 feet of sea level rise (MMMW of 9.6 feet NAVD 88) where feasible given the physical limitations of these former tidelands.

Protection Strategies

Protection strategies for the Eureka-Fay Slough diked lands area include the following actions**:**

- Address shoreline vulnerability and risk for entire discrete hydrologic units, such as Eureka-Fay Slough sub-unit.
- Increase resiliency of vulnerable dike reaches to protect land uses and developments within the entire hydrologic unit from tidal inundation.
- Enhance the resiliency of the entire shoreline within the Eureka-Fay Slough hydrologic unit to account for 2 to 3 feet of sea level rise.

Protection Measures

Protection measuring for the Eureka-Fay Slough diked lands area include the following actions**:**

- Adopt a sea level rise planning area (SLRPA) for 2 feet of predicted sea level rise (MMMW of 9.6 feet), with references to FEMA's FIRM AE flood zone and BFE of 10.2 feet.
- Increase the height of shoreline structures for the entire 3.1 miles length of the Eureka-Fay Slough hydrologic unit to approximately 11 feet or more to protect lands behind shoreline structures that are lower than FEMA's BFE of 10.2 feet with 1 foot of free board and from up to 3.2 feet of sea level rise, which is the high projection for 2070.
- Relocate shoreline structures landward on public lands to create a salt marsh living shoreline to afford protection from wave induced erosion and overtopping.
- Utilize FEMA siting and building standards to mitigate vulnerability and risk to land uses and developments in the FIRM AE zone and City's SLRPA for Eureka-Fay Slough unit.
- Utilize green and hard engineering measures, including constructing salt marsh plains (living shorelines) to protect dikes, to protect shoreline dikes from erosion.
- Disclose in real estate transactions for properties in the Eureka-Fay Slough SLRPA that they are potentially vulnerable and at risk from tidal inundation.
- Coordinate with the Humboldt County Flood Control District to secure funds to design, permit, elevate and maintain shoreline structures or a certified levee system.
- Create a federally certified coastal levee system (minimum of ~11 feet (10.2 foot BFE plus 1.0 freeboard) on Eureka-Fay Slough.
- Construct a tidal dam at the entrance to Eureka Slough to mute the tide cycle and reduce vulnerability and risk from tidal inundation.

Accommodation Strategies

As sea levels rise, so too does mean low water elevations, and tide gates associated with shoreline dikes, levees, and stormwater outlets. These water control structures will experience reduced capacity to drain stormwater runoff. Impounding stormwater runoff or elevated groundwater behind protective dikes or tide gates may result in flooding of land uses and developments. Rising sea levels will impede stormwater runoff likely causing backwater flooding upstream of outlet structures on the shoreline of Humboldt Bay. Accommodation strategies for the Eureka-Fay Slough diked lands area include the following actions**:**

- Enhance drainage capacity of diked lands vulnerable and at risk from tidal inundation due to sea level rise to reduce their flooding; and
- Increase the elevation of lands and infrastructure vulnerable and at risk from tidal inundation due to sea level rise to reduce their flooding.

Accommodation Measures

Accommodation measures for the Eureka-Fay Slough diked lands area include the following actions**:**

- Increase drainage capacity of dikes, levees, and stormwater outlets to accommodate 2 to 3 feet of sea level rise by upgrading existing water control structures and installing additional water control structures to increase the volume and extend duration of drainage;
- Install pumps to accelerate drainage of stormwater behind shoreline structures; and
- Import fill to increase the elevation of land and infrastructure vulnerable and at risk form tidal inundation and flooding.

3.1.2 Waterfront Area:

By 2050 or from 2 feet of sea level rise, only a few areas in the waterfront area will be tidally inundated: (PALCO marsh) interior of the NCRA railroad and Waterfront Trail, a portion of the Chevron bulk fuel terminal property, City's marina property and Waterfront Drive, short segments of Commercial fishing property and adjacent City streets are likely to become tidally inundated if adaptation measures are not implemented, also piers anchoring commercial and recreational boating docks on the waterfront may also need to be extended. As Eureka's Waterfront Trail is completed, it will form a new shoreline in many locations and help protect areas from 2 feet of sea level rise from Elk River to Eureka Slough.

Adaptation Goals

Adaptation goals for the waterfront area including the following actions;

- Protect people, land uses, and development by enhancing the shoreline and mitigating existing vulnerability and risk from tidal inundation where feasible; and
- Protect people, development, and the environment from 2 feet of sea level rise (MMMW of 9.6 feet NAVD 88).

Protection Strategies

Protection strategies for the waterfront area including the following actions;

- Make vulnerable artificial shoreline reaches more resilient to sea level rise to protect land uses and developments from tidal inundation;
- Enhance the resiliency of all shoreline structures to protect land uses and developments from 2 feet of sea level rise;
- Recognize the uncertainty of sea level rise projections for 2050 to 2100.

- Update the City's LCP Safety Element as necessary to incorporate the best available science of sea level rise projections;
- Utilize Humboldt County's Hazard Mitigation Plan to help reduce the level of risk to people, development, and the environment from tidal inundation;
- Re-assess sea level rise projections in the next LCP update of 2040; and consider appropriate land use goals if projections confirm that 3 or more feet of sea level rise is likely between 2050 and 2100.

Protection Measures

Protection measures for the waterfront area including the following actions;

- Increase the height of shoreline structures for the entire length of the waterfront to approximately 11 feet (NAVD 88) or more to protect lands behind shoreline structures that are lower than FEMA's BFE of 10.2 feet with 1 foot of free board and from up to 3.2 feet of sea level rise, the high projection for 2070;
- Utilize FEMA siting and building standards to mitigate vulnerability and risk to land uses and developments in the FIRM AE zones and City's waterfront SLRPA; and
- Disclose in real estate transactions whether properties are in a SLRPA and that they are potentially vulnerable and at risk from tidal inundation;

Accommodation Strategies

Accommodation strategies for the waterfront area including the following actions;

- Increase the elevation of waterfront lands vulnerable and at risk from tidal inundation due to 2 feet of sea level rise; and
- Enhance stormwater runoff capacity to protect land uses and developments from backwater flooding.

Accommodation Measures

Adaptation measures for the waterfront area including the following actions;

- Import fill to increase the elevation of land vulnerable and at risk form tidal inundation and flooding;
- Increase drainage capacity of stormwater outlets to accommodate 2 to 3 feet of sea level rise (2050 to 2070 based on high projections) by upgrading existing and installing more water control structures to increase the volume and extend duration of drainage;
- Install pumps to accelerate drainage of stormwater behind shoreline structures; and

- Create stormwater runoff detention basins to attenuate backwater flooding upstream of stormwater outlets.

4 REFERENCES

California Climate Action Team. 2013. State of California Sea-Level Rise Guidance Document (2015).

California Coastal Commission. 2015. Sea Level Rise Policy Guidance: interpretive guidelines for addressing sea level rise in local coastal programs and coastal development permits.

California Natural Resources Agency. 2012. California Climate Adaptation Planning Guide.

Cascadia Geosciences (CG). 2015. *Tectonic land level changes and their contribution to sea-level rise, Humboldt Bay region, Northern California*. Prepared for U.S. Fish and Wildlife Service Coastal Program.

Environmental Services Associates (ESA). 2016. Adaptation Strategies, Measures and Alternatives for the Eureka General Plan and LCP LUP response to Sea Level Rise. Prepared for City of Eureka.

Laird, Aldaron, Brian Powell. 2013. Humboldt Bay sea level rise adaptation planning project: Phase II report. Humboldt Bay shoreline inventory, mapping, and sea level rise vulnerability assessment, with an Addendum: Shoreline Vulnerability Ratings. Prepared for the California State Coastal Conservancy.

Laird, Aldaron. 2015. Humboldt Bay sea level rise adaptation planning project: Phase II report. Prepared for the California State Coastal Conservancy.

Laird, Aldaron. 2016. City of Eureka Sea Level Rise Assets Vulnerability and Risk Assessment. Prepared for the Ocean Protection Council.

Northern Hydrology and Engineering. 2014a. Estimates of local or relative sea level rise for Humboldt Bay region. Prepared for the California State Coastal Conservancy and Coastal Ecosystems Institute of Northern California.

Northern Hydrology and Engineering. 2015. Humboldt Bay Sea Level Rise Hydrodynamic Modeling and Inundation Vulnerability Mapping. Prepared for the California State Coastal Conservancy.

Seemann, Hank. 2016. Updated Coastal Flood Hazard Maps from FEMA. Prepared for Humboldt Bay Symposium, October 22, 2016.

5 ADDENDUM 1 (see separate cover)

SEA LEVEL RISE

ADAPTION PLANNING REPORT ADDENDUM No. 1

City of Eureka

December 15, 2016

Prepared By: Bayview Consulting

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PURPOSE:

The purpose of this Addendum is to provide additional clarification and analysis on the information that was presented in the Sea Level Rise Adaptation Planning Report dated December 2016. This report is not intended to supersede the original report, rather it is intended to provide decision makers additional details regarding:

1. Draft goals and policies that could potentially be included in the City's Local Coastal Plan.
2. Potential strategies that could be utilized to protect those priority assets.
3. How and why the City's selected a specific projected sea level rise elevation.
4. What are other issues to consider besides "best available science" when making policy decisions.
5. Compliance with specific Coastal Act sections that requires certain assets to be protected, as well as, local "common sense" priority assets.

II DRAFT GOALS, POLICIES, AND REGULATIONS:

The following draft Goals, Polices, and Regulations are not intended to be viewed as a stand-alone regulatory document. These draft regulations when adopted and certified by the Coastal Commission will be one section of the City's overall Local Coastal Program. The City's Local Coastal Program currently includes detailed policies and standards regarding wetlands and other environmentally sensitive habit areas. These draft regulations must be both horizontally and vertically consistent with the other sections, as well as, the implementing zoning standards. Therefore, it is unnecessary to include those policies and standards as they are already included in the existing Local Coastal Program and Coastal Act.

The following goals, policies, and regulations were developed based on the legislatures intention and the specific requirements that are outline in the Coastal Act. The Coastal Act is clear that there are urban areas and rural areas; developed areas and undeveloped areas; and existing development and new development on California's Coastline. The Coastal Act does not treat these areas the same and therefore, the City's policies treat them differently. The following facts should be carefully reviewed when developing sea level rise regulations:

1. *The ports of the State of California, including the Humboldt Bay Harbor, Recreation, and Conservation District, constitute one of the state's primary economic and coastal resources and are an essential element of the national maritime industry (Section 30701 (a).*
2. *Approval of a local coastal program shall not be withheld because of the inability of the local government to financially support or implement any policy or policies contained in this division; provided, however, that this shall not require the approval of a local coastal program*

allowing development not in conformity with the policies in Chapter 3 (commencing with Section 30200) (Section 30516(a)).

3. *The Legislature further finds and recognizes that conflicts may occur between one or more policies of the division. The Legislature therefore declares that in carrying out the provisions of this division such conflicts be resolved in a manner which on balance is the most protective of significant coastal resources. In this context, the Legislature declares that broader policies which, for example, serve to concentrate development in close proximity to urban and employment centers may be more protective, overall, than specific wildlife habitat and other similar resource policies. (30007.5).*
4. The City's Coastal Commission Certified Local Coastal Plan established the "urban and employment centers" in the City of Eureka (Section 1 Land Use and Community Design).
5. *The Coastal Act requires protection, and therefore, policies must be in place to protect:*
   a. *Public Access (Section 30210).*
   b. *Commercial Fishing and Recreational Boating (Section 30234, 30220, and 30703).*
   c. *Coastal Visitor Serving Uses (Section 30235).*
   d. *Coastal Dependent Uses and Existing Structures (Section 30235)*
   e. *Environmentally Sensitive Habitat Areas (Section 30240)*
   f. *Agricultural Lands (Section 30242).*
   g. *Cultural, Archeological and Paleontological Resources (section 30244).*
6. *Coastal-dependent developments shall have priority over other developments on or near the shoreline. Except as provided elsewhere in this division, coastal-dependent developments shall not be sited in a wetland. When appropriate, coastal-related developments should be accommodated within reasonable proximity to the coastal-dependent uses they support (Section 30255).*
7. *Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fish kills should be phased out or upgraded where feasible (Section 30235).*

In addition the Coastal Commissions Strategic Plan for 2013 – 2018 under Goal # 3 states: *"Global sea level rise is accelerating and extreme storm events are increasing in intensity, both of which are exacerbating coastal shoreline hazards that the Commission must address, including coastal erosion and flooding. Public beaches and public access will be placed at increased risk in urban areas where there may be significant coastal armoring and little opportunity for natural retreat of the beach. Wetland protection and restoration decisions will need to account for changes in sea level rise. Coastal terrestrial and marine habitats are already changing with shifts in climate patterns."*

In Chapter 8: Legal Context of Adaptation Planning of the Coastal Commission's Sea Level Rise Guidance Document it states:

"Section 30235 of the Coastal Act provides that seawalls and other forms of construction that alter natural shoreline processes "shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply." Despite other Coastal Act provisions that could often serve as the basis for denial of shoreline protective devices (for example, new development requiring shoreline protection can also conflict with Coastal Act policies requiring protection of public access and recreation, coastal waters and marine resources, natural landforms, and visual resources), the Coastal Commission has interpreted Section 30235 as a more specific overriding policy that requires the approval of Coastal Development Permits for construction intended to protect coastal-dependent uses[47] or existing structures if the other requirements of Section 30235 are also satisfied.[48] The Commission thus will generally permit a shoreline protective device if (1) there is an existing structure, public beach, or coastal-dependent use that is (2) in danger from erosion; and (3) the shoreline protection is both required to address the danger (the least environmentally-damaging, feasible alternative) and (4) designed to eliminate or mitigate impacts on sand supply."

Chapter 7 of the Commission's document gives the following policy guidance regarding ports critical facilities and Coastal Dependent Infrastructure. We were unable to find any guidance on protecting commercial fishing, recreational boating facilities, and coastal dependent development.

A.26 Plan ahead to preserve function of critical facilities*: Addressing sea level rise impacts to critical facilities and infrastructure will likely be more complex than for other resources and may require greater amounts of planning time, impacts analyses, public input, and funding. To address these complexities, establish measures that ensure continued function of critical infrastructure, or the basic facilities, service, networks, and systems needed for the functioning of a community. Programs and measures within an LCP could include identification of critical infrastructure that is vulnerable to SLR hazards, establishment of a plan for managed relocation of at-risk facilities, and/or other measures to ensure functional continuity of the critical services provided by infrastructure at risk from sea level rise and extreme storms. Repair and maintenance, elevation or spot-repair of key components, or fortification of structures where consistent with the Coastal Act may be implemented through CDPs.*

A.26a Develop or update a long-term public works plan for critical facilities to address sea level rise*: Develop a long-term management plan to address the complexities of planning for sea level rise that incorporates any potential maintenance, relocation, or retrofits and structural changes to critical facilities to accommodate changes in sea level, and obtain Coastal Commission certification.*

A.27 Apply high sea level rise projections for siting and design of critical facilities: *Given the planning complexities, high costs, and potential impacts resulting from damage, there is reason to be particularly cautious when planning and designing new critical facilities and/or retrofitting existing facilities. Ensure that critical facilities are designed to function even if the highest* *projected amounts of sea level rise occur and that sites with hazardous materials are protected from worst-case scenario sea level rise impacts.*

A.27a Design coastal-dependent infrastructure to accommodate worst case scenario sea level rise*: Include policies that would require proposals and/or expansion plans to address sea level rise for coastal dependent infrastructure that must necessarily be sited in potentially hazardous areas, such as industrial, energy, and port facilities. Such facilities should be designed to withstand worst case future impacts while minimizing risks to other coastal resources through initial siting, design, and/or inclusion of features that will allow for future adaptation.*

A.28 Site and design wastewater disposal systems to avoid risks from sea level rise*: Wastewater treatment and disposal systems are particularly challenging in that they are often located in areas that will be impacted by sea level rise. Ensure that these systems are not adversely affected by the impacts of sea level rise over the full life of the structure and ensure that damage to these facilities would not result in impacts to water quality or other coastal resources. Avoid locating new facilities in hazardous areas if possible. If complete avoidance is not possible, minimize elements of the system that are in hazardous areas (for example, locate the main facility on higher ground and only place pump stations in potentially hazardous areas), and design any facilities in hazardous areas to withstand worst-case scenario sea level rise impacts.*

A.33 Incorporate sea level rise considerations into Port Master Plans and other port activities*: Ensure that ports and related infrastructure are designed to function given anticipated sea level rise. In some cases, this may mean initially designing structures to accommodate projected sea level rise impacts. Other options may include planning for and ensuring capacity for future adaptive actions.*

A.33a Retrofit existing port infrastructure as necessary: *Given the coastal-dependent nature of many port structures, it may not be feasible to site or relocate development to avoid hazards. In these instances it may be more appropriate to include efforts to accommodate and withstand sea level rise during actions to repair or retrofit existing structures. Options may include using more robust designs or materials or elevating structures.*

A.33b Minimize resource impacts that may result from future use of shoreline protective structures*: If existing, coastal-dependent port structures require shoreline protective structures, minimize resource impacts as feasible and consistent with Chapter 3 and/or Chapter 8 of the Coastal Act, as applicable, by encouraging inland expansion of protective devices rather than further fill of coastal waters.*

A.33c Ensure that linkages to overland transportation networks are able to adapt to sea level rise impacts*: Coordinate with relevant stakeholders to ensure that linkages between port infrastructure and overland transportation networks will be resilient to future sea level rise impacts.*

SEA LEVEL RISE AND SHORELINE EROSION

GOAL SLR 1
Preserve, enhance, and restore the shoreline while protecting public access, scenic quality, natural resources, critical public infrastructure, and existing development from coastal hazards.

SLR 1.1 Structures. Shoreline structures (boardwalks, seawalls, revetments, piers, docks, marina's, dikes, levees, and other structures) shall:

a. be designed for multiple urban purposes such as flood protection, transportation, public access trails, wastewater management, recreation, wildlife, nature, and tourism wherever practical.
b. incorporate an interconnected system of public access trails, boardwalks, and viewpoints wherever practical.
c. assure shore stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area.
d. avoid, minimize, and mitigate impacts on environmentally sensitive habitat areas, public recreation, coastal access, and navigation.
e. incorporate soft coastal protection such as engineered "living shoreline" or fringe salt marshes where practical to reduce wave run up, coastal erosion, and reduce the height of hard shoreline structures. Soft coastal protection shall not diminish navigation or recreational activities on the bay.
f. include vegetation and other features designed to soften rock revetments, rock boulders rip rap, or other hard armoring structures and make them more atheistically pleasing wherever practical.

SLR 1.2 Preserving Undeveloped Shorelines: The City shall encourage the preservation and habitat enhancement of natural shoreline areas that were identified in the 2013 shoreline mapping assessment as these areas are vulnerable to future flooding and contain significant habitats or species and are especially suitable for ecosystem enhancement.

SLR 1.3 Fill Material in Bay. Safe fill material such as dredge spoils, rock, and oyster shells may be placed in the Bay to protect existing and planned development from flooding as well as erosion.

SLR 1.4 Adaptation Measures. As per the Coastal Act and common sense, the City shall prioritize developing and implementing adaptation measures to protect the following assets:

a. Public Coastal Access Points identified in the General Plan (Coastal Act Section 30210).
b. Eureka Waterfront Trail from the Elk River to Humboldt Bay Trail near Highway 101 (Coastal Act Section 30210).
c. Commercial Fishing and Recreational boating facilities (Coastal Act Section 30234 and 30220).
   1. Marina
      i. Woodley Island Marina
      ii. Eureka Public Marina
   2. Docks
      i. Humboldt Bay Rowing Association Dock (Samoa Bridge)
      ii. Bonnie Gool Dock (Adorni Center)
      iii. F Street Dock (Boardwalk)
      iv. Coast Guard Dock (Commercial Street)
   3. Boat Ramps
      i. Samoa Bridge Boat Ramp
      ii. Eureka Public Marina (500 W Waterfront Drive)
      iii. Montgomery Ward Boat Ramp (Behind Target)
d. Coastal Visitor Serving Uses (Coastal Act Section 30235)
e. Coastal Dependent Uses and Existing Structures (Coastal Act Section 30235).
   1. Coastal Dependent Industrial Uses.
   2. Waterfront Commercial.
   3. Use Existing Structures.
f. Environmentally Sensitive Habitat Areas (Coastal Act Section 30240)
g. Agricultural Lands (Coastal Act Section 30242).
h. Cultural, Archaeological and Paleontological Resources (Coastal Act Section 30244).
i. Wastewater Treatment Plant and Associated Facilities (Common Sense).
j. Highway 101 north and south (Common Sense).
k. Other Critical Infrastructure as established by the City Council (Common Sense).

SLR 1.5 **Removal of Shoreline Protective Structures**. If the “tipping point” is reached at a specific location and it is determined that it is no longer feasible to construct and maintain shoreline structures from the effects of sea level rise, the City may need to abandon certain developed areas. If currently developed areas are abandoned, and development is relocated outside of the coastal hazard areas, existing shoreline protective structures will either modified into a revised adaptation measure or be removed to allow natural processes and responses to sea level rise.

GOAL SLR 2:
Protect all lands currently developed with urban growth and all undeveloped lands designated for urban uses that provide valuable infill development opportunities until the magnitude of Sea Level Rise change is such that the protection management strategy can no longer be achieved.

SLR 2.1 Existing Shoreline Structures. To protect development located behind the shoreline from storm events, wave run-up, and coastal erosion; the existing shoreline structures (boardwalks, seawalls, revetments, piers, docks, marina's, dikes, levees, and other structures) shall be maintained and enlarged. To protect development from potential shoreline erosion and flooding hazards the City shall utilize the projected 2100 low intermediate model 100-year storm event projection of 2.7 feet (12.5 NAVD 88) plus a minimum of two additional feet (one foot for waves and one foot safety).

SLR 2.2 Gaps in Lines of Defense. Low points and gaps in the City's coastal flooding lines of defense shall be identified and tied into either higher existing land or be continued to avoid "back door" flooding.

SLR 2.3 New Shoreline Structures. New development along the shoreline shall assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area.

SLR 2.4 Development Not Protected by Shoreline Structures: New development and substantial improvements to existing development located in areas that are not protected from coastal flooding as established by Policy SLR 2.1 shall be designed and constructed to minimize risks to life and property due to flooding. These potentially unprotected structures shall have a finish floor elevation one foot above the following low intermediate model MMMW (NAVD 88) elevation:

Type	Elevation Established by SLR Model Year	RSLR (Feet)	NAVD 88 (Feet)	Structure "Expected Life"	Structure "Expected Life" Applies To These Structure Types
A	2050	0.5	8.6	Less than 25 years	Temporary structures, ancillary development, amenity structures, and other development with an expected life of less than 25 years. Also includes substantial improvements to existing structures.
B	2070	0.9	9.2	25 to 75 years	Permanent commercial, industrial, and other non-critical facilities type projects.
C	2100	2.7	10.4	Greater than 75 years	Permanent residential and critical facilities such as wastewater treatment facilities, arterial roadways, hospitals, power substations, police, and fire stations.

SLR 2.5 **Vulnerability Assessment, Adaptation Plans, and Mapping.** The City's Flood Administrator shall periodically update and amended, as necessary, the sea level rise vulnerability assessment, adaptation plans, and mapping periodically based on the best available science warranting significant adjustments to established projections.

GOAL SLR-3

Utilize the best available science, planning, and engineering to identify and disclose the potential for sea level rise impacts, well in advance, so that we can design and implement adaptation measures to minimize the risk of any actual future hazard.

SLR 3.1 **Safety of New Development.** The City will review projects and establish appropriate standards in the zoning code to:

a. Ensure that risks to life and property are minimized and that new development is safe from and does not contribute to flooding.
b. Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. (NOTE CA Section 30253)

SLR 3.2 **Potential SLR Maps**. Potential Sea Level Rise Map: Sea level rise flooding areas are defined as those areas that have the "potential" to be subject to flooding as modeled utilizing the low intermediate greenhouse gas emissions scenario as determined by the Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping (Northern Hydrology and Engineering 2015) as recommended by the Coastal Commission in their Sea Level Rise Guidance Document 2016. The map shall be reviewed to determine if a proposed development is in an area of potential current or future high coastal flooding. The areas identified on the map are not an indication of a definite hazard on a specific parcel. It is possible that hazards may exist outside of the mapped area. If a specific study indicates that a hazard does not exist on a property that is within the mapped hazard area, development can proceed as if the property were not located within that mapped hazard area. The maps shall be based on the best available science and updated when new information warranting significant adjustments to projections becomes available. (Figure X).

SLR 3.3 **Specific Study Requirement.** For development proposed within a mapped hazard area, the zoning code will identify any specific study requirements that are needed to document any specific construction standards; minimum floor elevations; and to ensure that shoreline development will not create a hazard.

SLR 3.4 **Applicant's Assumption and Disclosure of Risk.** To ensure that future property owners are notified that their property is in a hazard area, development approval for projects located in hazardous areas shall be required to record on title a risk disclosure notice. The zoning code shall establish the minimum required risk disclosures requirements.

GOAL CH 4
Collaborate with other agencies and the public, to develop local and regional strategies to collectively improve our ability to adapt to sea level rise in ways that advance economic prosperity, social equality, and environmental protection.

CH 4 1 **Stakeholder Collaboration.** The City shall actively encourage, lead, and/or participate in collaborative stakeholder group(s) that includes critical asset owners, property owners, shoreline protective structure managers and business owners, regulatory agencies and interested public to develop bay wide, watershed, drainage basin, and project specific multipurpose sea-level rise adaptation strategies and measures.

CH 4.2 **Innovative Solutions.** The City will explore and encourage innovative solutions to reduce peak tidal and storm events thereby reducing the vulnerability and risk from tidal inundation. Potential regional solutions may include by are not limited to:

a. installing hard engineered tidal barriers at the Humboldt Bay entrance, Eureka Slough entrance, and/or between Indian, Woodley, and Daby Islands that allow continued navigation, fish passage, and sediment transport while allowing temporary sea gates, pump stations, and offshore structures to be put in place.
b. constructing soft engineered islands, reefs, marshes, living shorelines or other features which mimic natural process and shoreline protection by filling portions of Humboldt Bay.
c. utilizing oyster shells, navigation channel dredge spoils and other safe local waste material to implement adaptation measures inland, along the shoreline, and within the waters of Humboldt Bay.

CH 4.3 **Education.** The City will work with community partners to educate the community about sea-level rise hazards and property owners, land, and water managers about how to implement best management practices that reduce vulnerability and risk from sea-level rise and flooding hazards.

CH 4.4 **Research and Funding.** The City will encourage state and federal agencies to research and fund sea level rise projections, tidal inundation mapping for Humboldt Bay, and adaptation construction projects.

CH 4.5 **Flexibility in Decision Making Process.** The City will encourage the State Legislature to adopt revisions to the California Coastal Act and other laws which require the California Coastal Commission and other agencies to implement a flexible approach to approving reasonable sea level rise adaption projects that are based on the best available science, but may not strictly meet every Coastal Act and/or other government regulation.

CH 4.6 **Beach and Dune Nourishment.** The City will encourage the U.S. Army Corps of Engineers and other State and federal agencies to develop and implement a beach nourishment programs to ensure that the region's beaches and dunes remain intact as they are our regions outer front line of defense.

CH 4.7 **North and South Harbor Entrance.** The City will encourage the Humboldt Bay Harbor, Recreation, and Conservation District, U.S. Army Corps of Engineers, and other State and federal agencies to maintain and enhance the North and South Jetty's to ensure that harbors entrance is safe for continued navigation.

CH 4.8 **Cultural Resources.** The City will work with our local tribes to protect the areas cultural resources from the effects of sea level rise and coastal flooding.

III CONCEPTUAL ADAPTION STRATEGIES.

The City could utilize the conceptual adaptation strategies to protect Eureka from the effects of Sea Level Rise. These conceptual strategies are intended to provide decision makers an overview of potential strategies, where the strategy may be appropriate to constructed, as well as the pros and cons of the strategy. It must be made clear that before any strategy could be implemented, a detailed site specific engineering/financial feasibility analysis, CEQA environmental review, public input/comment and permitting process would need to be completed.

The conceptual strategies are purposefully present with rough outlines illustrating where they could potentially be constructed. No engineering was completed nor were any feasibility study or environmental review completed.

These processes to select, design, permit, finance, and construct adaptation measures will take time. Local projects such as the construction of the Eureka Waterfront and Arcata McDaniel Slough levee projects in Arcata took years. One good thing about sea level rise adaptation measures is that we have time to plan, fund and build these measures. All projections indicate that most of Eureka's shoreline will remain protected through at least the 2040-time for the City's Local Coastal Program update.

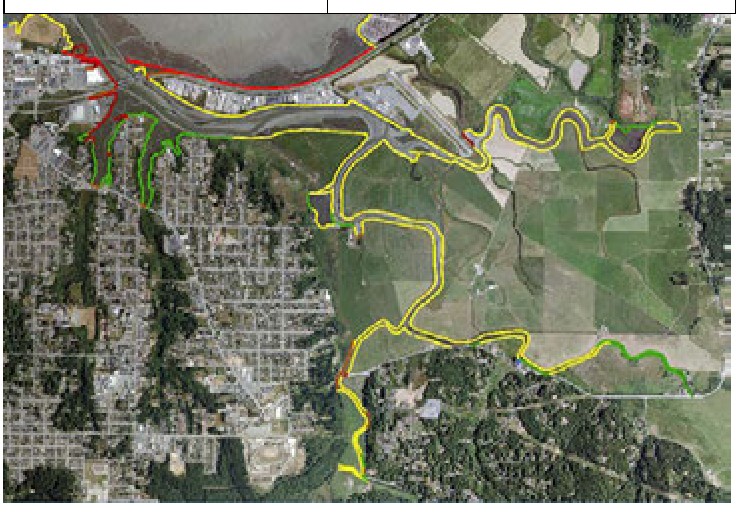
Concept 1. Perimeter Shoreline Levee Protection

THE CONCEPT: Build, enlarge, or maintain a dike/levee along the existing shoreline.

POTENTIAL LOCATIONS STRATEGY COULD BE APPLIED:

- California Redwood Company on Highway 101
- Fay Slough, Jacobs Avenue and Murray Field levee complex
- Highway 101 Bridge behind Target to Highway 255 Bridge.
- Elk River Slough

PROS	CONS
Comparatively low cost alternative	Visual barrier along the waterfront
Limited space requirements	Piers and docks not protected
Easy to fit in existing infrastructure	Sets area up for a future below sea level
Robust: Limited failure risk	



The illustrations above are from the 2013 Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment. These show the distribution of shoreline structure types on Eureka's shoreline: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

Concept 2. Wide Levee Shoreline (elevate land surface behind levee with fill material)

THE CONCEPT: Create a wide multipurpose levee along the existing shoreline that provides opportunities for integrated development. The wide levee would be designed to accommodate sea level rise, and reduce inundation from storms and storm surge well beyond 2100. The shoreline structure could be a levee, boardwalk, seawall, or other structure. The area behind the shoreline would be a continuous raised landmass along the waterfront that serves as a levee. However, because the levee would be so wide, it would also support opportunities for development on top of the levee, including residential and commercial buildings, and could be integrated into the natural and urban fabric of the existing shoreline. This is not a new concept and in fact since the 1850's much of Eureka's shoreline was created using this method.

POTENTIAL LOCATIONS STRATEGY COULD BE APPLIED:

- Area between the Adorni Center and the raised area near the Blue Ox Mill.
- Waterfront between G to I Streets
- Coastal Dependent Industrial zoned lands from Wharfinger Building to Del Norte Street

PROS	CONS
Fail safe.	Requires large amounts of structurally sound fill material.
Creates opportunities for return on investment for dual functions (development and protection).	Expensive to implement.
New Bayfront development possible.	Need to integrate with existing buildings, roads, and infrastructure.

Concept 3 Maintain Eureka's Boardwalk and Working Waterfront Piers and Docks

THE CONCEPT: Three general adaption measures are to: 1) retrofit piers to either accommodate periodic flooding, modify existing structures to dampen tidal impacts; or raise the surface; 2) rebuild and raise above projected sea level rise elevation; 3) maintain the piers and docks for as long as practical and safe, then remove structure. Eureka's waterfront is an active working waterfront with a vibrant visitor serving commercial core along the shoreline. This shoreline is a mix of existing boardwalk and working piers and docks. To maintain these coastal dependent uses, a resilient pier adaptation strategy will need to be developed.

POTENTIAL LOCATIONS STRATEGY COULD BE APPLIED:

- Between Adorni Center and the Wharfinger building.
- Coastal Dependent Industrial zoned lands from Wharfinger Building to Del Norte Street

PROS	CONS
Working waterfront maintained (fishing, shipping, and tourism).	Expensive to implement.
Public access points maintained.	Need to integrate with existing buildings.
Visitor serving commercial and lodging facilities maintained.	

Concept 4 Elevated Street Behind Shoreline.

THE CONCEPT: Retreat to a street, trail, or other natural or manmade topographic feature as the main line of protection by connecting buildings, roads, and elevated land to create a line of protection. This adaptation concept will embrace how Eureka could be "living with water" by integrating structural and non-structural adaptation measures along the line of defense. Truesdale, Felt Street and Broadway would be the main line of flood protection by connecting buildings, roads, and elevated land to create a line of defense. This approach minimizes the scope and scale of sea level rise impacts - as opposed to entirely suspending them. Some buildings should be retrofitted with materials and uses that could adapt to potential flooding.

POTENTIAL LOCATIONS STRATEGY COULD BE APPLIED:

- Del Norte Felt Streets would be raised.
- Levee behind waste transfer station would be raised and a new levee would be constructed around Palco Marsh protecting Broadway (Hwy 101) and the Bayshore Mall.
- The railroad/waterfront trail from Del Norte to the Elk River could be raised to maintain public access and create an increase layer of protection.

- Concept could also be feasible on Waterfront Drive from C Street to the Wharfinger Building behind the Eureka Marina.

PROS
Palco Marsh natural area retained.
Waterfront trail retained.
Three layers of defense (shoreline, railroad/ Waterfront trail levee, and raised road.)
Complete reconfiguration of uses can be embedded within elevated roadway-barrier.

CONS
Long line of defense.
Need for modification of Bay interior drainage behind Bayshore Mall.
Expensive.

Concept 5.   Tidal Control.

THE CONCEPT: Outer layers are typically offshore and are large and expensive engineered systems such as tidal barriers at the mouth of a river, estuary, or bay. Outer layers are designed to keep the water out before it reaches the shore. On Humboldt Bay, such a tidal barrier might be designed similar to what is currently constructed on the Thames River near London. This barrier was originally planned to be closed once a decade. Today, the barrier closes the Thames River several times a year during high tidal events. These barriers are designed to allows navigation to continue, except when the barrier is closed. Failure to close during a high tide coupled with a storm event would likely result in flooding.

POTENTIAL LOCATIONS:

- Eureka Fay Slough
- Between Indian, Woodley, and Daby Island
- Mouth of Humboldt Bay

PROS
Reduced need to increase height of flood protection behind structure.
Tidal flows maintained most of the time.
Channel navigability, sediment transport, and fish migration maintained.

CONS
Expensive to implement.
More frequent closures as sea level rises.
Risk of operational failure.

Concept 6. Living Shoreline and Islands

THE CONCEPT: Create a new salt marsh in the Bay. The new salt marsh would be over the existing mudflats that are immediately adjacent to the shore. The new salt marsh would be fortified with logs and artificial reef on the outer edge and interior marsh. The artificial reef could be constructed with oyster shells or other natural materials.   Dredge fill material would be deposited to elevate the existing mudflat to support salt marsh vegetation. The existing island that forms the mouth of the Elk River could also be fortified and raised with similar materials.

POTENTIAL LOCATIONS:

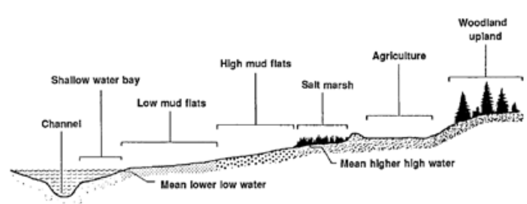
- Between Del Norte Street and Elk River Slough
- Potentially anywhere along the shoreline where there are existing mudflats

PROS:

- New habitat areas ecological transition zone.
- Public/private partnerships could potentially fund project.
- Piers could be protected.
- Failure risk low.
- Reduces storm wave run-up impacts.
- Tsumani protection

CONS:

- Permitting highly uncertain.
- Filling the Bay required.



Concept 7. New Waterfront or Islands

THE CONCEPT: Create a landmass in the Bay outboard and parallel to the existing shoreline, to be used for new habitat, recreation, development, and recreation. Much of Eureka's waterfront, along with many working waterfronts throughout the world were created through this method.

POTENTIAL LOCATIONS:

- Potentially anywhere along the shoreline.

PROS:

- New habitat areas ecological transition zone.
- Public/private partnerships could potentially fund project.
- New development opportunities.
- Piers could be protected.
- Failure risk low.
- Reduces storm wave run-up impacts.

CONS:

- Permitting highly uncertain.
- Expensive.
- Filling the Bay required.

IV COASTAL COMMISSION SEA LEVEL RISE POLICY GUIDANCE.

The Coastal Act does not specify either a "100-year protection level or establish a 2100-year threshold for sea level rise protection. The level of risk for flooding is established in the Coastal Act Section 30253. Minimization of adverse impacts. Section 20253 specifies that new development shall: "(a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.". The Coastal Commission's Sea Level Rise Guidance document states that the guidance is advisory and not a regulatory document or legal standard of review for the actions that the Commission or local governments must take under the Coastal Act."

The Guidance Document goes on to states that the "best available science" for establishing sea level rise projections is the 2012 NRC report and recommends that adaptation measures and policies should minimize risks throughout the "expected life" of the development. Pages 50 and 51 of the Coastal Commission's Sea Level Rise Guidance document recommends that jurisdictions:

- *"…identify a range of sea level rise scenarios including the high projection, low projection, and one or more intermediate projections".*
- *"For a Local Coastal Program (LCP), the general goal is to assess the potential impacts from sea level rise over the entire planning area and over a range of time horizons so that both short and long term adaptation strategies can be identified and implemented."*
- *"In practice, the process for choosing scenarios and performing scenario-based analysis will be slightly different for LCP planning and CDP applications due to the different planning goals and levels of technical detail required for each."*
- *"Similar to the recommendation in the OPC's 2011 State Sea-Level Rise Resolution, the Commission does not recommend using values solely in the lower third of the NRC's projections as this does not give a full picture of the risks. Looking instead at both the high and low projections allows users to build an understanding of the overall risk sea level rise poses to the region or site."*
- *"By exploring the range of future scenarios based on the best available science, users of this document can make decisions based on full understanding of possible future hazards, ultimately achieve outcomes that are safer for both development and coastal resources, and avoid costly damages to projects."*

Once the range of future sea level rise scenarios has been developed and different adaptation measures analyzed, the next step will be to take a broader perspective and develop goals policies to be amended into the City's Local Coastal Program. The City's Local Coastal Program is essentially the ground rules for regulating future development and protecting coastal resources. The Local Coastal Plan consists of a Land Use Plan which contains policies and an Implementation Plan which is essentially the zoning regulations within the coastal portion of the City. The City's Local Coastal Program requires certification by the Coastal Commission and must be consistent with the Coastal Act.

When developing goals, and polices which require certification from the Coastal Commission, it may be helpful to understand what the criteria the Commission will utilize to evaluate the City's proposed new policies and regulations.

Section 30512.2 Land use plan; criteria for decision to certify or refuse certification

The following provisions shall apply to the commission's decision to certify or refuse certification of a land use plan pursuant to Section 30512:

(a) The commission's review of a land use plan shall be limited to its administrative determination that the land use plan submitted by the local government does, or does not, conform with the requirements of Chapter 3 (commencing with Section 30200). In making this review, the commission is not authorized by any provision of this division to diminish or abridge the authority of a local government to adopt and establish, by ordinance, the precise content of its land use plan.
(b) The commission shall require conformance with the policies and requirements of Chapter 3 (commencing with Section 30200) ***only to the extent necessary to achieve the basic state goals specified in Section 30001.5.*** *(emphasis added)*

Section 30001.5 Legislative findings and declarations; goals

The Legislature further finds and declares that the basic goals of the state for the coastal zone are to:
(a) Protect, maintain, and where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and artificial resources.
(b) Assure orderly, balanced utilization and conservation of coastal zone resources taking into account the social and economic needs of the people of the state.
(c) Maximize public access to and along the coast and maximize public recreational opportunities in the coastal zone consistent with sound resources conservation principles and constitutionally protected rights of private property owners.
(d) Assure priority for coastal-dependent and coastal-related development over other development on the coast.

Establishing goals and policies are a balancing act and the Coastal Act is not one dimensional. The protecting natural resources goal in Section 30005.1(a) must met along with the social and economic needs of the people of the state (30005.1(b); public access and recreation (30005.1(c); and coastal-dependent and coastal-related development (3005.1(d).

The legislature also found in Section 30001 (d): *"That existing developed uses, and future developments that are carefully planned and developed consistent with the policies of this division, are essential to the economic and social well-being of the people of this state and especially to working persons employed within the coastal zone."* Policies that protect the protect coastal access, commercial fishing, recreational boating, coastal dependent industries, visitor serving facilities, and the economic and social well-being of the people of Eureka are crucial to the core identity of Eureka.

V. SEA LEVEL RISE SCIENCE:

The Coastal Commission's guidance, as well as common planning practices, dictate that the policies surrounding sea level rise be made after considering the best available science. The City's adaptation planning efforts have utilized the best available science as recommended. To develop regional solutions to adapt to sea level rise, the Humboldt Bay Sea Level Rise Adaptation Planning Working Group (APWG) was formed by the Humboldt Bay Harbor, Conservation, and Recreation District and Humboldt County Public Works Department. The City of Eureka was an active member.

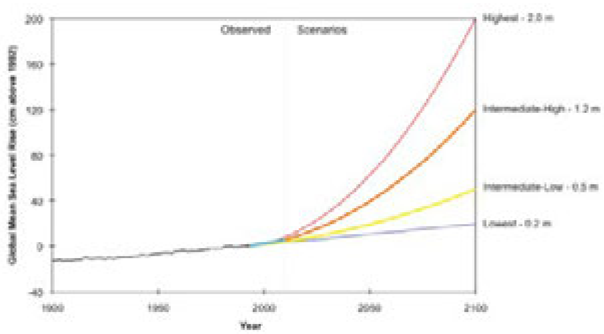
The APWG commissioned Northern Hydrology and Engineering (NHE) and Trinity Associates to develop the science utilized to determine sea level rise vulnerabilities in Humboldt Bay. As part of these efforts the following work products were completed:

1. Laird, Aldaron, Brian Powell. 2013. Humboldt Bay sea level rise adaptation planning project: Phase II report. Humboldt Bay shoreline inventory, mapping, and sea level rise vulnerability assessment, with an Addendum: Shoreline Vulnerability Ratings.
2. Laird, Aldaron. 2015. Humboldt Bay sea level rise adaptation planning project: Phase II report.
3. Laird, Aldaron. 2016. City of Eureka Sea Level Rise Assets Vulnerability and Risk Assessment.
4. Northern Hydrology and Engineering. 2014a. Estimates of local or relative sea level rise for Humboldt Bay region.
5. Northern Hydrology and Engineering. 2015. Humboldt Bay Sea Level Rise Hydrodynamic Modeling and Inundation Vulnerability Mapping.
6. Pacific Watershed Associates. 2014. A seamless topographic/bathymetric digital elevation model (DEM) of Humboldt Bay using the recent 2009-2011 California Coastal Conservancy LiDAR Project Hydro-flattened Bare Earth DEM (California Coastal DEM) and various subtidal bathymetric data sets to support the modeling efforts.
7. Dr. Robert Willis. 2014. A conceptual groundwater model to analyze the effects of SLR on groundwater levels and saltwater intrusion in the Eureka-Arcata coastal plain.

The science and planning efforts made by APWG were recognized by the Coastal Commission in the Commissions Sea Level Rise document when they specified that:

> *Humboldt Bay has not experienced the regional uplift that characterizes most of the coast north of Cape Mendocino, and instead has shown the highest subsidence recorded for the California coast. As a result, the projections for north of Cape Mendocino may not be appropriate for use in or near Humboldt Bay and the Eel River Estuary. Please see Humboldt Bay: Sea Level Rise Hydrodynamic Modeling, and Inundation Vulnerability Mapping (Northern Hydrology and Engineering 2015) for additional information on sea level rise projections for the Humboldt Bay region.*

Both the NHE 2015 sea level rise projections and the Coastal Commission recommended projections in their Guidance Document are based on the 2012 NRC report. Table 3 and Figure 5 from the Commission's Guidance document outlined a range of four global sea level rise scenarios. Per page 35 of the NHE 2015 report: *"The Highest Scenario of GMSL rise was based on the Pfeffer et al. (2008) estimate of maximum possible glacier and ice sheet loss by 2100, and should be used when there is little tolerance for risk. The Intermediate-High Scenario was based on the average of the upper end of semi-empirical model projections, and the Intermediate-Low Scenario was based on the upper end of the 2007 IPCC AR4 projections. The Lowest Scenario was based on a linear extrapolation of the 20th century GMSL rate of ~1.7 mm/yr. Given the range of GMSL rise projections used in developing the scenarios, the authors concluded that they have very high confidence (>9 in 10 chance) that GMSL will rise at least 20 cm and no more than 200 cm by 2100 (Parris et al., 2012)."*



Source: Figure 5 from SLR Guidance Document (NOTE 20 CM = 7.9 inches and 200 cm = 78.7 inches)

TIME PERIOD*	NORTH OF CAPE MENDOCINO[19]	SOUTH OF CAPE MENDOCINO	
by 2030	-2 – 9 in (-4 – +23 cm)	2 – 12 in (4 – 30 cm)	
by 2050	-1 – 19 in (-3 – + 48 cm)	5 – 24 in (12 – 61 cm)	
by 2100	4 – 56 in (10 – 143 cm)	17 – 66 in (42 – 167 cm)	

*with Year 2000 as a baseline

Source: Table 3 from SLR Guidance Document

To come up with a Humboldt Bay projections, the 2015 NHE Report took the mid-point in the NRC 2012 projected range and removed the upward vertical land motion assumption of 1 mm/yr from the 2012 NRC projection and replaced the value with the -2.33 mm/yr vertical land motion which Humboldt Bay is experiencing.

Like the San Francisco's 2016 Sea Level Rise Action Plan, and several other jurisdictions, the 2015 NHE report selected the midpoint as this represents the most *likely* projections for a moderate level of global greenhouse gas (GHG) emissions and continued accelerating land ice melt patterns. The "high" range estimates represent *unlikely, but possible* levels of sea level rise using very high greenhouse gas emissions scenarios with significant land ice melt.

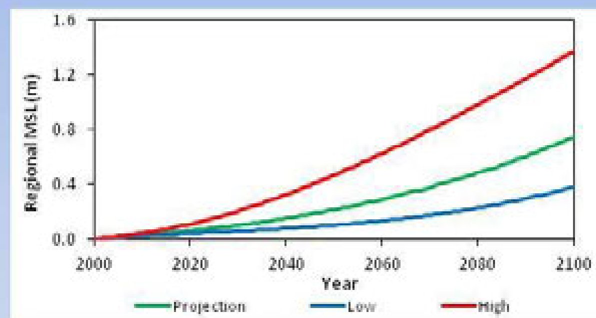
Based on Humboldt Bay's North Spit tide gage, relative sea level rise (i.e., the combination of regional sea level rise rates and local vertical land motion rates) was estimated to be approximately 7 inches by 2030, 13 inches by 2050, 22 inches by 2070 and 39 inches by 2100.

Sea-Level Rise Projections for Humboldt Bay Region

Sea-Level Rise Projections Based on National Research Council (2012) Study

Regional mean sea-level rise (ReSLR) projections for different scenarios in Humboldt Bay Region without vertical land motion effect

	ReSLR Projections Relative to Year 2000 (cm (in))		
Year	Low	Projection	High
2030	3.9 (1.5)	9.9 (3.9)	21.3 (8.4)
2050	10.9 (4.3)	21.4 (8.4)	46.2 (18.2)
2100	38.6 (15.2)	75.1 (29.6)	137.9 (54.3)



Relative mean sea level rise (RSLR) projections for different scenarios in Humboldt Bay with vertical land motion effect (VLM at North Spit gage = -2.30 mm yr^{-1} downward)

	RSLR Projections Relative to Year 2000 (cm (in))		
Year	Low	Projection	High
2030	12.5 (4.9)	16.8 (6.6)	27.3 (10.7)
2050	21.4 (8.4)	32.8 (12.9)	58.1 (22.9)
2100	61.2 (24.1)	97.7 (38.5)	160.4 (63.2)

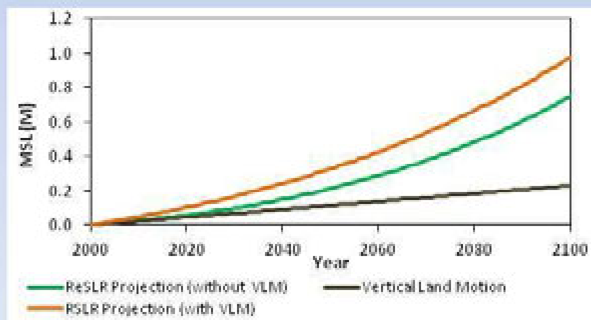


Figure 1. Regional and relative sea level rise projections for Humboldt Bay (NHE 2013).

The City of Eureka, its consultants and regional partners have done a great deal of research and have analyzed many scenarios over the last few years to determine the potential impacts associated with sea level rise. Because there is a significant range in sea level rise projections for 2050 (8.4 to 22.9 inches) and 2100 (24.1 to 63.2 inches), there will be uncertainty regarding the use of any projections for sea level rise 84 years into the future. This is especially true since these time horizons are well beyond the 2040 term of the City's proposed Local Coastal Program amendments.

After all the analysis is completed and science has presented their conclusions, it is always a good practice for decision makers to take a good step or two back from the nuances best available science, and organizational "agenda's" and opinions. Scientist, planners, boards, and commissions often get so far "into the weeds" that they overlook the social and economic needs of the community.

VI SEA LEVEL RISE ADAPTAION APPROACH:

The impacts associated with sea level rise generally include erosion, inundation, flooding, wave impacts, and saltwater intrusion. Adaptation planning in the original Sea Level Rise Adaptation Report was analyzed using three different approaches: assets, planning horizons/ water elevations, and specific geographic areas of the City most likely to be affected by sea level rise. The inundation mapping in the reports was not based on the NHE 2015 projection number, but instead was based on a 0.5, 1.0, 1.5, and 2.0-meter water sea level rise increase.

It is important to note that all mapping in the report assumes a "bathtub" model. The "bathtub' model assumes that there are no existing dikes, levees, tide gates or other adaptation measures currently protecting Eureka shoreline and that no adaptation measures or actions will be implemented in the future. In other words, the maps do not reflect the actual current conditions. The "bathtub" model assumes that not only will the City not take any additional action to protect the areas, it also assumes, that the existing adaptation measure currently in place will not be maintained and they fail.

This addendum builds upon the work of developing the three approaches in the original report as well as the Coastal Commissions Guidance document and takes a hybrid approach of simply looking at assets that are of such high value that the Coastal Act and common sense mandates that the City take every effort to protect them. The logic is that if you are going to protect these valuable assets, what other assets will automatically, and by default, receive some level of protected behind them.

The Coastal Act has several sections that focus on protecting coastal access, commercial fishing, recreational boating, coastal dependent industries, visitor serving facilities, and the social and economic vitality of a community. There is a big difference between developing sea level rise adaption measure for Eureka's urban waterfront and adaptation measures for undeveloped portion of the coast such as Clam Beach, Table Bluff, and the mouths of the Klamath, Mad, and Eel Rivers.

The following are the specific Coastal Act requirements and the assets which the Act specifies what you can and shall protect.

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

<u>Protected Assets:</u>
1. The Coastal Zone Access points identified in Table 5-2 of the Eureka General Plan.
2. Waterfront Trail:

a. Section A: Hikshari' Trail running from Elk River to Truesdale St., runs behind the Bayshore Mall and along Humboldt Bay to the foot of Del Norte St., landing right at the Del Norte St. Fishing Pier.

b. Section B: Waterfront Drive Trail running directly adjacent to Railroad Ave. and Waterfront Dr., this portion of the Waterfront Trail begins at Del Norte St. and ends at the foot of C St., and

c. Section C: Boardwalk Trail running from C Street along the south shore of Humboldt Bay under Highway 255 and then follows the south side of the Eureka Slough, passing underneath the bridge decks of Highway 101, providing the only alternative route in the City for pedestrians and non-motorized vehicles to cross US 101 without having to physically attempt to cross through traffic**,** eventually ending at Tydd St.

Coastal Act Section 30234: Commercial fishing and recreational boating facilities: *<u>Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded.</u> Existing commercial fishing and recreational boating harbor space <u>shall not be reduced</u> unless the demand for those facilities no longer exists or adequate substitute space has been provided. Proposed recreational boating facilities shall, where feasible, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry.*

Coastal Act Section 30220. Protection of certain water-oriented activities*: Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas <u>shall be protected</u> for such uses.*

Coastal Act Section 30703. Protection of commercial fishing harbor space: *The California commercial fishing industry is important to the State of California; therefore, ports shall not eliminate or reduce existing commercial fishing harbor space, unless the demand for commercial fishing facilities no longer exists or adequate alternative space has been provided. Proposed recreational boating facilities within port areas shall, to the extent it is feasible to do so, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry. (Section 30703).*

<u>Protected Assets:</u>

1. Marina
   a. Woodley Island Marina
   b. Eureka Public Marina

2. Docks
    a. Humboldt Bay Rowing Association Dock (Samoa Bridge)
    b. Bonnie Gool Dock (Adorni Center)
    c. F Street Dock (Boardwalk)
    d. Coast Guard Dock (Commercial Street)
3. Boat Ramps
    a. Samoa Bridge Boat Ramp (under Highway 255)
    b. Eureka Public Marina (500 W Waterfront Drive)

Coastal Act Section 30255 Priority of coastal-dependent developments: *<u>Coastal-dependent developments shall have priority over other developments on or near the shoreline</u>. Except as provided elsewhere in this division, coastal-dependent developments shall not be sited in a wetland. When appropriate, coastal-related developments should be accommodated within reasonable proximity to the coastal-dependent uses they support.*

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

<u>Protected Assets:</u>
1. Coastal Dependent Industrial Uses.
2. Waterfront Commercial Uses.
3. Existing Structures.

Coastal Act Section 30240. Environmentally sensitive habitat areas; adjacent developments:
(a) <u>Environmentally sensitive habitat areas shall be protected</u> against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.

<u>Protected Assets:</u>
1. Environmentally sensitive habitat areas.

Coastal Act Section 30242 Lands suitable for agricultural use; conversion: *All other <u>lands suitable for agricultural use shall not be converted</u> to nonagricultural uses unless (l) continued or renewed agricultural use is not feasible, or (2) such conversion would preserve prime agricultural land or concentrate development consistent with Section 30250. Any such permitted conversion shall be compatible with continued agricultural use on surrounding lands.*

<u>Protected Assets:</u>
1. Agricultural Lands until they are no longer economically viable.

Section 30244 of the Coastal Act (Archaeological or paleontological resources)*.*
Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.

Protected Assets:
1. Cultural, archaeological, or paleontological resources.

General Common Sense Protection:

Protected Assets:
1. Wastewater Treatment Plant and associated facilities.
2. Highway 101 North of the Eureka Slough Bridge to Arcata
3. Highway 101 South from Broadway to Fortuna.
4. Other Critical Infrastructure

The adaptation strategies outline in this addendum assume that the Coastal Act and general common sense dictates that the assets listed above will be protected until the magnitude of Sea Level Rise change is such that the protection management strategy can no longer protect the asset. Once the tipping point is reached it does not mean that the asset will be abandoned or that the City will retreat. Rather, it requires that alternative strategies be considered and implemented.

VII LEVEL OF PROTECTION (TOLERANCE):

When developing an adaptation strategy, a primary starting point is “what level of protection” is appropriate, or, “how safe is safe enough” “and how high should it be?” Historically, emphasis in the United States has been on achieving a “100-year” level of protection. However, this was a standard for the National Flood Insurance Program and was not developed for safety or for what level of flooding and impacts would be considered tolerable. Rather, it was selected as the minimum threshold by which one not need to purchase federal flood insurance. “how safe is safe enough” needs to be made by the community and its stakeholders based on what frequency and impacts of flooding they consider tolerable.

The Guidance Document recommends that adaptation measures and policies should minimize risks throughout the “expected life” of the development. The local jurisdiction has the discretion to establish reasonable “expected life” timeframes. The Guidance Document gives examples of “expected life” timeframes of:

1. 25 years or less for temporary structures, ancillary development, amenity structures, or moveable or expendable construction;
2. 75 to 100 years for residential or commercial structures;

3. over 100 years for critical facilities such as infrastructure, bridges, or industrial facilities and
4. perpetuity for conservation or restoration projects.

Although, the SLR modeling utilizes the 2050 and 2100 thresholds, the Commission will likely require projects to documents that they "minimize risks to life and property" for a specific timeframe such as 25, 50, or 100 years from the date of approval. This will mean that the projected sea level rise elevations utilized to permit projects will need to be continually be revised throughout the life of the Local Coastal Plan. This also means that the City should consider carefully drafting policies and standards so that individual development projects are not overly burdened with preparing complicated and expensive sea level rise projections for each individual project.

VIII COASTAL HAZARDS:

Coastal hazards associated with sea level rise come in a variety of types. The magnitude and frequency of these events will likely increase over time unless adaptation measures are implemented.

1. Daily tidal inundation. As sea level rises, the elevation of average daily high tides will continue to increase. It is anticipated that the mean high higher water (MHHW) will increase from the current 6.7 feet to 7.3 feet in 2030, 7.8 feet in 2050 and to 10 feet in 2100.
2. 100-year Storm Event with King Tides. Eureka's shoreline experience daily tides, King Tides, and temporary "extreme" tides. Temporary "extreme" tides are thought to be the result of higher periodic water elevations of coastal waters, caused by storms, El Niño, or other factors. If these "extreme" tidal events happen concurrently with both King Tides and 100-year storm events water elevations can be up to 3 feet higher than the MHHW tidal events. As overall climate change continues and sea levels rise, the frequency and intensity of storms temporary coastal flooding will likely also increase. Coastal flooding is the result of ocean water (saltwater) inundation. If adaptation measures are not implemented, future coastal flooding issues may include damaged infrastructure, impacted sewage system, and road closures.
3. Urban flooding. Unlike coastal flooding, rainfall runoff causes urban flooding. When the Bay waters are high enough, streams and storm water infrastructure backs up and urban freshwater flooding occurs.
4. Shoreline erosion. Shoreline areas are susceptible to increased erosion associated with extreme tides and increased wave action. Without protective action, rising seas will increase erosion hazards. A clear consensus has not fully emerged regarding climate changes, but a commonly identified trend is a tendency toward increased wind speed and wave height along northern California. This may increase both erosion rates and extreme tide frequency within the Bay.

IX GUIDING PRINCIPALS FOR CONSIDERING ADAPTATION STRATEGIES:

1. Consider all options: even if they are expensive, difficult to permit, and not yet tried in other places.
2. Develop site specific solutions instead of a one size fits all approach.
3. Always remember that water can come in from all sides including up (rain) and down (groundwater).
4. Utilize multipurpose solutions that integrate flood protection into urban design that result in an attractive and economically viable city.
5. Where ever practical, incorporate natural and habitat development into urban waterfront protection design.

X SEA LEVEL RISE MAPPING:

As previously discussed, the mapping done previously projected a sea level rise elevation of 0.5, 1.0, 1.5, and 2 meters. Planners then utilized the mapped elevation that most closely matched the "projected" sea level rise elevation to represent sea level inundation. As an example, if sea level was "projected" to 1.1 feet by 2100, planners would use the 0.5-meter map. The "bathtub' is useful for planners and the community to get a general idea of inundation. However, in practice this method has several important flaws such as:

1. 0.5 meters equals 1.64 feet not the 1.1 feet of actual projected sea level rise.
2. The model assumes that there are no existing dikes, levees, tide gates or other adaptation measures currently protecting Eureka shoreline.
3. The model assumes that none of the adaptation measures will be implemented in the future.

The areas of the City that are vulnerable and at-risk from sea level rise by 2050, 2070 and 2100 are presented in the Potential Sea Level Rise map (PSLR). For long-range planning, environmental review and project approvals, this report recommends that decision makers establish four SLRHZ elevations. Decision makers would select an elevation in the range between the NRC intermediate low projection and the NHE 2015 projection. If the NHE 2015 projection were selected, Type "A" would reflect 1.1 feet of SLR for the year 2050. Type "A" would map the 2050 Mean Monthly Maximum Water (MMMW) elevation at 8.8 feet (NAVD 88) and is intended to be used for projects such as temporary structures, ancillary development, amenity structures, and other development with an expected life of less than 35 years. Type "B" would utilize the 2070 projection of 1.8 feet (9.5 feet NAVD 88). Type "B" is intended for permanent commercial, industrial, and other non-critical facilities type projects.

Type "C" would utilize the 2100 "High" projection of 3.3 feet MMMW (11.0 feet NAVD 88). Type "C" is intended to be used for permanent residential structures and critical facilities such as wastewater treatment facilities, arterial roadways, police, and fire stations. Type "D" would utilize the 2100 - 100-year storm event projection of 3.3 feet (13.1 NAVD 88). Type "D" is intended to be used for shoreline structures such as dikes, levees, sea walls, boardwalks, and other features that are located on the immediate shoreline and intended to protect inland areas.

Type	Elevation Established by SLR Model Year	RSLR (Feet)	NAVD 88 (Feet)	Structure "Expected Life"	Structure "Expected Life" Applies to These Structure Types
A	2050	0.5	8.6	Less than 35 years	Temporary structures, ancillary development, amenity structures, and other development with an expected life of less than 35 years.
B	2070	0.9	9.2	35 to 75 years	Permanent commercial, industrial, and other non-critical facilities type projects.
C	2100	2.7	10.4	Greater than 75 years	Permanent residential and critical facilities such as wastewater treatment facilities, arterial roadways, hospitals, power substations, police, and fire stations.

XI ADAPTATION: MULTIPLE LAYERS AND MULTIPLE LINES OF DEFENSE:

Once it is determined what will be protected, for how long, and what elevation the water is projected to rise; the next key questions is where to put the line of defense? To put this another way, what will we allowed to be flooded and what not? Does the City want the protection to be along the existing shoreline, out into the bay, or pulled back from the current shoreline? Flood risk protection measures generally happens through an approach that utilizes not one but multiple lines of defense. These multiple layers of defense are coordinated into integrated solutions where each measure contributes to reduce overall flood risk. In general, coastal adaptation measures are classified as either Inner, middle, and outer layers.

Outer layers are typically offshore and are large and expensive engineered systems such as tidal barriers at the mouth of a river, estuary, or bay. Outer layers are designed to keep the water out before it reaches the shore. On Humboldt Bay, such a tidal barrier might be designed similar to what is currently constructed on the Thames River near London. This barrier was originally planned to be closed once a decade. Today, the barrier closes the Thames River several times a year during high tidal events. These barriers are designed to allows navigation to continue, except when the barrier is closed. If such a barrier was constructed, it could potentially be located between the north and south jetties of Humboldt Bay; between Woodley, Indian and Daby Islands or at the entrance to Faye Slough.

Middle layers are what most people think about when they imagine coastal protection solutions. These solutions typically include levees, seawalls, boardwalks, piers, strands, marshes, and estuaries as they are located right at the interface between the bay waters and the shoreline. The levees behind Jacobs Ave, Eureka Boardwalk, and the railroad levee along Highway 101 are local examples of these middle structures.

Inner solutions may include watershed protection, stream and estuary restoration, storm drains, pumps, and detention basins. Basically, anything that is behind the immediate shoreline is considered an inner solution. It should be noted that no matter what layer we are discussing; these lines of defense should tie into either higher existing land or be continued to avoid "back-door" flooding.

As was stated in the Guiding Principles section: always remember that water can come in from all sides including up (rain) and down (groundwater). High tides create backwater flooding that can get trapped behind levees and other shoreline structures. Storm water management is a critical element of sea level rise adaption.

Groundwater infiltration must also be closely considered. This will be most evident in the low-lying areas and especially in the former tidelands. As sea levels rise there is increased pressures from groundwater. This pressure comes in several forms, and includes but are not limited to:

1. saltwater intrusion into freshwater supplies;
2. higher groundwater tables;
3. inflow and infiltration of water into the wastewater collection system and other critical infrastructure; and
4. structural competency issues for building construction.

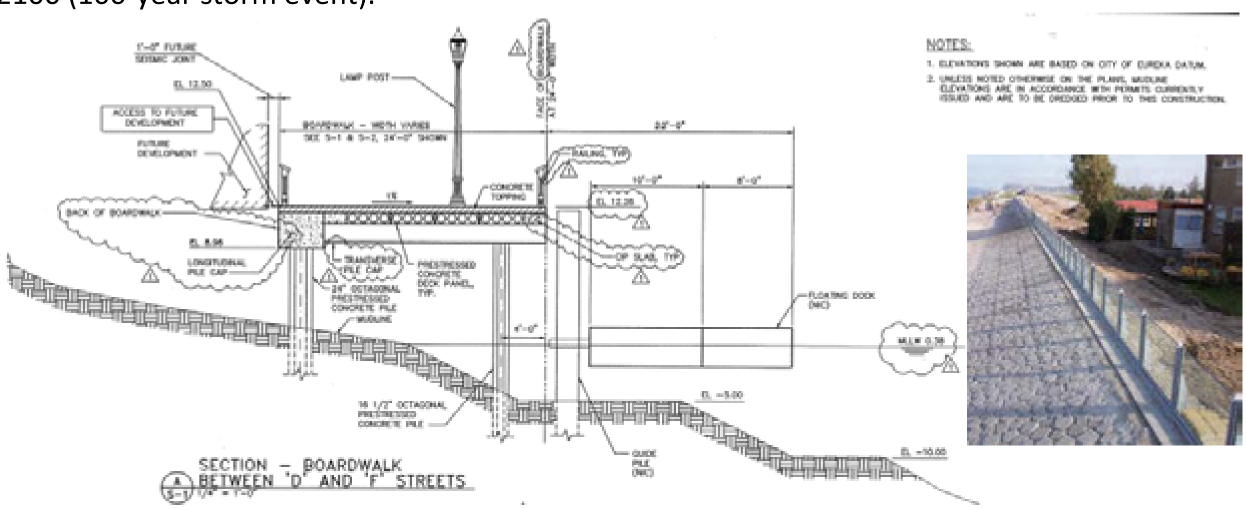
The first area to be significantly impacted by groundwater infiltration will likely be the low lying agricultural lands on the north and south entrances to the City. Groundwater tables will likely rise to the point that they no longer support the growth of grasses suitable for grazing. Adaptation measures can delay the groundwater intrusion. However, if sea levels continue to rise and the lands continue to sink, these areas will likely eventually convert to wetlands at some point in the future. For how long and at what cost will the community and property owners continue to protect those resources is unknown?

XII ADAPTATION GOALS:

The City's overall goal is to protect all lands currently zoned for urban growth until the magnitude of Sea Level Rise change is such that the protection management strategy can no longer protect all the lands zoned for urban growth. Once this "adaptive tipping point" is reached, an alternative adaption strategy will be needed. The concept of "adaptation tipping points", has been utilized in the Netherlands and other areas for years. Expressing uncertainty in terms of the period that the existing strategy is effective (when will a critical point be reached) was found to be useful for the policy makers.

Per the Article Using adaptation tipping points to prepare for climate change and sea level rise, a case study for in the Netherlands: “An ATP analysis starts from the perspective that a water system provides the natural boundary conditions for living and working in this region, summarized as the boundary conditions for socio-economic activities. The system needs to be managed to maintain the proper conditions and achieve our objectives for living in the delta.”

The adaptation tipping point approach could be useful for Eureka and the region to consider. An example, of this approach is the Eureka Boardwalk between D and F Streets. This section was designed with the top of the concrete at the end of the Boardwalk at an elevation of 12 feet 4 inches with the top of the railing approximately an additional 3 feet 8 inches. If at some point in the distant future the railing will be converted from bars to a heavy duty solid barrier designed to withstand wave run-up, the Boardwalk at this location would have 16 feet of protection. The adaptation tipping point method would tell you that this location on the Boardwalk with relatively small improvements could protect beyond the projected 13.1 feet 2100 (100-year storm event).



Glass or acrylic over-topping walls provide strong and safe resistance to periodic stormwater surges while avoiding view disruption.
Source: SF Mission Creek Adaptation Study

XIII Eureka’s Shoreline:

As with almost all other coastal cities, Eureka, and the property owners along the bay, have a great deal of experience with managing the regular threat of coastal flooding and the regular the constant pounding shoreline structures take with every rising tide. Although we have not historically called them “Sea Level Rise Adaptation Measures”, almost all of Eureka’s shoreline is composed of man-made structures which have effectively “held back” and protected the City from the approximately eighteen inches of sea level rise which has already occurred over the last century. The City will need to continue to maintain existing, replace decaying, and construct new and improved adaptation measures over the next century to remain protected.

The type and condition of man-made shoreline is important when evaluating an area's vulnerability to erosion and future sea level rise. In January, 2013, Trinity Associates published the Humboldt Bay Sea Level Rise Adaptation Planning Project: Phase 1 Shoreline Inventory, Mapping, and Vulnerability Assessment. The 2013 Report was prepared to:

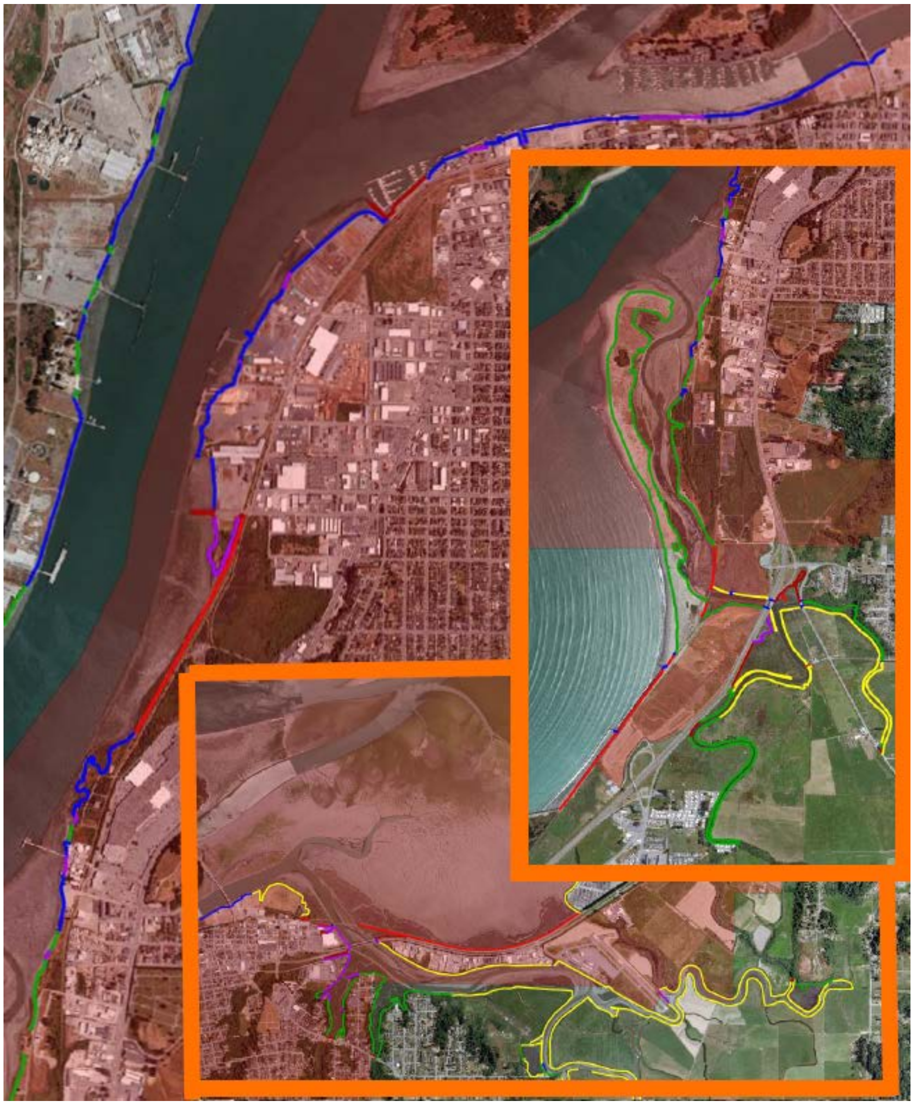
- Inventory and map existing shoreline conditions on Humboldt Bay;
- Assess existing shoreline vulnerability to breaching or overtopping, under current tidal and climatic conditions;
- Assess existing shoreline vulnerability to sea level rise; and
- Identify land uses and infrastructure that could be affected if the existing shoreline fails to retain the tides.

The 2013 Report provides the most detailed and current assessment available of the natural and man-made shoreline of Humboldt Bay, including those sections within the Eureka LCP Area. As such, the Eureka Local Coastal Plan Update is expected to rely extensively on the findings of the 2013 Report to establish appropriate policies and programs.

Man-made shoreline cover was categorized as either fortified or unfortified. Fortified shorelines consist of revetments or rip rap made of rock or concrete, or bulwarks of wood and steel. Unfortified shorelines include earthen levees that were either vegetated or exposed are more prone to erosion and failure. A substantial portion of the man-mad structures along Eureka's shoreline have not been properly maintained and the Report documents that sever erosion and failure have occurred.

The report states that: "The shoreline of Eureka Bay is 15.9 miles long and 71% of the shoreline is composed of artificial structures, but only 6% of the artificial shoreline is exposed (3,587 feet) (Figure 76). The two dominant artificial shoreline structures are fortified shoreline segments (49%, 29,657 feet) and the NCRA's railroad grade (15%, 8,794 feet). Other types of artificial shorelines are fill (10%), bulwarks (6 %), and roadways (6%). The railroad grade is mostly fortified (66%), 2,980 feet are vegetated, and none is exposed. There are 2,015 feet of exposed fill and 963 feet of exposed road way."

The following figure illustrates the sections of the Eureka's shoreline that are natural shoreline (green), dikes (yellow), railroad, (red), and the remaining colors represent other artificial shoreline types such as the Eureka Boardwalk, bulwarks, and roads. These Figures show how almost all of Eureka's shoreline is comprised of artificial man-made structures. To assist with analyzing potential alternative adaptation measures much of the information is available as GIS data files.



Natural shoreline (green), dikes (yellow), railroad, (red), and the remaining colors represent other artificial shoreline types such as the Eureka Boardwalk, bulwarks, and roads.

XIV WATERSHED BASINS:

There are several creeks traversing Eureka's urban area that drain into Humboldt Bay as well as several unnamed watershed sub basins in Eureka's urban core. It is critical that sea level rise adaptation measures be designed at the watershed and sub basin level. In Eureka's urban core these sub basins have been significantly altered and managed. Road, rail lines, levees and other man-made features form barriers to the natural flow of runoff and it is common that ditches, tide gates, and storm water collection lines artificially redirect the water that flows into the bay.

These man-made features serve multiple roles and are critical to not only direct and redirect storm water runoff, but also serve as barriers and reconveyance features to hold back or delay

Eureka's tidewaters. The elevations of the tiers, or barriers, that form may of the sub-basins adjacent to Eureka's shoreline. To plan and adapt to sea level rise, it will be essential for planners, engineers, and resource managers to drill down to the creeks, watershed sub-basin, levees, roads, rail lines, tide gates, storm water collection lines, and other natural and man-made features that form additional barriers behind the immediate shoreline.

XV Storm Water:

Critical infrastructure required to manage Eureka's storm water that is expected to be affected by sea level rise includes tide gates, levees, and storm water lines. Understanding the interrelationship and interface between Eureka's storm water runoff/floodwaters and the ever-rising tidewaters is fundamental to Eureka's efforts to adapt to sea level rise. As the tidewater continues to rise with sea level rise, we are also expected to see an increase in the frequency and intensity of storms that will generate rising floodwaters. Eureka's weather patterns typically bring the highest runoff at the same general season that we experience our highest tides. Eureka is the most vulnerable when these "king tides" occur at the same time that ocean storms generate the highest tidal surge, and inland storms result in coastal flooding.

HUMBOLDT BAY

Shoreline Inventory, Mapping and Sea Level Rise Vulnerability Assessment

Aldaron Laird
Trinity Associates

Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment

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January 2013

Humboldt Bay Sea Level Rise Adaptation Planning Project:
Phase 1
Shoreline Inventory, Mapping, and Vulnerability Assessment

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All photographs are by Aldaron Laird, unless otherwise credited.
Cover photograph of Wiyot Tribe's world renewal ceremonial site, Tuluwat, during a King Tide.

The Birth and Growth of Humboldt Bay
in
Indian Lore of the North California Coast
by
Austen D. Warburton and Joseph F. Endert

1966

A long time ago there was a small grassy pool located where Humboldt Bay [Wigi] now lies. In this pool there were many frogs, so many that there was not food enough for all of them. They became very hungry and talked loud and long at night, calling to their friends, the Indians, for help. In those days there was great friendship between the two peoples.

There was an old man commonly known as May-wee-Mur. May-wee-Mur went to the see what was troubling the frogs after hearing them talk so much at night. The frogs told him that they wanted a bigger pool where there would be more food. May-wee-Mur told them that he would try to find such a pool, and in return the frogs said that they would help him. They told the old man that a deer had passed that way going to the ocean to lick salt off the rocks. The old man had his bow and quiver full of arrows with him, and headed for the ocean.

When the old man came near the ocean he saw the deer licking the rocks, and the old man was able to kill it with his first arrow. While May-wee-Mur was dressing the deer, Ka-Ha-mis, the Water Spirit, came close to shore in the breakers near where the old man was. Ka-ha-mis said: "I am very hungry. The sea has been so rough I have not been able to get any food. If you will give me the deer I will do much for you in your life time."

The old man was sorry for Ka-ha-mis as he, too, knew what hunger was in his younger life, and he gave the deer to the Water Spirit.

In those days the Indians used to hunt sea lions for food on the rocks toward Trinidad, and when one would be killed the carcass of the animal would be towed in the water behind the Indian's sea going canoe to the place where the entrance to Humboldt Bay now is. The carcass was there dragged across the sand and over swampy land to the place where the Indian village was located. This required a great deal of effort and consumed a great deal of time. When Ka-ha-mis saw how hard the Indians had to work to get their food, he was sorry for them. He also wanted to show his appreciation to May-wee-Mur, and decided to help the Indians.

Kah-ha-mis went to the little pond and thrashed around with his great strong body many times, until it grew to its present size. He then had to connect it with the ocean. To do this he had to thrash his way back and forth between the bay and the ocean many times before he had a channel wide and deep enough for ocean going canoes to travel freely. A great earthquake occurred and a tidal wave came which further widened the entrance to the bay now known as Humboldt. Ever since the Indians had no trouble in bringing the sea lions and their canoes right up to their village. Thus, for the old man's kindness to Kah-ha-mis he was repaid many times. "It is always that way," say the Indian grandmothers.

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Chapter 1 Introduction

In 2008, Governor Schwarzenegger issued Executive Order S-13-08 which identified the necessity to plan for and adapt to sea level rise. In response, the State Coastal Conservancy (SCC) authorized funding for a multi-phase sea level rise adaptation planning effort for Humboldt Bay. The Humboldt Bay Inventory, Mapping, and Sea Level Rise Vulnerability Assessment Project is the first phase of this effort.

The purpose of this project is to:

- inventory and map existing shoreline conditions on Humboldt Bay,
- assess existing shoreline vulnerability to breaching or overtopping, under current tidal and climatic conditions,
- assess existing shoreline vulnerability to sea level rise,
- identify land uses and infrastructure that could be affected if the existing shoreline fails to retain the tides.

This project is needed because:

- a comprehensive inventory and mapping of artificial shoreline structure, cover, and elevation, does not exist for Humboldt Bay,
- in the last decade, state declarations of emergency and shoreline breaching and overtopping illustrate the vulnerability of existing shoreline structures which has resulted in salt water flooding of lands behind these structures,
- during this century, global sea levels are predicted to rise at an increasing rate; conservative estimates are 6 inches by 2030, 12 inches by 2050, and 36 inches by 2100 (Griggs 2012),
- relative sea level rise rates may be greater on Humboldt Bay because of tectonic subsidence of the land and compaction of former tidelands.

This project will create a GIS database containing geo-spatial data of Humboldt Bay's shoreline. The database will build upon existing inventories of water control structures such as tide gates and culverts, and distribution of salt marsh. Chapter 2 will describe the methods employed to inventory and map the shoreline. Chapter 3, based upon the results of the inventory and mapping, will describe existing shoreline conditions of structure, cover, and elevation. Chapter 4 contains a vulnerability assessment of existing shoreline conditions under current tidal and climatic conditions as well as to rising sea levels. Chapter 5 summarizes the project's findings and vulnerability assessment along with recommendations on subsequent phases of the sea level rise adaptation planning for Humboldt Bay.

a) Humboldt Bay Shoreline Changes/Historical Context

Historically, the original U.S. Surveyor General Township Plats of 1854 depicted Humboldt Bay as occupying approximately 25,800 acres, of which 15,300 acres (59.3 percent) were tidal channels and inter-tidal mudflats, and 10,500 acres (40.7 percent) were inter-tidal wetlands, salt marsh (Laird 2007). Today, salt marsh occupies just 4 percent of Humboldt Bay (Barnhart 1992). Between 1890 and 1910, Humboldt Bay underwent a dramatic change on the scale that we perhaps now face with sea level rise. A comparison of the 2009 shoreline location with that depicted in the 1870 US Coast and Geodetic Survey (USCGS) of Humboldt Bay, serves to illustrate the magnitude of change to the Bay (Figure 1). Nearly 90 percent of the salt marsh (8,100 acres) was diked and drained for agricultural uses or walled off from tidal inundation with the construction of the Northwest Pacific Railroad (Pickart 2006). Over the last century, with the loss of sediment accretion from daily tidal inundation, these former tidelands have compacted as organic material has decomposed. Also, subsidence is occurring and has been recorded at the North Spit tidal station. Humboldt Bay has the highest rate of sea level rise (18.6 inches per century) in California (Russell 2012). Today, the result of compaction and subsidence is that former tidelands behind dikes are lower in elevation than the Bay and high tides. Absent a tide water flood model based on existing conditions, the former tideland footprint surveyed in 1870 will be considered, at a minimum, the potential inundation zone for this project vulnerability assessment.

Figure 1, 1870 USCGS survey of Humboldt Bay, with 1870 shoreline (blue) and 2009 shoreline (red for artificial and green for natural) serves to illustrate the magnitude of change to the Bay.

b) Humboldt Bay Shoreline Survey

For purposes of this vulnerability assessment, because rising tides do not recognize property boundaries; Humboldt Bay has been segregated into six individual hydrologic units: Arcata Bay, Eureka Bay, South Bay, Mad River Slough, Eureka Slough, and Elk River Slough (Figure 2). The shoreline of Humboldt Bay is defined as the boundary between the upper reach of the tidal zone and adjacent upland, often visible as the boundary between salt tolerant vegetation versus freshwater vegetation. On natural shorelines the tidal boundary was found to be closely associated with the mean monthly maximum water (MMMW) surface elevation in Humboldt Bay, which is the average of the maximum measured tide levels each month. The MMMW tide elevation is 7.74 feet (all elevations used in this report are referenced to the North American Vertical Datum of 1988 (NAVD 88) at the North Spit tide gage (National Oceanic and Atmospheric Agency (NOAA) Station 9418767). Utilizing geographic information system (GIS) software, the shoreline was first digitized and segmented based upon physical attributes on 2009 aerial photography; then the entire shoreline of Humboldt Bay was ground truthed to verify shoreline location, attributes, and segment boundaries. The GIS shoreline layer has been updated to reflect field observations. Lastly, NOAA coastal light direction and ranging (LiDAR) data from 2010 and a three dimensional tidal grid of the MMMW surface elevation (Anderson 2012) were utilized to re-align the digitized natural shoreline, if needed, where the vegetative boundary was difficult to discern or non-existent.

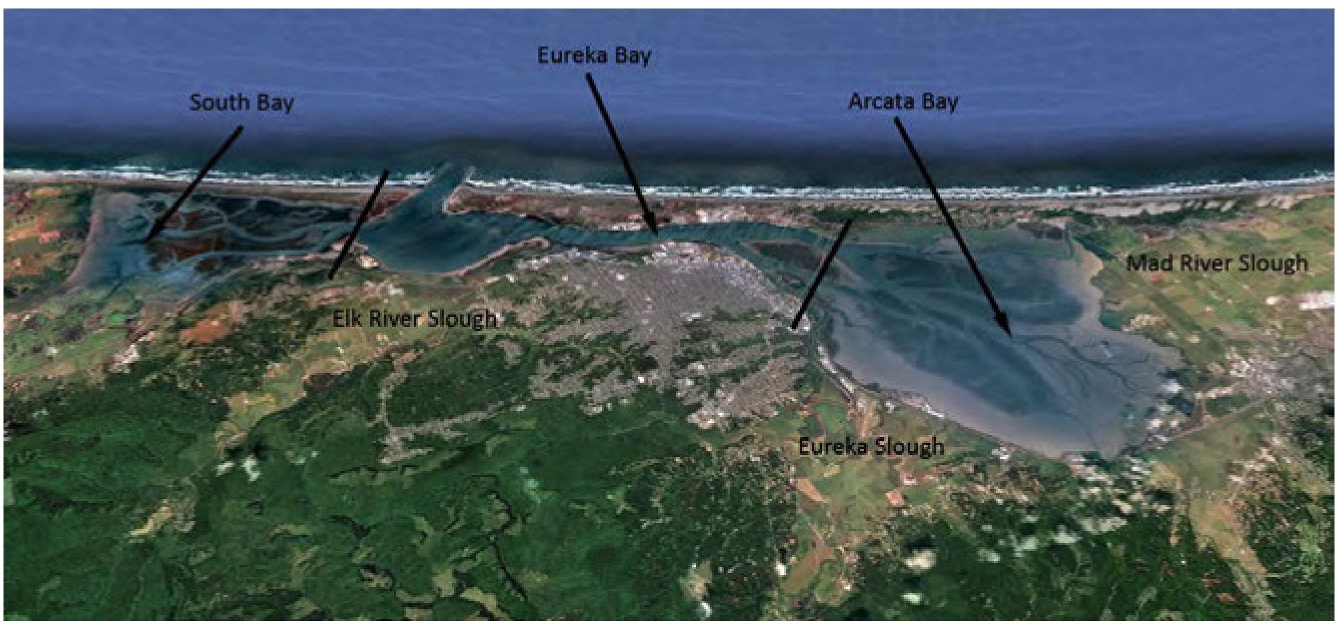

Figure 2, Humboldt Bay's hydrologic units (Google 2012).

c) Humboldt Bay Shoreline Vulnerability Assessment

Sea level rise adaptation planning should begin with a vulnerability assessment (Griggs 2012). This project's vulnerability assessment focuses upon the shoreline of Humboldt Bay and its resiliency to coastal hazards such as erosion and flooding under current and future sea levels. The current shoreline of Humboldt Bay, especially its dikes, have never been comprehensively inventoried or mapped. Creation of a baseline of existing shoreline conditions will facilitate assessment of the current vulnerability of the shoreline and the flooding risk of lands, uses, and infrastructure on former tidelands, if nothing is done to rehabilitate or enhance the existing shoreline conditions.

As mentioned earlier, global or eustatic sea levels are predicted to rise at an increasing rate during this century; conservative estimates of sea level rise are 6 inches by 2030, 12 inches by 2050 and 36 inches by 2100 (Griggs 2012). However, relative sea level is subject to change if land levels fall (National Research Council (NRC) 2012). Based upon the North Spit tide gage record, since 1977, Humboldt Bay is subsiding and its average rate of relative sea level rise, 4.72 mm/yr (18.6 inches per century), is greater than anywhere else in California (Russell 2012).

El Nino events with elevated water temperatures can also increase sea levels for several winter months by as much as 1 foot. On Humboldt Bay during the El Nino events of 1983, the winter extreme high tide (EHT), known as King Tide, was 9.38 feet and in 1998, it was 9.07 feet. Since 2000, King Tides during seven of the last twelve years have exceeded the average EHT of 8.79 feet at the North Spit tidal station, with the highest tide reaching 9.55 feet. In 2003, the EHT combined with a storm surge reached 9.51 feet, breaching an un-fortified earthen dike on Mad River Slough flooding nearly six hundred acres of pasture (Figure 3). In 2006, the maximum high tide after a period of heavy rainfall reached 9.49 feet and Arcata Bay's northern diked shoreline and City of Arcata's wastewater treatment ponds and marsh dikes were over topped in multiple locations (Figure 4). In response to a combination of a storm surge and EHT shoreline damages, the Governor, in 2006, declared a state of emergency on Humboldt Bay. Emergency dike repairs were authorized at least five locations (Reclamation District 768-Mad River Slough & Arcata Bay, City of Arcata-Arcata Bay, California Redwood Company-Arcata Bay, North Coast Railroad Authority (NCRA)-Eureka Bay, and Humboldt Bay National Wildlife Refuge (HBNWR)-South Bay). In 2010, the maximum high tide reached 8.94 feet and a dike on Fay Slough, a tributary to Eureka Slough, was overtopped flooding 16 acres of state wildlife refuge (Figure 5). This project will identify shoreline areas that are currently in an eroded state and are vulnerable to breaching and shoreline areas of low elevation that are vulnerable to being overtopped by EHT with or without the effects of El Nino. This project will also identify shoreline areas that are vulnerable to overtopping at MMMW and EHT and with sea level rise if existing conditions persist.

Figure 3, 2003 breach on Mad River Slough, 9.51 foot tide and storm surge (Times Standard, Andrew Bird, January 26, 2004).

Figure 4, 2006, the maximum high tide after a period of heavy rainfall reached 9.49 feet and Arcata Bay's northern diked shoreline and City of Arcata's wastewater treatment ponds and marsh dikes were over topped in multiple locations.

Figure 5, 2010, the maximum high tide reached 8.94 feet and a dike on Fay Slough, a tributary to Eureka Slough, was overtopped flooding 16 acres of state wildlife refuge.

Chapter 2 Description of Shoreline Inventory and Mapping Methods

The intent of this shoreline inventory and mapping is to create a GIS database containing spatial data on the location of the tidal/upland boundary and distribution of shoreline attributes. As described previously, a unique aspect of this inventory and mapping effort is that the entire 102 miles of shoreline was ground truthed to verify shoreline location, attributes, and segment boundaries. In 2012, NOAA released a LiDAR dataset which was utilized to establish shoreline elevations. USFWS 2007 water control structure survey and NOAA's 2009 benthic habitat GIS databases for Humboldt Bay have been incorporated and expanded in this project's database. This project's database should be updated as new shorelines are created or existing shoreline conditions are modified.

The inventory and mapping of existing shoreline conditions on Humboldt Bay contains three elements: structure, cover, and elevation. The presence of water control structures and salt marsh are also included. A GIS database containing spatial data of existing shoreline conditions has been created for these five attributes. These attributes were selected to quantify existing conditions and to support a vulnerability assessment of existing shoreline conditions and various sea level scenarios.

This project utilized 2009 color aerial photography that has been orthorectified and geo-referenced to real word coordinates (UTM Nad 83 meters). Through photographic interpretation, the tidal/upland shoreline was digitized on the 2009 aerial photography. Aerial photograph/map sheets, 11x17 at a scale of 1" = 200', covering the entire perimeter of each hydrologic unit, were printed and used in the field to ground truth the computer based shoreline delineation and photographic interpretations of shoreline attributes and segment boundaries (Figure 6). Changes to shoreline location, segment attributes, or unit boundaries, were corrected directly on the map sheets. Following ground truthing, GIS databases were updated. Digital photographs were taken to record conditions at each shoreline unit and the boundary between units.

Historical maps (1854, 1870, 1890, 1916, 1921, 1933, and 1942) and aerial photography (1948, 54, 58, 65, 70, 81, and 88) from the 2007 Digital Historical Atlas of Humboldt Bay and Eel River Delta (Laird 2007) were incorporated into this project's GIS database to facilitate interpretations of historical changes in shoreline conditions and location such as placement of fill (Figure 7).

The shoreline was segmented; individual units were delineated based upon changes in physical attributes of type, structure, cover, and whether salt marsh habitat is present (Table 1). Initial attributes of structure and cover, developed during interpretation of aerial photographs, were augmented as new attributes where encountered during ground truthing. The list of attributes below is represented by at least one shoreline segment.

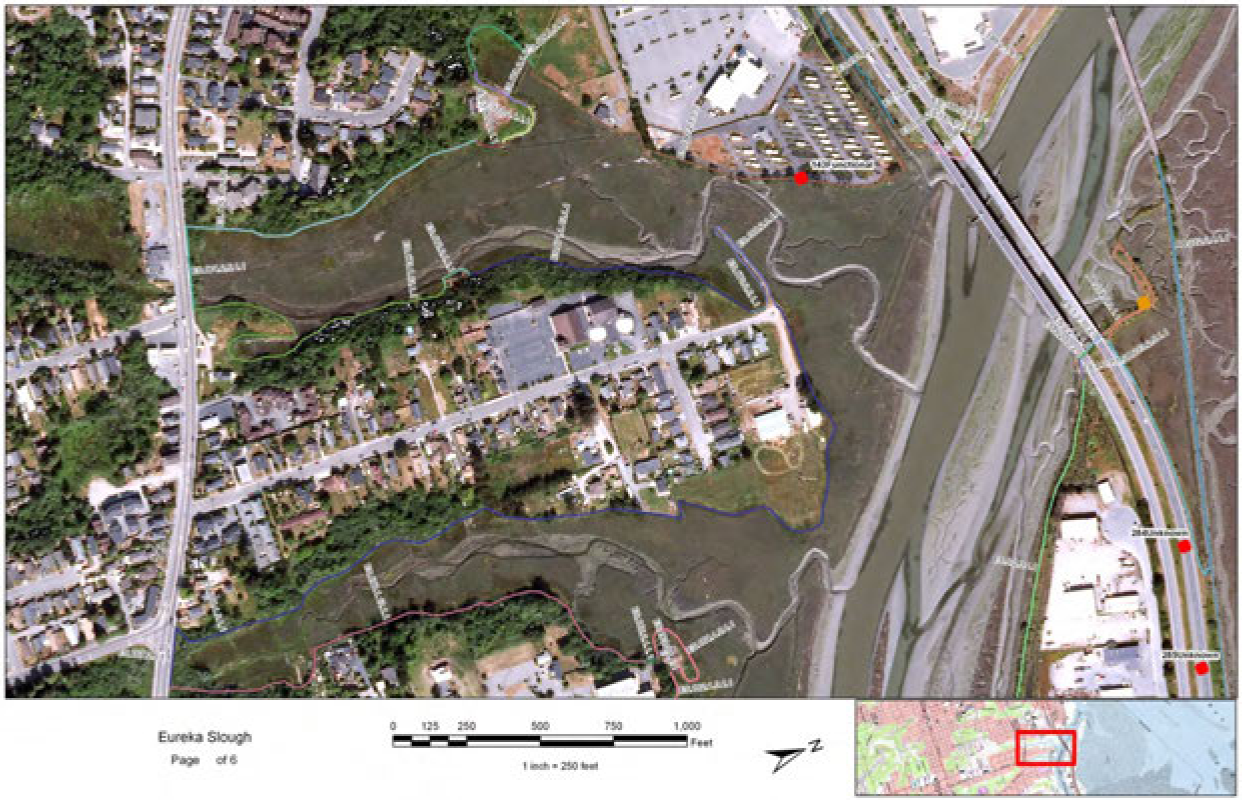

Figure 6. Example of aerial photograph/map sheets used during ground truthing the computer based shoreline delineation and photographic interpretations of shoreline attributes and segment boundaries.

Figure 7. Comparison of 1948 and 2009 aerial photographs documents the placement of fill in Mad River Slough, current shoreline depicting artificial (red) and natural (green) segments.

ATTRIBUTES					
Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Area	Segment	Type	Structure	Cover	Salt Marsh
MRS	Unit #	Natural-1	None-0	None-0	None-0
AB		Artificial-2	Fill-1	Vegetated-1	Salt Marsh-1
ES			Fortified-2	Exposed-2	Brackish Marsh-2
EB			Dike-3	Rock-3	
ERS			Railroad-4	Concrete-4	
SB			Road-5	Wood-5	
			Bulwark-6	Steel-6	
			Building-7	Rock/Concrete-7	
			Pond-8	Asphalt-8	
			Boat Ramp-9		
			Bridge Abutment-10		
			Tidegate-11		
			Cliff/Bluff-12		
			Fore Dune-13		
			Jetty-14		

Table 1. Hydrologic unit codes and attributes used to delineate and identify individual shoreline units.

The following is an example of shoreline segment identification code, which is unique to that unit.

- MRS.8.2.3.3.0
    - MRS = Mad River Slough hydrologic unit
    - 8 = Sequential segment number
    - 2 = Artificial shoreline type
    - 3 = Dike structure
    - 3 = Rock cover
    - 0 = Salt marsh not present

a) Shoreline Structure

Shorelines are either natural or artificial. Artificial shorelines are composed of man-made structures that, without maintenance, may fail to serve the function that they were constructed to serve. Shoreline structures can either armor or harden an existing natural shoreline or create a new shoreline where none existed previously. The following definitions were utilized to describe the types of shoreline structures encountered:

Type:

- Natural

A shoreline that appears natural and when there is no historical evidence of the shoreline having been artificially manipulated (Figure 8).

Figure 8. West side of South Bay is an example of a natural shoreline.

- Artificial.

A shoreline that is composed of a man-made structure, or in the case of *fill,* where there is historical evidence of the Bay having been artificially filled (Figure 9).

Figure 9. West side of Eureka Bay, the Coast Guard station is an example of a man-made or artificial shoreline.

Structure:

- None.

A shoreline with no structure is a natural shore or slough bank that is neither a cliff/bluff nor a fore dune (Figure 10).

Figure 10. Eureka Bay is an example of a shoreline with no structure eroding on Humboldt Bay.

- Fill.

A new shoreline created by filling the Bay or former inter-tidal wetlands with soil or other materials; placement of fill is established by reviewing historical maps or aerial photographs.

- Fortified.

A natural shoreline structure, which has been armored with revetment, is a fortified shoreline.

- Dike.

An earthen wall-like structure constructed to prevent tides from inundating land behind the dike (Figure 11). Most dikes on Humboldt Bay were constructed at the inter-tidal boundary between mudflats and salt marsh; lands behind the dikes were drained and converted to agricultural uses.

Figure 11. Hookton Slough on South Bay is an example of an earthen dike with rock revetment and roadway that is being maintained.

- Railroad.

Generally a trapezoidal fill prism constructed to support rails for use by trains to transport materials and people (Figure 12). Most of the railroad grade traverses former inter-tidal areas and railroad grades provide similar protection to landward areas as do dikes on Humboldt Bay. At this time the railroad has not been used commercially for more than a decade and much of the railroad grade has not been maintained.

Figure 12. West-side of Arcata Bay is an example of the railroad grade on Humboldt Bay with rock revetment.

- Road.

A road is a transportation corridor generally surfaced with asphalt; most often publicly owned and maintained (Figure 13).

Figure 13. Arcata Bay, State Highway 255 is an example of a roadway forming the shoreline on Humboldt Bay.

- Bulwark.

A bulwark is a solid wall generally constructed of wood, concrete, or steel to protect the land behind from wave induced erosion (Figure 14).

Figure 14. Eureka Bay is an example of a concrete bulwark forming the shoreline of Humboldt Bay.

- Building.

A structure forms the shore which is made up of a building or its foundation (Figure 15).

Figure 15. Eureka Bay is an example of a building and its foundation forming the shoreline of Humboldt Bay.

- Pond.

A pond is a type of dike that is constructed to enclose and protect an aquatic environment such as in a waste water treatment facility rather than former inter-tidal lands (Figure 16).

Figure 16. Arcata Bay is an example of a wastewater treatment pond forming the current shoreline of Humboldt Bay.

- Boat Ramp.

A boat ramp is a structure traversing the shore to allow boats to enter or exit the water (Figure 17).

Figure 17. City of Eureka marina is an example of a boat ramp forming the shoreline of Humboldt Bay.

- Bridge Abutment.

An abutment is a footing structure that supports one end of a bridge spanning a water body (Figure 18).

Figure 18. Eureka Slough is an example of a bridge abutment forming the shoreline of Humboldt Bay.

- Tidegate.

A tidegate is a water control structure, often set in a concrete wall-like structure, which enables the land behind a dike to drain on an ebbing tide but closes to prevent tidal inundation on a rising tide (Figure 19).

Figure 19. Elk River Slough is an example of a tidegate forming the shoreline of Humboldt Bay.

- Cliff/Bluff.

A cliff or bluff is a type of natural shoreline structure which is nearly vertical, formed by wave induced erosion or tectonic activity (Figure 20).

Figure 20. Table Bluff on South Bay is an example of a cliff/bluff forming the shoreline of Humboldt Bay.

- Fore dune.

A fore dune is a type of natural shoreline structure made up of a ridge of sand parallel to the shoreline that rises above mean high water elevation and is generally vegetated with plants tolerant of sand and salt spray (Figure 21).

Figure 21. Elk River Spit on Eureka Bay is an example of a fore dune forming the shoreline of Humboldt Bay.

- Jetty.

A structure, generally made of rock, that extends out into a body of water to influence the current or tide to protect the shore (Figure 22).

Figure 22. King Salmon on Eureka Bay is an example of a jetty forming the shoreline of Humboldt Bay.

b) Shoreline Cover

The following definitions were utilized to describe shoreline cover:

- None.

An absence of shore cover generally associated with a natural shoreline with no structure or an area of fill, without vegetation, that is not fortified or eroding (Figure 23).

Figure 23. Elk River Spit on Eureka Bay is an example of a shoreline with no cover on Humboldt Bay.

- Vegetated.

A vegetated shore is predominately covered with vegetation (Figure 24 a and b).

Figure 24a. Mad River Slough is an example of a shoreline with vegetated cover that is gazed on Humboldt Bay.

Figure 24b. Fay Slough is an example of a shoreline with vegetated cover that is not grazed on Humboldt Bay.

- Exposed.

An exposed shore is one that is generally vertical and eroding and is without vegetation or armorment (Figure 25).

Figure 25. Mad River Slough is an example of contrasting shorelines one that is exposed and the other with concrete revetment on Humboldt Bay.

- Rock.

A shore fortified with rock revetment (Figure 26).

Figure 26. Eureka Bay is an example of a shoreline with rock revetment on Humboldt Bay.

- Concrete.

A shore fortified with broken concrete revetment or a structure constructed of concrete (Figure 27).

Figure 27. Arcata Bay is an example of a shoreline that is covered with concrete revetment on Humboldt Bay.

- Wood.

A shoreline structure constructed of wood (Figure 28).

Figure 28. Eureka Bay is an example of a shoreline that is covered by a wood bulwark on Humboldt Bay.

- Steel.

A shoreline structure constructed of steel (Figure 29).

Figure 29. Mad River Slough is an example of a shoreline that is covered by a steel bulwark on Humboldt Bay.

- Rock/Concrete.

A shore fortified with rock and broken concrete revetment (Figure 30).

Figure 30. Arcata Bay is an example of a shoreline that is covered by a rock and concrete revetment on Humboldt Bay.

- Asphalt.

A shoreline covered in asphalt such as along a roadway.

c) Shoreline Elevation

In early 2012, the NOAA Coastal LiDAR dataset became available as a “hydro-flattened bare earth” digital elevation model (DEM). The LiDAR dataset reflects field conditions of 2010. Metadata provided with the DEM reported a vertical accuracy RMSE less than or equal to 18 centimeter (cm) and a horizontal accuracy of 50 cm RMSE or better. Brian Powell, GIS Specialist with McBain and Trush took a subset of the LiDAR DEM that included all portions of the Humboldt Bay shoreline (Figure 31). A contour layer was derived from the DEM and the DEM was color coded in 0.5 meter elevation increments. Digitized artificial shoreline segments were realigned with the contours and color coded DEM to ensure that the segments were aligned with the structures which they represent.

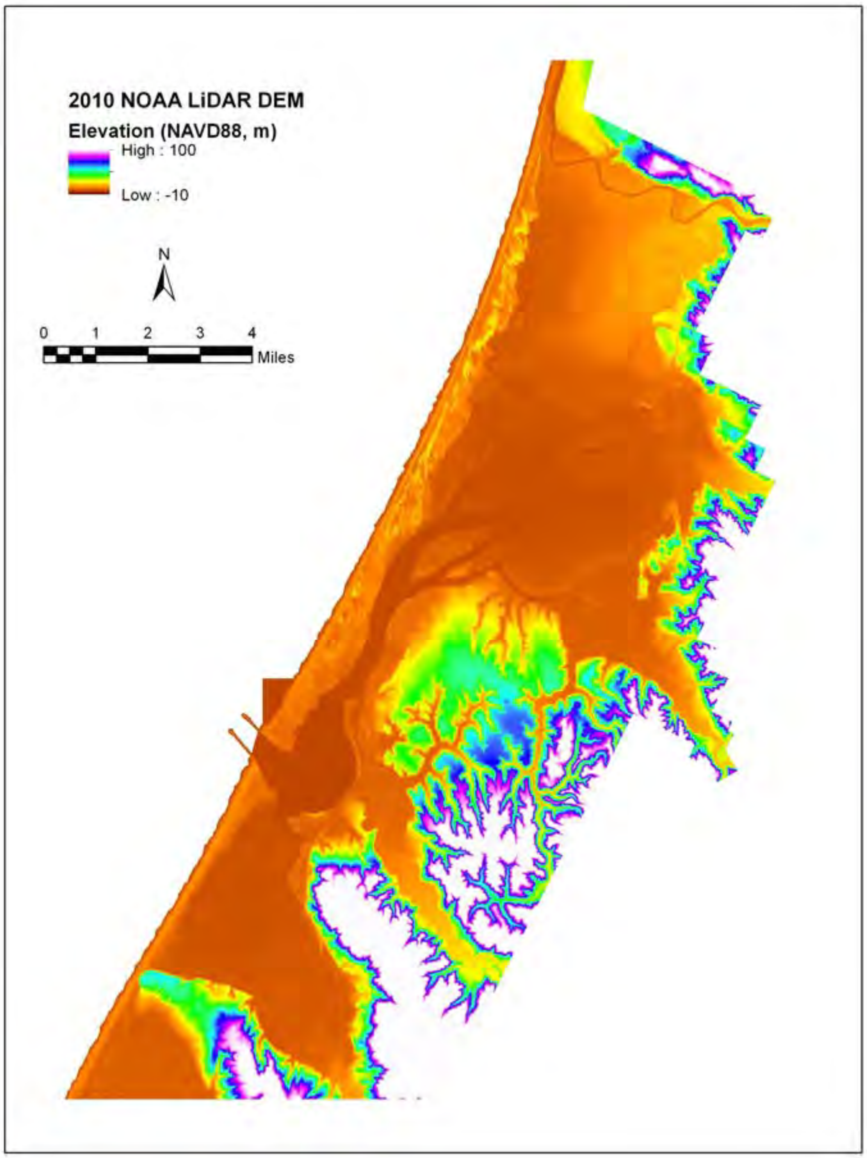

Figure 31. Humboldt Bay Lidar digital elevation model used in this project, NOAA 2012.

Generally twice a month, the Sun, Moon, and Earth align at the new moon and full moon phases. At these phases, the tidal force of the Sun and Moon is at its maximum, and the higher tides are known as spring tides, as in a rising spring, not the season. The average of the monthly maximum high tide, MMMW, was selected as the baseline water surface elevation to describe existing shoreline elevations and to assess the vulnerability of the shoreline.

Jeff Anderson, P.E. of Northern Hydrology and Engineering, prepared a DEM of Humboldt Bay representing water surface elevations of the present day MMMW surface (Figure 32). The MMMW surface was subtracted from the LiDAR DEM to produce a third DEM of relative elevations to the MMMW. These relative elevations were assigned to the shoreline segments at one meter spacing as the DEM is comprised of a one meter pixel resolution. The 1 meter spaced vertices of the shoreline segments were exported to a 3D point feature class. The shoreline segments were then broken at each vertex to produce 170,666 1 meter shoreline segments which all contained the original unique segment identifier, shoreline attributes, and start and end relative elevation values in the attribute table. An average relative elevation was calculated for each one meter shoreline segment and used as the basis for analysis. Identifying the location of the MMMW elevation for those reaches with natural shoreline segments verified or adjusted shoreline locations that relied on a demarcation between salt marsh and upland or freshwater wetland vegetation.

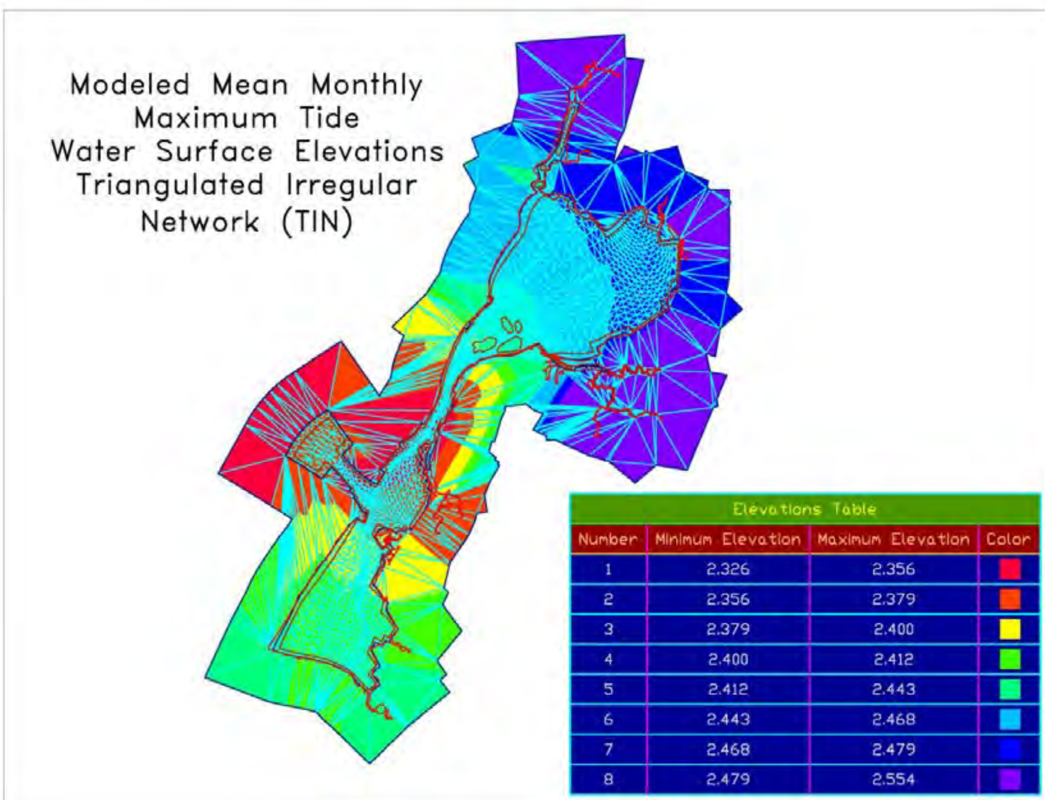

Figure 32. A DEM of Humboldt Bay representing water surface elevations of the present day MMMW surface.

d) Salt Marsh

In 2006, the SCC and its partners conducted the “Northern California Coastal Conservation Needs Assessment,” which highlighted the need for coastal and marine spatial data to protect resources and support ecosystem-based management (EBM). EBM program partners described and evaluated the inter-tidal and sub-tidal habitats of Humboldt Bay. Their work was greatly aided by acquiring high-resolution multispectral imagery in 2009, from which they generated a benthic habitat data set of the Bay and Estuary. Salt marsh was one of seven benthic habitats that were mapped (Figure 33).

Figure 33. NOAA's Coastal Services Center’s, Humboldt Bay 2009 GIS database of salt marsh habitat distribution on Humboldt Bay.

NOAA's Coastal Services Center's Humboldt Bay, California Benthic Habitats 2009 GIS database of salt marsh habitat distribution was incorporated into this project's GIS database. The area of coverage for the 2009 salt marsh survey was up to mean high water elevation on the shoreline of Humboldt Bay. Salt marshes behind dikes or water control structures were not included in the 2009 survey. Areas of salt marsh habitat that were not mapped by NOAA in 2009 but were located during the ground truthing phase of the shoreline inventory and mapping effort have been identified on a separate GIS layer. The extent of salt marsh habitat in these previously un-mapped areas has not been delineated.

Whether salt marsh habitat was present and attached to the shoreline was one of the attributes used to stratify shoreline segments. Narrow benches on earthen dikes are a common feature that has formed as result of cattle traversing dikes; these benches are often occupied by salt marsh vegetation. An arbitrary threshold was established of a minimum width of four feet of salt marsh for shoreline mapping purposes (Pickart pers. comm. 2011).

e) Water Control Structures

The USFWS conducted a comprehensive water control structure inventory, assessment, and mapping, of Humboldt Bay (Goldsmith 2007). The survey of culverts and tidegates controlling drainage to Humboldt Bay identified the location and function of these water control structures. The original diking and draining of former tidelands around Humboldt Bay, for agricultural purposes, required the installation of tide gates. The construction of railroads, highways, and streets, required the installation of culverts or bridges at the numerous streams or slough crossings around the Bay. These structures are owned and maintained by a multitude of private, local, state, and federal, agencies. The USFWs created a GIS database containing spatial data for all tidegates, culverts, and other water control structures, surrounding Humboldt Bay (Figure 34). The USFWS incorporated existing datasets and also conducted site visits to locate and assess water control structures. The USFWS water control database includes a total of 371 structures; 164 structures were field inventoried by USFWS, and the remaining 207 structures were imported from existing datasets. A total of 79 tidegates and 282 culverts were identified, as well as 10 other structures, principally splash board weir structures. The USFWS water control GIS database has been incorporated into this project's database.

While delineating the shoreline on the 2009 aerial photography, potential water control structures not previously mapped in 2007 were identified where drainage channels emanated from shoreline structures such as dikes into the Bay (Figure 35). During ground truthing of the shoreline, inventory and mapping the existence of these potential water control structures was either confirmed or denied. Confirmed water control structures location and type were identified on the field aerial photo sheets, photographed, and measurements taken, when possible, of the structure. A new layer in the GIS database contains the location and attributes of these newly located water control structures.

Figure 34. USFWS's 2007 GIS database, distribution of water control structures on Humboldt Bay.

3. Description of Existing Shoreline Conditions

The shoreline inventory and mapping has produced a comprehensive geo-spatial baseline of existing conditions: structure, cover, and elevation. This baseline also updates USFWS' 2007 database of the distribution of water control structures and NOAA's 2009 database of the distribution of salt marsh habitat. It is now possible to quantify shoreline conditions on Humboldt Bay as well as for each of the six hydrologic units that make up Humboldt Bay. With this database it is possible to locate shoreline units with specific characteristics such as the type of structure, cover, and elevation. The inventory and mapping data of shoreline attributes of structure, cover, and elevation will be summarized for Humboldt Bay in its entirety, and for the six hydrologic units.

a) Shoreline Structure

Humboldt Bay:

The perimeter of Humboldt Bay in 1870, as surveyed by the USCGS, was 60 miles, and today it is 102 miles in length. The two basic structural types are natural and artificial. The variety of shoreline structures on Humboldt Bay is impressive; dune and forest ecosystems, natural bluffs that form the linear southern boundary of the Bay, Elk River Spit and its fore dunes and salt marsh extending out into the shipping channel, miles of earthen dikes protecting vast areas of agricultural lands and wildlife refuges, a neglected railroad grade along much of the east shore of South, Eureka, and Arcata Bays and the west shore of Arcata Bay, working docks and fortified waterfront on Eureka Bay, two marinas, an imposing rock rip rap wall facing the harbor entrance and protecting the PG&E power plant, abandoned waterfronts at Fields Landing, Fairhaven, and Samoa, waste water treatment ponds, wildlife marshes, dense residential areas along the canals of King Salmon and First and Second Sloughs in Eureka, and the new boardwalk in Eureka.

Individual hydrologic units ranked by percent of Humboldt Bay's shoreline length:

- South Bay 21.3%
- Eureka Slough 20.3%
- Arcata Bay 20.0%
- Eureka Bay 15.5%
- Mad River Slough 13.4%
- Elk River Slough 9.5%

The shoreline is composed of 959 discrete segments; 75% of the shoreline is made up of artificial structures (76.7 miles) and 25% is natural (25.7 miles) (Figure 35) (Table 2). It is significant that 75% of the shoreline is artificial. Much of the artificial shoreline is over 100 years old. Artificial structures need to be maintained in order to retain their integrity and protect land uses and infrastructure behind these structures; particularly in the case of dikes, where lands reclaimed from the Bay are now lower in elevation than the daily high tides.

Figure 35. Humboldt Bay shoreline structure: 75% is artificial (red) and 25% is natural (green).

SHORELINE TYPE		ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET	TOTAL MILES	TOTAL PERCENT
Artificial	**Length (ft)**	98,619	59,772	78,132	57,623	87,834	22,829	**404,810**	**77**	**75%**
	Percent	91.2%	71.2%	67.8%	79.9%	80.1%	44.6%			
Natural	**Length (ft)**	9,486	24,131	37,122	14,508	21,854	28,396	**135,498**	**26**	**25%**
	Percent	8.8%	28.8%	32.2%	20.1%	19.9%	55.4%			
Total	**Length (ft)**	108,104	83,903	115,255	72,131	109,688	51,226	**540,307**	**102**	
	Percent	20.0%	15.5%	21.3%	13.4%	20.3%	9.5%			

Table 2. Humboldt Bay, artificial and natural shoreline length and percentage by hydrologic unit.

A significant portion of the shorelines in all of the hydrologic units are artificial (67.8-91.2%), except for Elk River Slough (44.6%). Arcata Bay contains the greatest amount of the artificial shoreline (98,619 feet) and South Bay has the greatest amount of the natural shoreline (37,122 feet). While there are 15 different types of shoreline structures, 95% of the shoreline is made up of just 6 types (Chart 1) (Figure 36). The dominant structural types are dikes occupying 40.7 miles of shoreline, natural 26.0 miles, railroad grade 10.5 miles, fill 7.7 miles, fortified 7.6 miles, and roadway 5.0 miles.

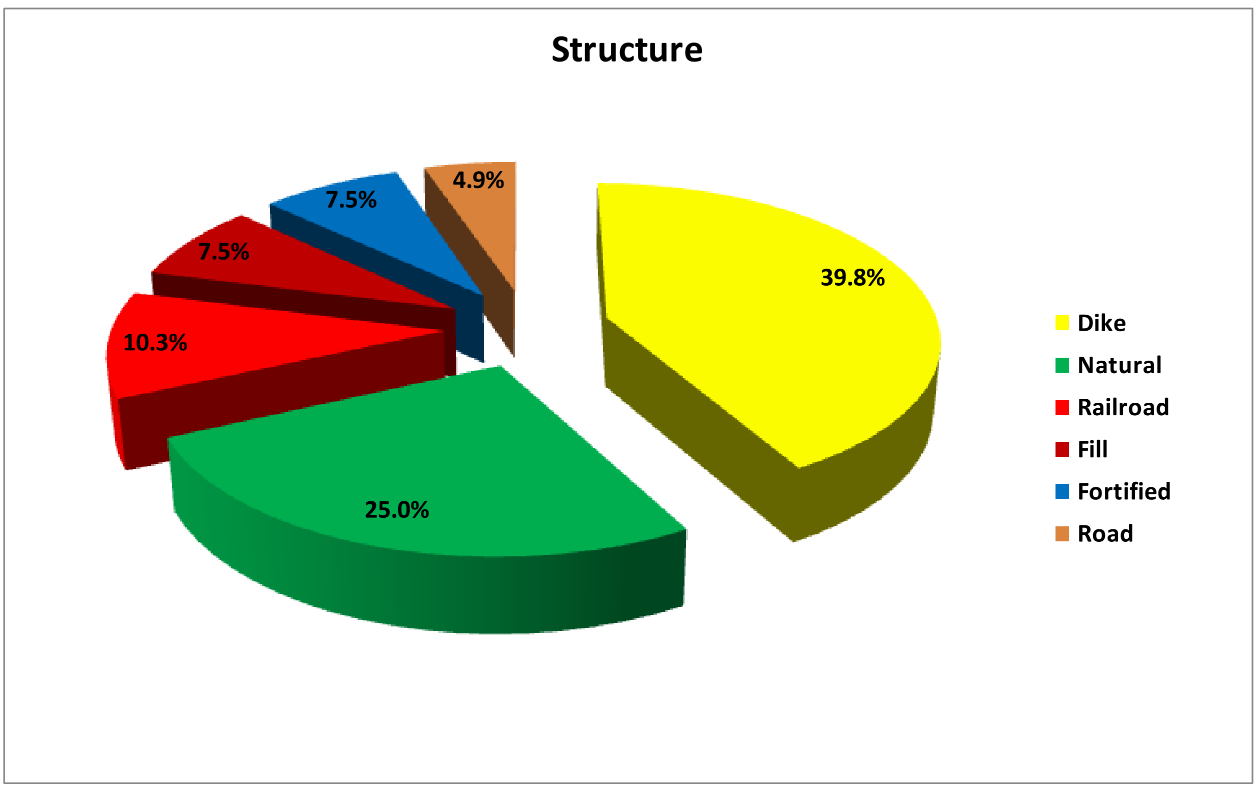

Chart 1. Percentage of Humboldt Bay shoreline occupied by the six most prevalent structures.

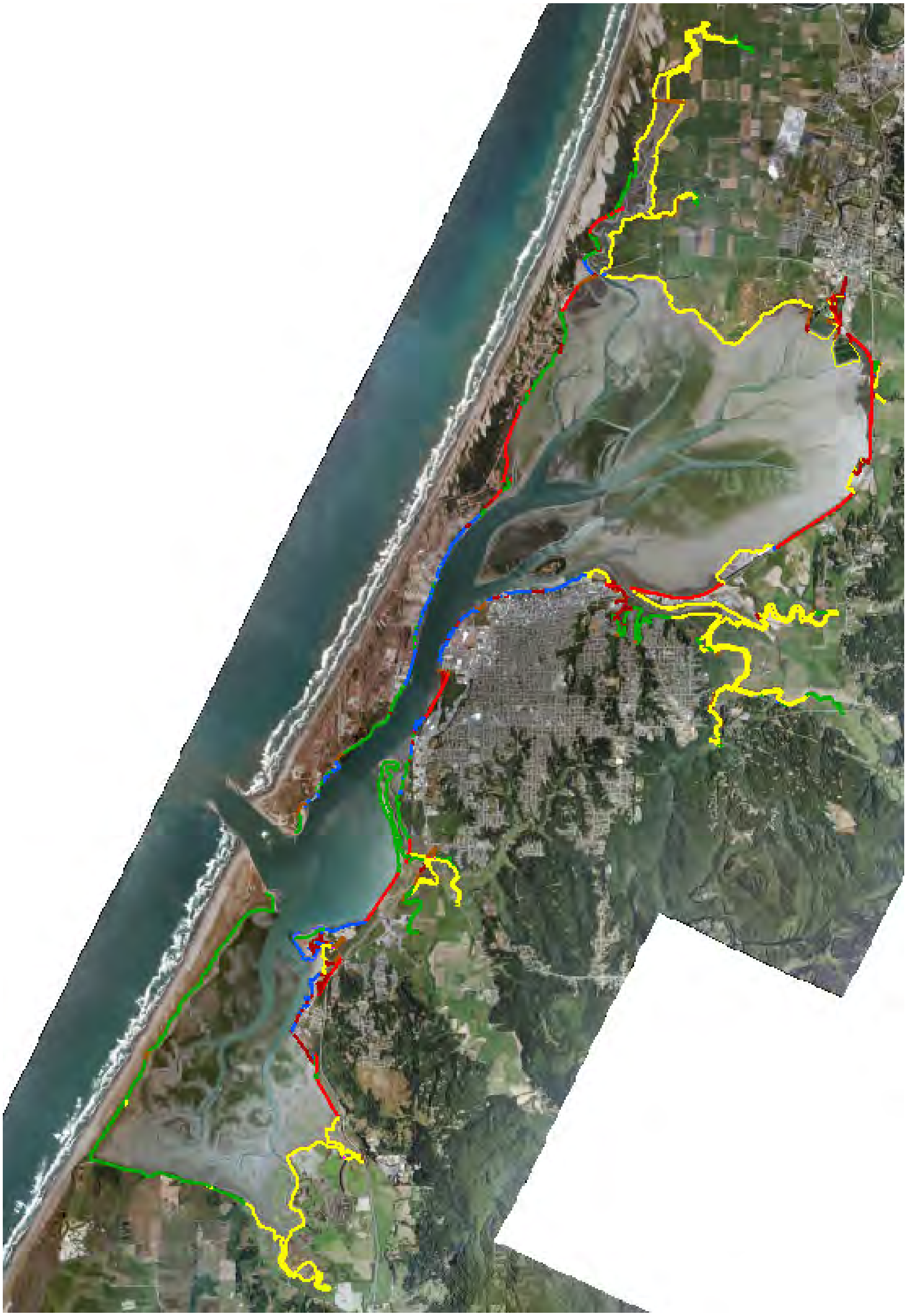

Figure 36. Distribution of shoreline structure types on Humboldt Bay: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

Of the five dominant artificial shoreline structures found on Humboldt Bay: Eureka Slough contains 35.2% of the diked shoreline on Humboldt Bay, Arcata Bay has 61.9% of the rail road, South Bay 24.1% of the fill, Eureka Bay 73.7% of the fortified shoreline, and Arcata Bay 25.7% of the roadway shoreline (Table 3).

ARTIFICIAL SHORELINE STRUCTURE		ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET	TOTAL MILES	TOTAL PERCENT
Dike	**Length (ft)**	33,107	3,077	40,215	47,471	75,588	15,334	**214,792**	**41**	**53.1%**
	Percent	15.4%	1.4%	18.7%	22.1%	35.2%	7.1%			
Fill	**Length (ft)**	12,935	6,309	13,816	469	6,059	955	**40,543**	**8**	**10.0%**
	Percent	31.9%	15.6%	34.1%	1.2%	14.9%	2.4%			
Fortified	**Length (ft)**	331	29,657	8,019	1,345	163	748	**40,263**	**8**	**9.9%**
	Percent	0.8%	73.7%	19.9%	3.3%	0.4%	1.9%			
Railroad	**Length (ft)**	34,431	8,794	7,197	2,968	551	1,714	**55,655**	**11**	**13.7%**
	Percent	61.9%	15.8%	12.9%	5.3%	1.0%	3.1%			
Road	**Length (ft)**	6,788	3,851	3,607	5,050	3,666	3,443	**26,405**	**5**	**6.5%**
	Percent	25.7%	14.6%	13.7%	19.1%	13.9%	13.0%			

Table 3. Humboldt Bay shoreline length and percentage by structure type for each hydrologic unit.

Based on shoreline length, earthen dikes are the most common shoreline structure on Humboldt Bay, 40.7 miles. Many of these dikes were built over 100 years ago. The shores of Eureka, Mad River, and Elk River Sloughs contain 64.4% of the dikes on Humboldt Bay. Dikes protect thousands of acres of former tide land (approximately 90% of the original salt marsh habitat) that would flood if these dikes were breached or overtopped. These dikes, besides protecting agricultural lands, also protect important regional infrastructure (power plant, water transmission lines, gas transmission lines, electrical transmission towers, interstate and state highways, county roads, city service streets, county airport, and wastewater treatment facilities) from tidal inundation. Dike and railroad shorelines cover 51.2 miles, 50% of the shoreline on Humboldt Bay, and they both share two common features that will be significant when the affect of sea level rise manifests; they are nearly flat and of uniform elevation.

Arcata Bay:

The shoreline of Arcata Bay is mostly developed; what natural shoreline remains fronts the community of Manila (Figure 37). Arcata Bay has an extensive inter-tidal area of mudflats at low tide and a few deep water channels draining the Bay. Most of Humboldt Bay's shell fish maricultural operations are located in Arcata Bay. Arcata Bay has two freshwater drainages without tide gates that have open-ended channels at the tidal-freshwater interface (Jolly Giant Creek, Jacoby Creek, and soon to be three when Janes Creek McDaniel's Slough restoration is completed in 2013). These streams provide valuable brackish water fish habitat.

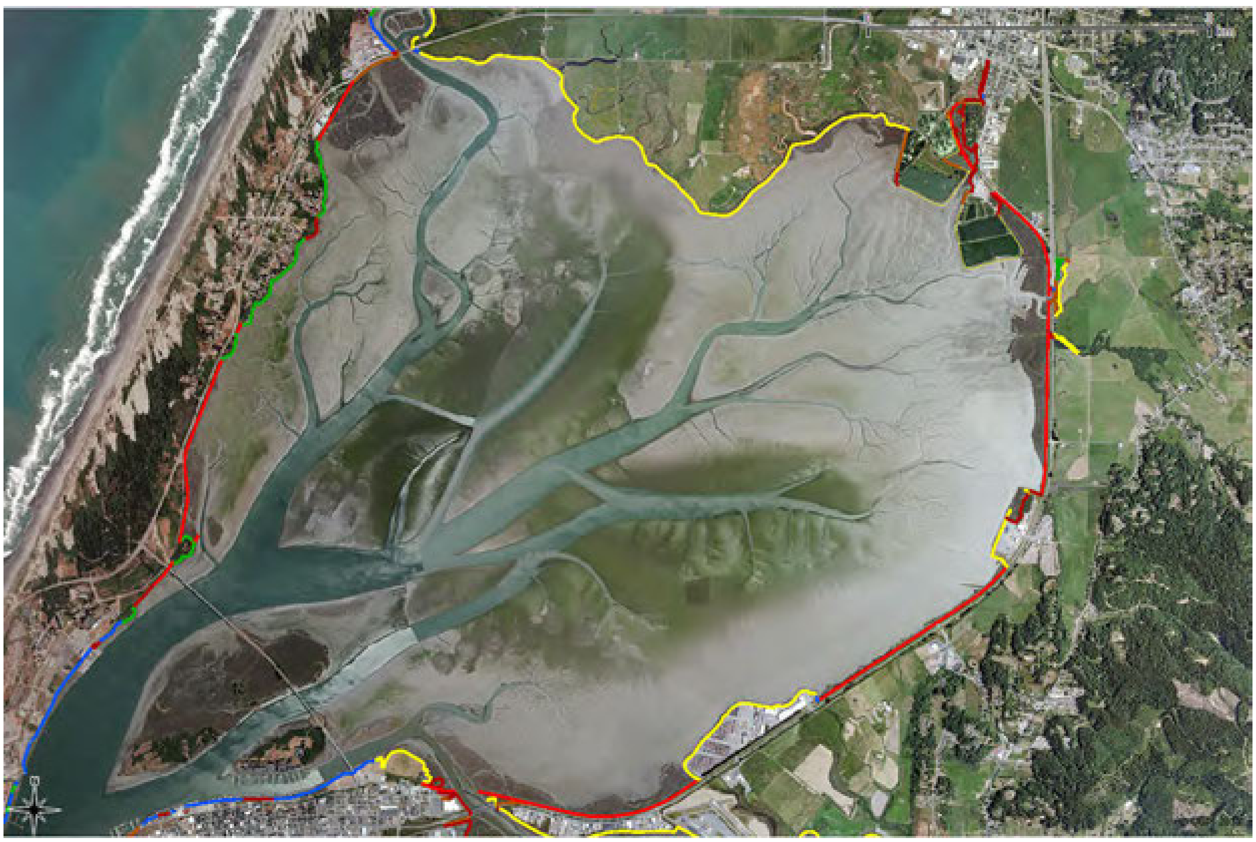

Figure 37. Distribution of shoreline structure types on Arcata Bay: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

The shoreline of Arcata Bay is 20.5 miles long; 91% of the shoreline is composed of artificial structures and 9% of the shoreline is natural. The two dominate shoreline structures are the NCRA grade with 6.5 miles, 32% of the shoreline (Table 4) and Reclamation District's 768 dike of 6.3 miles, 31% of the shoreline, which was rehabilitated in 2008. Other types of shorelines on Arcata Bay are fill 2.5 miles (12%), the City of Arcata's waste water treatment and marsh ponds 1.9 miles (9%), which were also rehabilitated in 2008, and roadways 1.3 miles (6%).

Structure		
Arcata Bay	**Length (ft)**	**Percent (%)**
Boat Ramp	44.5	0%
Bridge Abutment	430.3	0%
Bulwark	327.0	0%
Dike	33,107.1	31%
Fill	12,934.9	12%
Fortified	330.0	0%
None	9,485.6	9%
Pond	10,225.8	9%
Railroad	34,431.2	32%
Road	6,787.8	6%
TOTAL	**108,104.1**	

Table 4. Arcata Bay shoreline structures by type, with length and percentage of total.

Eureka Bay:

Figure 38. Distribution of shoreline structure types on Eureka Bay: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

Eureka Bay is a deep water harbor on Humboldt Bay. Its entrance is dredged annually to a depth of 40 feet and the shipping channel and turning basin are also dredged as are the two marinas periodically. There are several commercial docks still in operation and some which are not. While Eureka Bay is a working harbor, it has two and a half times as much natural shoreline as Arcata Bay; 4.6 miles versus 1.8 miles. Elk River Spit, one of the newest natural features on Humboldt Bay, protrudes out to the shipping channel and contains several unique shoreline environments: sandy beaches, foredunes, salt marsh and riparian-freshwater wetlands. Eureka Bay also has much of the historic (abandoned) waterfront on Humboldt Bay as well as the City of Eureka's newly re-developed waterfront and boardwalk.

The shoreline of Eureka Bay is 15.9 miles long; 71% of the shoreline is composed of artificial structures and 29% is natural. The dominant shoreline structures are fortified (5.6 miles, 35%) and foredunes (2.6 miles, 17%) (Table 5). Other types of shorelines are natural (2.0 miles, 12%), NCRA railroad (1.7 miles, 10%), fill (1.2 miles, 8%), and roadways (0.7 miles, 5%).

Structure		
Eureka Bay	**Length (ft)**	**Percent (%)**
Boat Ramp	417.4	0%
Building	293.3	0%
Bulwark	3,916.0	5%
Dike	3,077.0	4%
Fill	6,308.8	8%
Fore Dune	13,932.3	17%
Fortified	29,656.6	35%
Jetty	3,180.1	4%
None	10,446.6	12%
Railroad	8,794.1	10%
Road	3,851.5	5%
Tidegate	29.6	0%
TOTAL	**83,903.4**	

Table 5. Eureka Bay shorelines structure by type, with length and percentage of total.

South Bay:

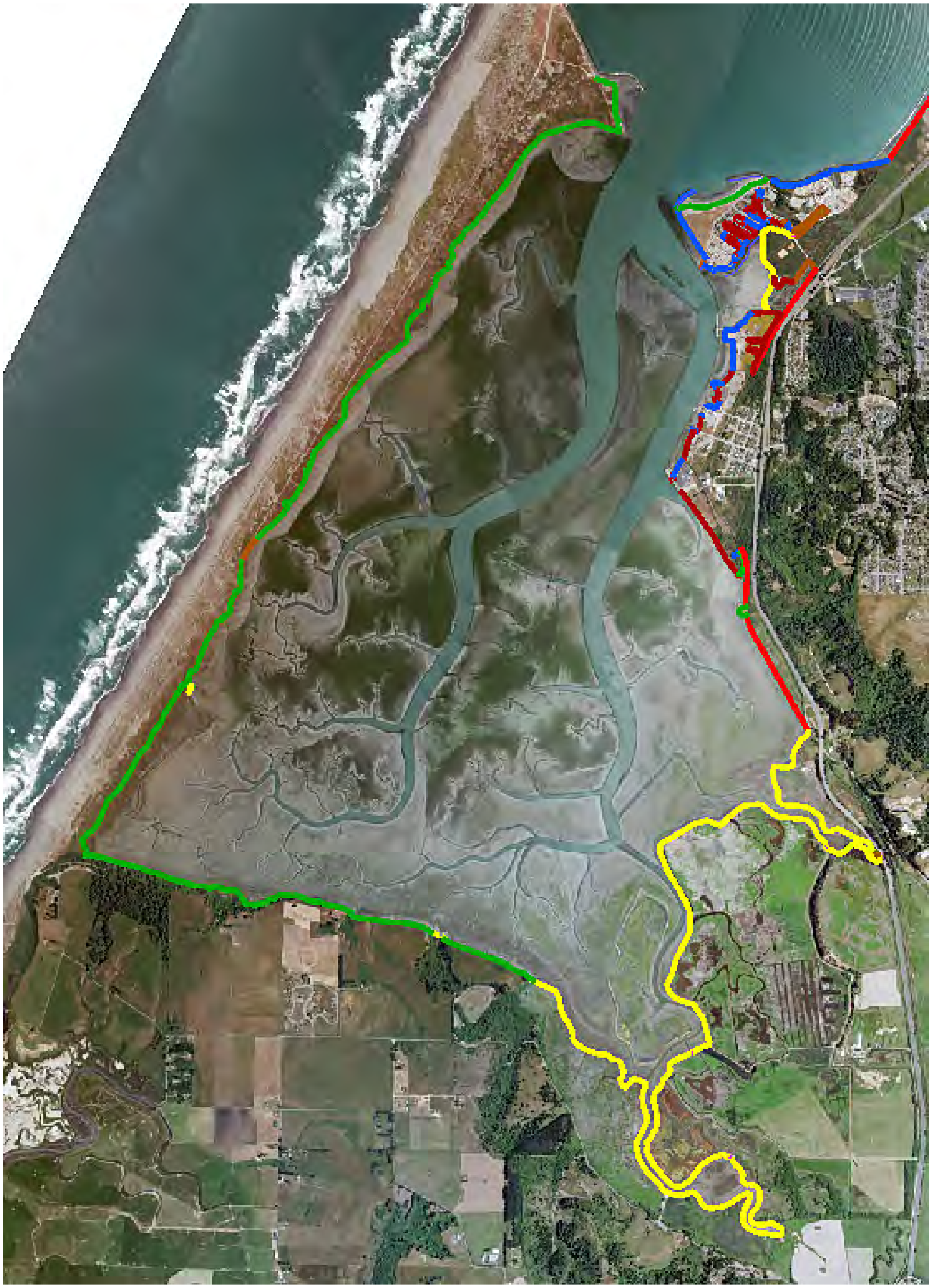

Figure 39. Distribution of shoreline structure types on South Bay: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

South Bay has the greatest amount of natural shoreline and a relatively rare shoreline type along Table Bluff: cliffs. South Bay, like Arcata Bay, also has extensive inter-tidal mudflats at low tide, as well as a deep water channel to Fields Landing that is periodically dredged. South Bay also has a rather unique waterfront residential area at King Salmon: commercial waterfront in Fields Landing. There are two wildlife areas on South Bay, HBNWR and the Mike Thompson Wildlife Area on South Spit. Freshwater inflow from Salmon Creek provides valuable brackish water fish habitat at the HBNWR.

The shoreline of South Bay is 21.8 miles long; 68% of the shoreline is composed of artificial structures and 32% of the shoreline is natural. The two dominant shoreline structures are earthen dikes (7.6 miles, 35%) and natural (4.8 miles, 22%) (Table 6). Other types of shorelines are fill (2.6 miles, 12%), cliff/bluffs (2.0 miles, 9%), fortified (1.5 miles, 7%), and railroad (1.4 miles, 6%).

Structure		
South Bay	**Length (ft)**	**Percent (%)**
Boat Ramp	99.0	0%
Bridge Abutmen	193.4	0%
Bulwark	1,557.4	1%
Cliff/Bluff	10,389.9	9%
Dike	40,214.9	35%
Fill	13,816.0	12%
Fore Dune	1,531.8	1%
Fortified	8,019.1	7%
Jetty	2,959.0	3%
None	25,244.2	22%
Railroad	7,197.3	6%
Road	3,606.7	3%
Tidegate	426.0	0%
TOTAL	**115,254.7**	

Table 6. South Bay shoreline structures by type, with length and percentage of total.

Mad River Slough:

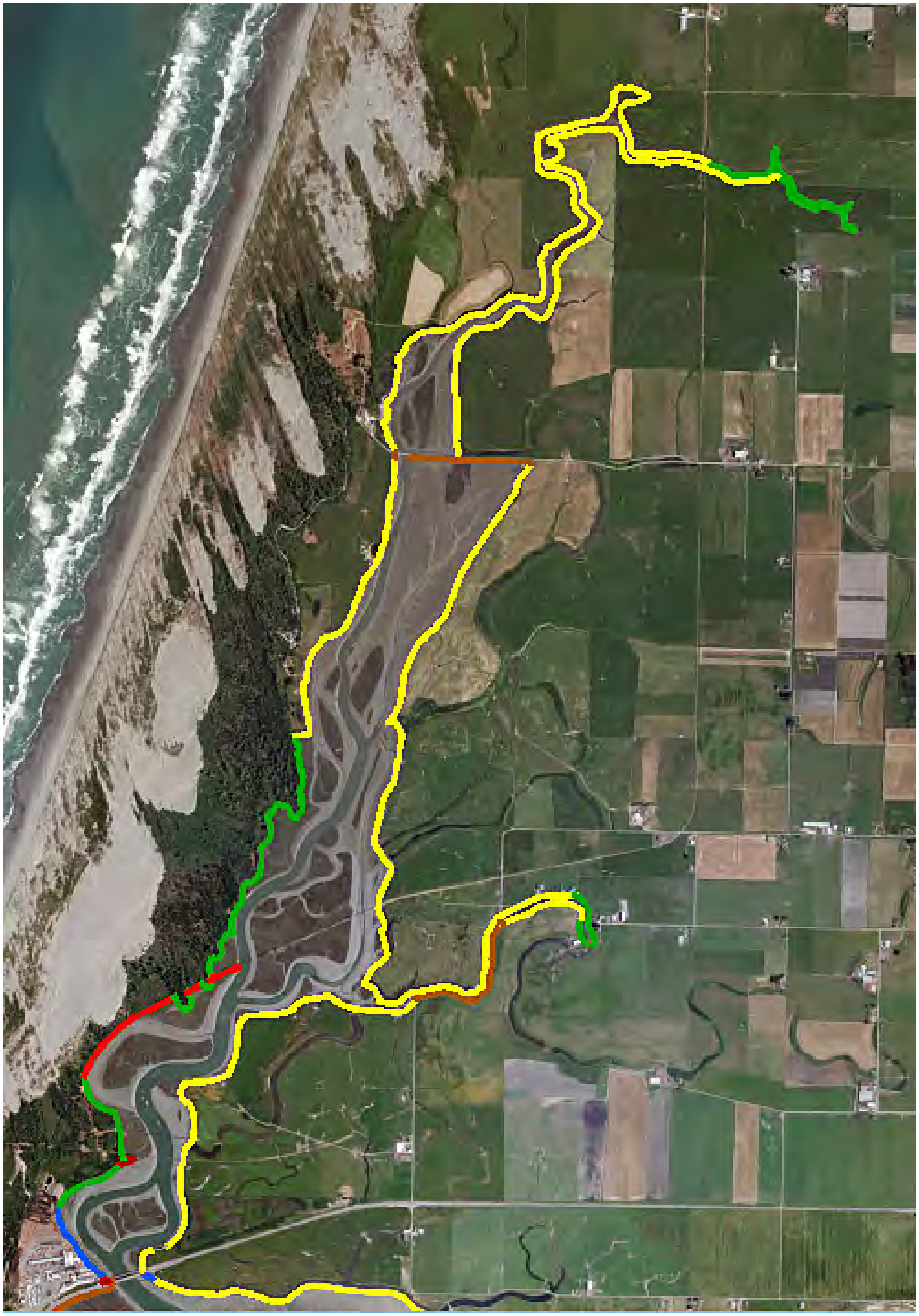

Figure 40. Distribution of shoreline structure types on Mad River Slough: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

Mad River Slough has a unique dune and forest ecosystem on its western shore, mostly within the HBNWR, but its shores are predominant earthen dikes that protect agricultural uses on former tide lands. Occasionally, the Mad River, which is located to the north, floods, and its overbank flow drains across the Mad River bottomland to the dikes along the slough then impounds water for days, or breaches, releasing sediment to the downstream reaches of the slough and Humboldt Bay. The upper end of Mad River Slough is an open channel, with no freshwater inflow, and its banks are un-diked natural bottom land. Liscom Slough is a channel that historically drained a large area of the Mad River Bottom to Mad River Slough but its upper reaches are now blocked off by a road crossing.

The shoreline of Mad River Slough is 13.7 miles long; 80% of the shoreline is composed of artificial structures and 20% of the shoreline is natural. The two dominant shoreline structures are earthen dikes (9.0 miles, 66%) and natural (2.8 miles, 20%) (Table 7). Other types of shorelines are roadway (1.0 miles, 7%), and an abandoned historic Hammond Railroad Grade (0.6 miles, 4%).

Structure		
Mad River Slough	**Length (ft)**	**Percent (%)**
Boat Ramp	22.1	0%
Bulwark	297.3	0%
Dike	47,471.4	66%
Fill	469.1	1%
Fortified	1,345.0	2%
None/Natural	14,508.3	20%
Railroad	2,968.0	4%
Road	5,050.0	7%
TOTAL	**72,131.1**	

Table 7. Mad River Slough shoreline structures by type, with length and percentage of total.

Eureka Slough:

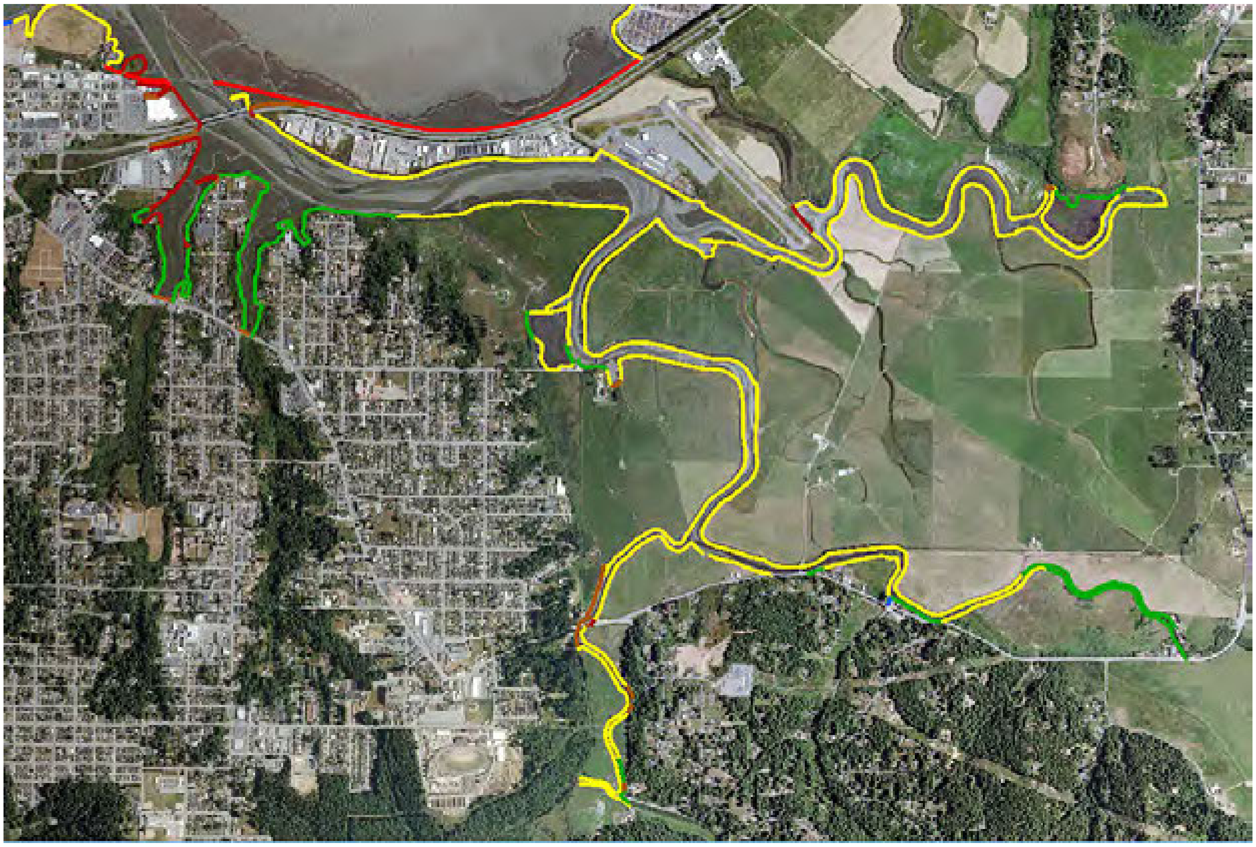

Figure 41. Distribution of shoreline structure types on Eureka Slough: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

Eureka Slough has three major tidal branches; Fay Slough, Freshwater Slough and Ryan Slough. Freshwater inflow from the upper watersheds of these Sloughs provides valuable brackish water fishery habitat. Eureka Slough has the greatest amount of diked shore on Humboldt Bay; many of these dikes were first constructed in 1894 (Susie Van Kirk 2007). The upper end of Freshwater Slough is an open channel and its banks are un-diked natural bottom land. The upper end of Fay Slough has unique brackish marsh habitat. There is a county airport along the shores of Fay and Eureka Sloughs.

The shoreline of Eureka Slough is 20.8 miles long; 80% of the shoreline is composed of artificial structures and 20% of the shoreline is natural. The two dominant shoreline structures are earthen dikes (14.3 miles, 69%) and natural (2.9 miles, 14%)(Table 8). Other types of shorelines are cliff/bluffs (1.3 miles, 6%), fill (1.2 miles, 6%), and roadway (0.7 miles, 3%).

Structure		
Eureka Slough	**Length (ft)**	**Percent (%)**
Boat Ramp	23.2	0%
Bridge Abutment	355.2	0%
Bulwark	1,334.2	1%
Cliff/Bluff	6,687.4	6%
Dike	75,588.1	69%
Fill	6,058.6	6%
Fortified	162.9	0%
None	15,166.8	14%
Railroad	551.5	1%
Road	3,666.1	3%
Tidegate	94.2	0%
TOTAL	**109,688.4**	

Table 8. Eureka Slough shoreline structures by type, with length and percentage of total.

Elk River Slough:

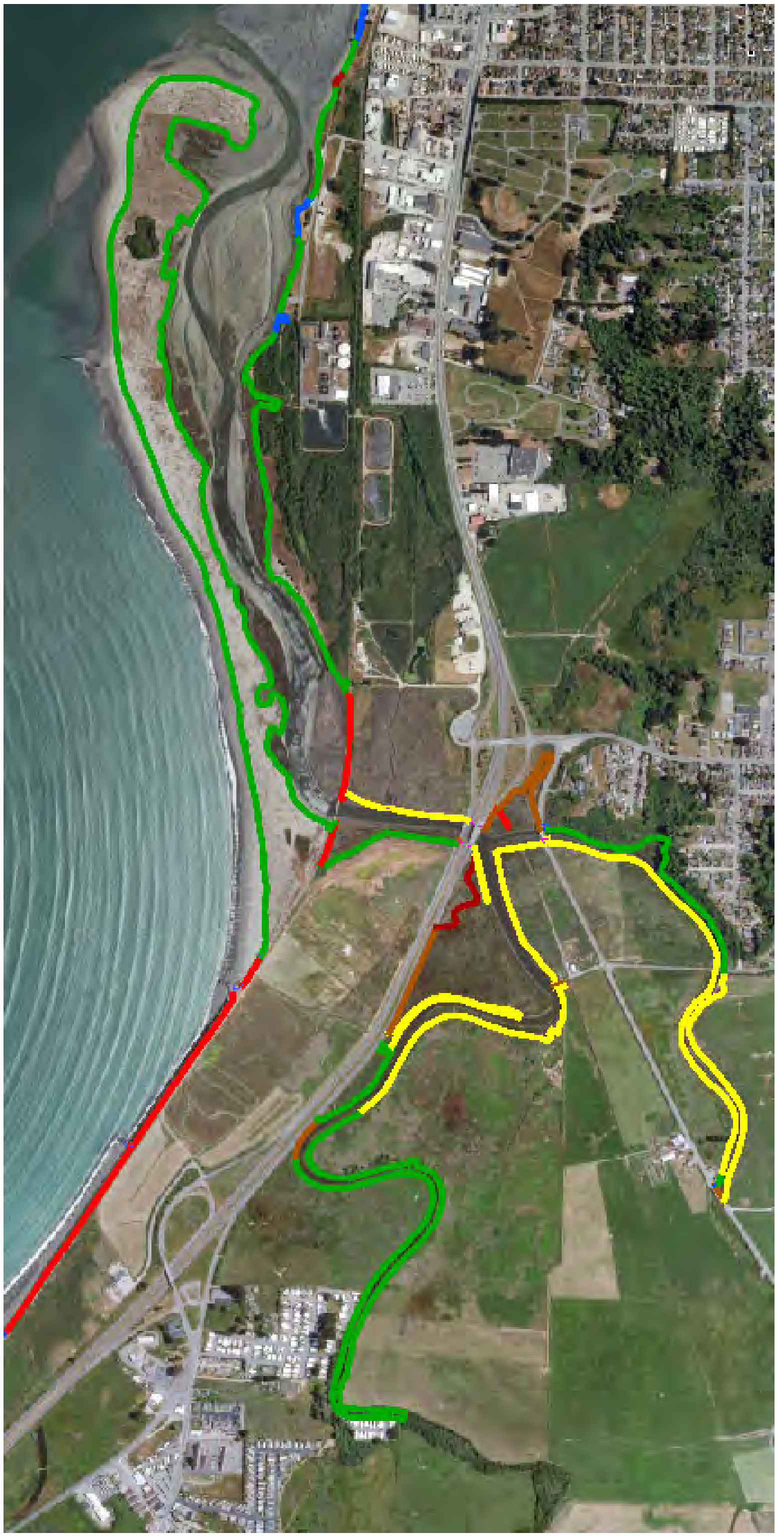

Figure 42. Distribution of shoreline structure types on Elk River Slough: dike (yellow), natural (green), railroad (red), fill (maroon), fortified (blue), and roadway (brown).

Elk River Slough is unique in that historical maps do not depict extensive areas of salt marsh and tidal channel networks (Laird 2007) (Figure 43). However, the 1921 soil survey of Humboldt Bay does indicate that Elk River Slough and its valleys was a zone of tidal and freshwater interface, with salt marsh to the south and north of Elk River Slough and up the valley reaches on Elk River and Ryan Slough (Watson 1925). Salt marsh and windblown soils were overlain with overbank deposits of freshwater sediments (Figure 44). A significant portion of the shoreline along Elk River Slough is not diked, approximately 4,500 feet; it is natural bottom land. The upper end of the Slough is an open channel that traverses the floodplain until riparian forest closes in on Elk River at the upper tidal limits. Another unique landscape feature of Elk River Slough is the spit that has accreted and extended out into the shipping channel of Eureka Bay. The spit is apparently a result of the construction of the Harbor entrance jetties and dredging that caused the erosion of historic Buhne Point, whose sediments then formed Elk River's spit (pers. comm. John Winzler 2012).

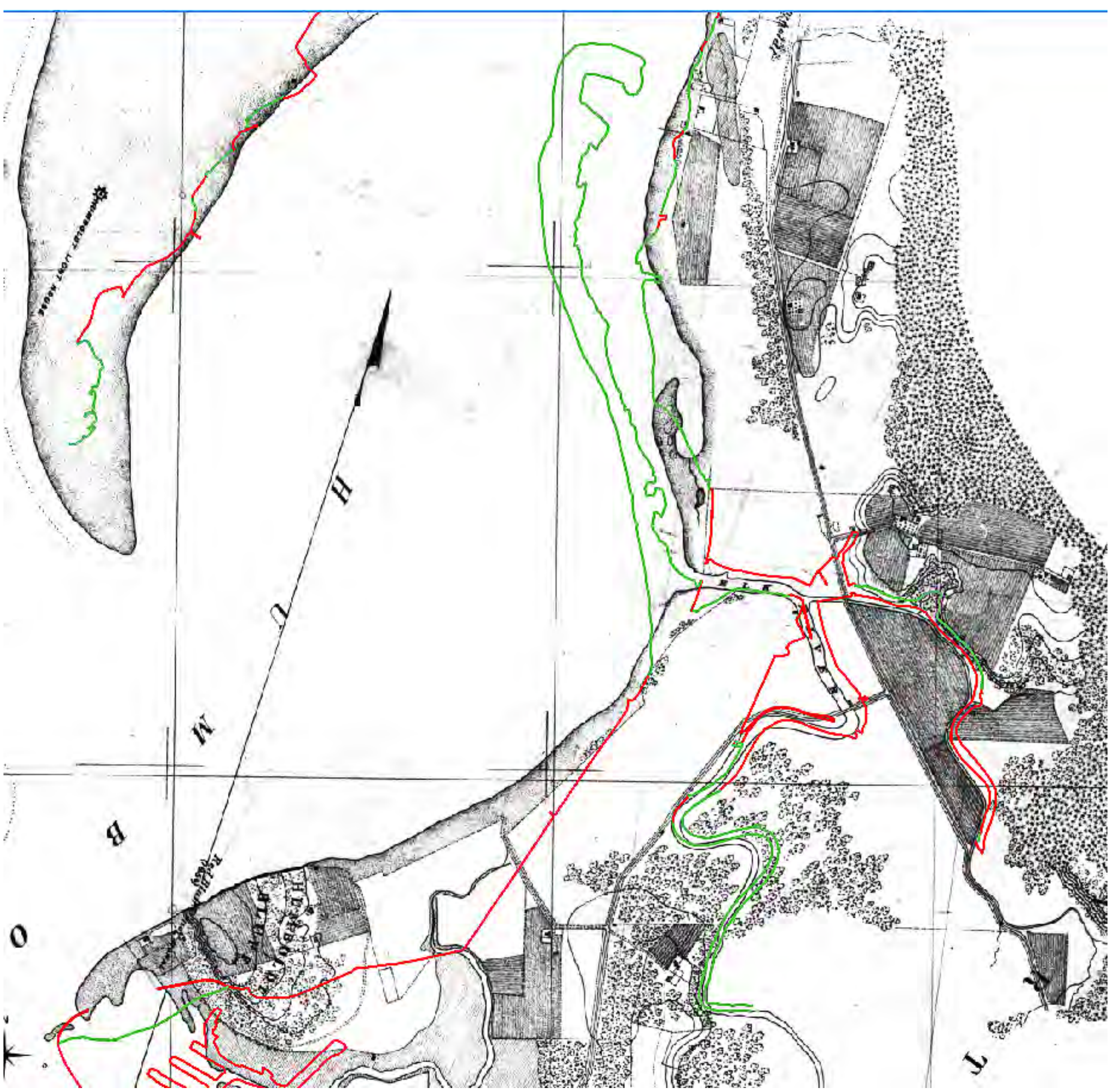

Figure 43. Elk River Slough, 2009 shoreline location overlaid on 1870 USCGS map.

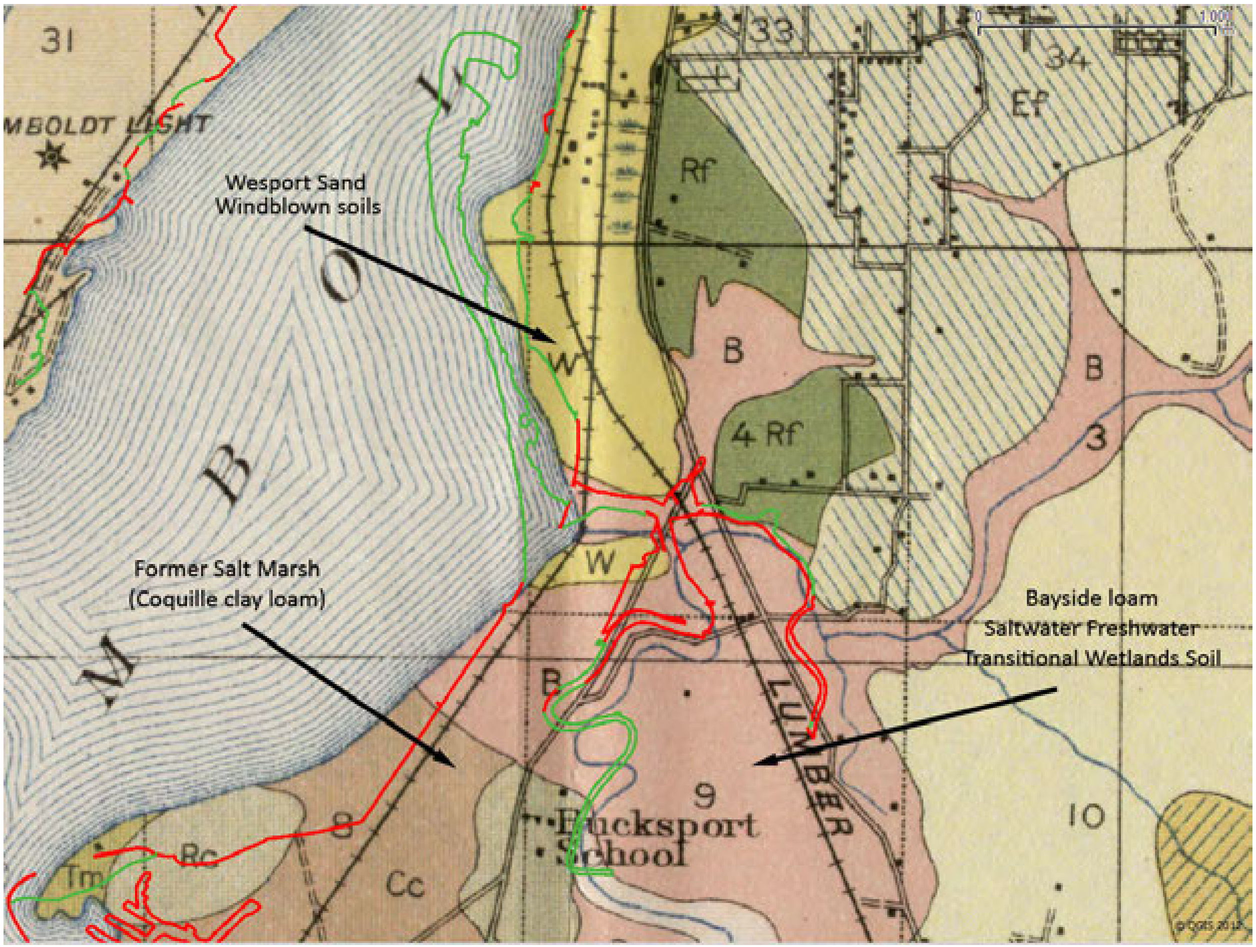

Figure 44. Elk River Slough, 2009 shoreline location overlaid on USDA 1916 soils map

The shoreline of Elk River Slough is 9.7 miles long; 55% of the shoreline is natural and 45% of the shoreline is composed of artificial structures. The three dominant shoreline structures are natural (3.0 miles, 31%), earthen dikes (2.9 miles, 30%) and fore dunes (1.7 miles, 18%)(Table 9). Other types of shorelines are roadway (0.6 miles, 7%), cliff/bluffs (0.6 miles, 6%), and NCRA rail road (0.3 miles, 3%).

Structure		
Elk River Slough	Length (ft)	Percent (%)
Bridge Abutment	520.2	1%
Bulwark	72.7	0%
Cliff/Bluff	3,231.1	6%
Dike	15,333.9	30%
Fill	955.2	2%
Fore Dune	9,246.1	18%
Fortified	748.5	1%
None	15,919.0	31%
Railroad	1,714.0	3%
Road	3,442.6	7%
Tidegate	42.6	0%
TOTAL	**51,225.7**	

Table 9. Elk River Slough shoreline structures by type, with length and percentage of total.

b) Shoreline Cover

The type and condition of shoreline cover is important when evaluating the ability of a shoreline to resist wave induced erosion or bank saturation and collapse. Man-made shoreline structures occupy 75% of the shoreline on Humboldt Bay and protect thousands of acres of property, land uses, and infrastructures. Earthen dikes are the most prevalent shoreline structure, functioning as an elevated tidal barrier shielding the lands behind them. The consequence of a dike breach can be substantial. For example, in 2003, a single dike breach on Mad River Slough flooded approximately 600 acres of former tidelands. On Humboldt Bay, railroad grades, dikes, and some roadways offer similar protection to the lands behind them. In order to assess the vulnerability of existing shorelines, it is important to inventory the type of cover on the shoreline's tidal slope. Shoreline cover can be grouped in two broad types: fortified and unfortified. Fortified shorelines can be a form of revetment or rip rap composed of materials such as rock, concrete, or even fronted by a structure such as a bulwark made of wood or steel. Unfortified shorelines found on Humboldt Bay are either vegetated or exposed; both of these conditions indicate a lack of maintenance. Earthen dikes that are not fortified and not maintained are more vulnerable to erosion and breaching.

Humboldt Bay

The Humboldt Bay shoreline is predominately unfortified (72.9%). Shoreline with vegetative cover occupies 65.4 miles (63.9%), 9.2 miles (9.0%) of the shoreline are exposed or with no cover, and 27.0 miles of shoreline are fortified (Figure 45, Table 10, Chart 2).

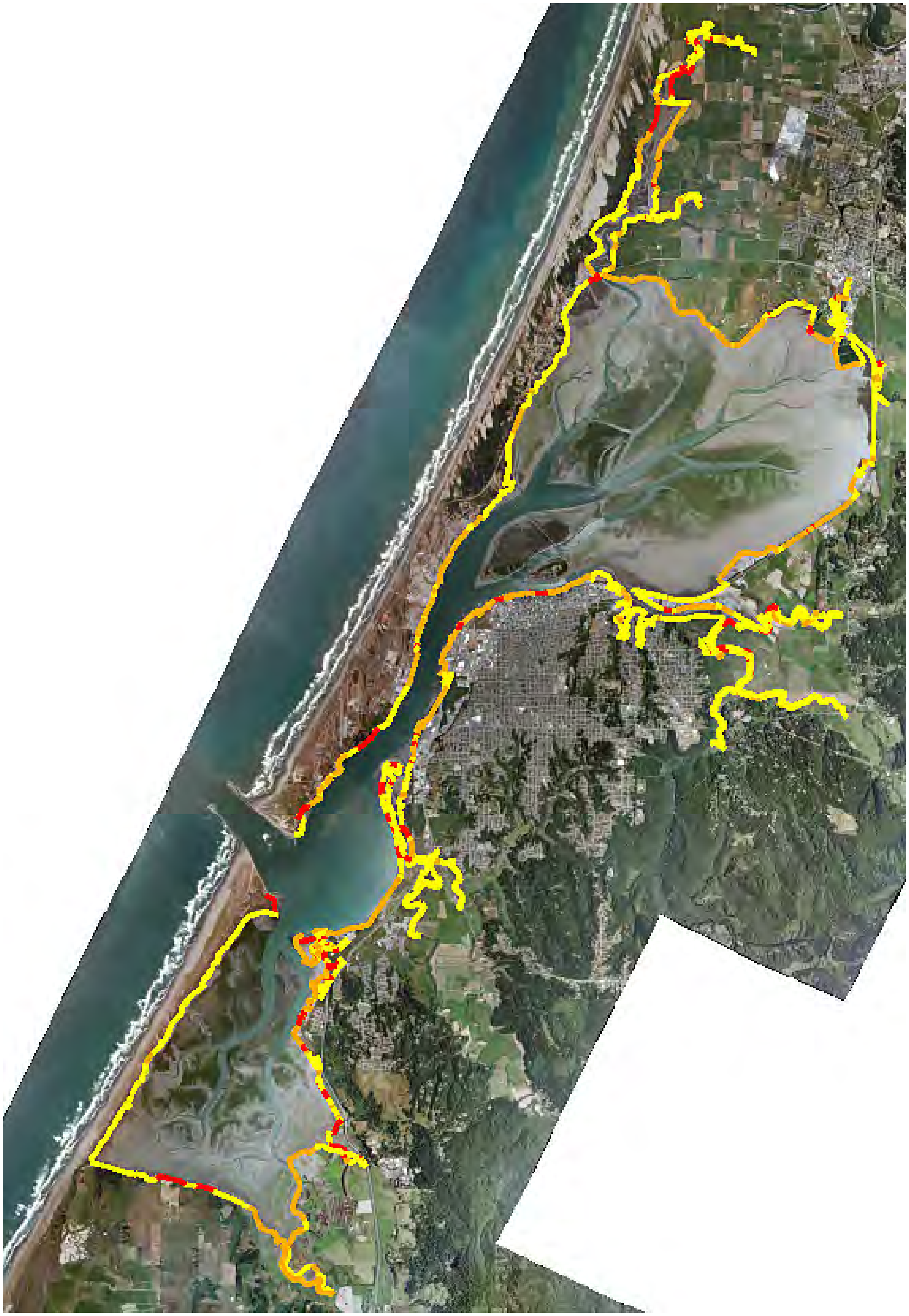

Figure 45. Distribution of shoreline cover on Humboldt Bay: vegetated (yellow), fortified (brown), and exposed (red).

SHORELINE COVER	ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET	TOTAL PERCENT
Exposed	9.3%	22.0%	33.9%	17.0%	13.9%	4.0%	**48,801**	**9.0%**
Vegetated	18.8%	8.0%	18.4%	14.0%	27.3%	13.6%	**345,390**	**63.9%**
Fortified	27.2%	30.6%	24.3%	10.7%	5.5%	1.7%	**142,325**	**26.3%**

Table 10. Humboldt Bay hydrologic unit's fortified versus un-fortified shoreline percentage and length.

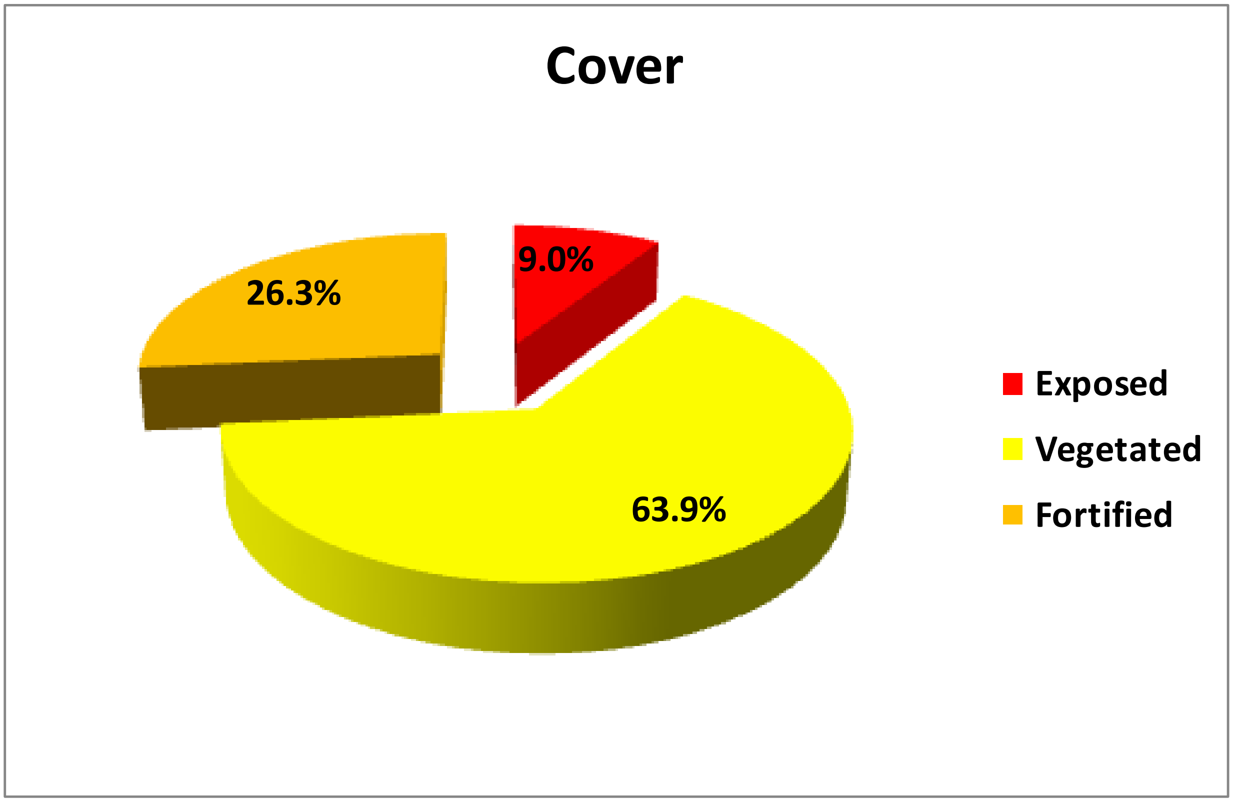

Chart 2. The percent of shoreline that is fortified or un-fortified: vegetated and exposed, on Humboldt Bay.

On Humboldt Bay, eight types of cover were encountered on the man-made shoreline of 76.7 miles; 42.5 miles were vegetated, 27.7 miles fortified (asphalt, concrete, rock, rock/concrete, steel, and wood), and 6.4 miles were exposed and eroding (Table 11).

ARTIFICIAL STRUCTURE COVER	ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET
Asphalt	0	0	0	0	113	0	**113**
Concrete	4,048	13,978	8,872	10,806	5,383	1,202	**44,289**
Exposed	3,605	3,587	11,936	8,189	6,166	100	**33,582**
Rock	26,864	29,419	25,094	4,374	2,093	1,155	**88,998**
Rock/Concrete	7,338	119	646	0	333	99	**8,535**
Steel	229	300	0	297	0	0	**826**
Vegetated	56,126	10,154	31,008	33,957	73,128	20,273	**224,646**
Wood	274	1,717	534	0	830	0	**3,356**
Total (ft)	**98,484**	**59,274**	**78,089**	**57,623**	**88,046**	**22,829**	**404,345**

Table 11. Humboldt Bay hydrologic unit's shoreline cover types, length (feet), and percentage.

The five most prevalent shoreline structures are: dikes (40.7 miles), railroad (10.5 miles), fill (7.7 miles), fortified (7.6 miles), and roadways (5.0 miles). There are 3.3 miles of exposed dikes, 2.0 miles of exposed fill, 0.2 miles of exposed fortified shoreline, 0.2 miles of exposed railroad, and 0.5 miles of exposed roadway (Table 12). Vegetation covers 25.7 miles of dikes, 7.1 miles of railroad, 5.3 miles of fill, and 3.3 miles of roadway (Table 13).

ARTIFICIAL STRUCTURE COVER-EXPOSED	ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET	TOTAL MILES
Dike	33,107	3,077	40,215	47,471	75,588	15,334	**214,792**	**40.7**
Length (ft)	116	-	3,429	7,969	6,098	74	**17,686**	**3.3**
Percent	0.1%	0.0%	1.6%	3.7%	2.8%	0.0%	**8.2%**	
Railroad	34,431	8,794	7,197	2,968	551	1,714	**55,655**	**10.5**
Length (ft)	525	-	346	25	-	-	**896**	**0.2**
Percent	0.9%	0.0%	0.6%	0.0%	0.0%	0.0%	**1.6%**	
Fill	12,935	6,309	13,816	469	6,059	955	**40,543**	**7.7**
Length (ft)	2,056	2,015	6,353	91	-	-	**10,516**	**2.0**
Percent	5.1%	5.0%	15.7%	0.2%	0.0%	0.0%	**25.9%**	
Fortified	330	29,657	8,019	1,345	163	749	**40,262**	**7.6**
Length (ft)	-	382	522	-	-	-	**904**	**0.2**
Percent	0.0%	0.9%	1.3%	0.0%	0.0%	0.0%	**2.2%**	
Roadway	6,788	3,851	3,607	5,050	3,666	3,443	**26,405**	**5.0**
Length (ft)	909	963	635	104	-	26	**2,636**	**0.5**
Percent	3.4%	3.6%	2.4%	0.4%	0.0%	0.1%	**10.0%**	

Table 12. Length of exposed shoreline for the five most prevalent shoreline structures and percentage of that structure's total length that is exposed.

ARTIFICIAL STRUCTURE COVER-VEGETATED	ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET	TOTAL MILES
Dike	33,107	3,077	40,215	47,471	75,588	15,334	**214,792**	**40.7**
Length (ft)	12,199	3,077	14,362	26,518	64,029	15,260	**135,444**	**25.7**
Percent	5.7%	1.4%	6.7%	12.3%	29.8%	7.1%	**63.1%**	
Railroad	34,431	8,794	7,197	2,968	551	1,714	**55,655**	**10.5**
Length (ft)	24,694	2,980	5,787	2,865	552	803	**37,680**	**7.1**
Percent	44.4%	5.4%	10.4%	5.1%	1.0%	1.4%	**67.7%**	
Fill	12,935	6,309	13,816	469	6,059	955	**40,543**	**7.7**
Length (ft)	10,277	4,043	6,981	378	5,224	955	**27,858**	**5.3**
Percent	25.3%	10.0%	17.2%	0.9%	12.9%	2.4%	**68.7%**	
Fortified	330	29,657	8,019	1,345	163	749	**40,262**	**7.6**
Length (ft)	-	-	23	-	-	-	**23**	**0.0**
Percent	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	**0.1%**	
Road	6,788	3,851	3,607	5,050	3,666	3,443	**26,405**	**5.0**
Length (ft)	4,484	54	2,288	4,196	3,323	3,256	**17,601**	**3.3**
Percent	17.0%	0.2%	8.7%	15.9%	12.6%	12.3%	**66.7%**	

Table 13. Length of vegetated shoreline for the five most prevalent shoreline structures and percentage of that structure's total length that is vegetated.

Arcata Bay

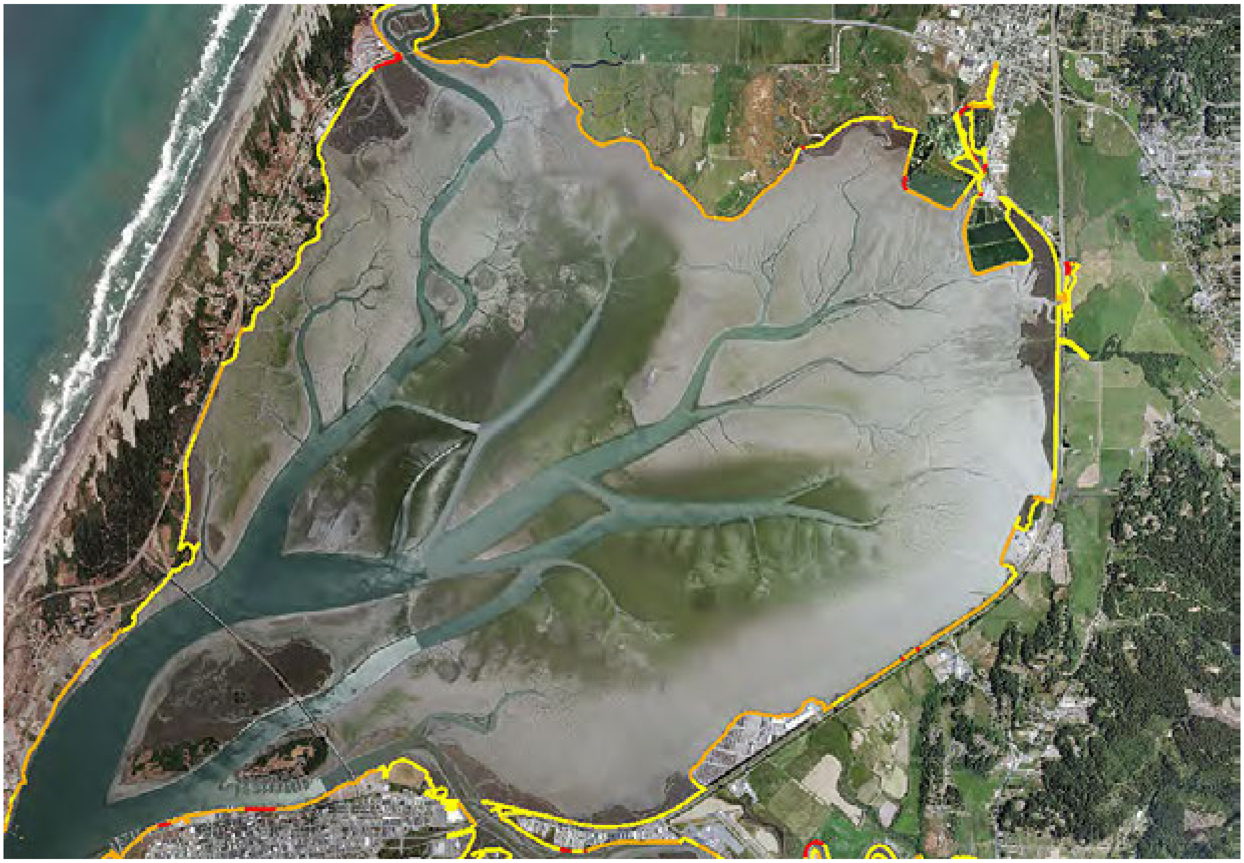

Figure 46. Distribution of shoreline cover types on Arcata Bay: vegetated (yellow), fortified (brown), and exposed (red).

The dominant shoreline cover on Arcata Bay is vegetation (12.3 miles, 60%), revetment covers 7.2 miles of shoreline (36%), and 0.8 miles is exposed or eroding (4%)(Table 14). The two dominant artificial shoreline structures on Arcata Bay are railroad grade (32%) and earthen dikes (31%). The railroad grade is mostly unfortified (4.8 miles, 73%); 4.7 miles is vegetated, 525 feet is exposed, and 1.7 miles is fortified (27%). A significant length of the dikes was recently fortified (3.9 miles, 62.8%) by Reclamation District 768 and the California Redwood Company. 2.3 miles of Arcata Bay are vegetated (36.8%), and just 116 feet are exposed.

Cover		
Arcata Bay	Length (ft)	Percent (%)
Concrete	4,048.1	4%
Exposed	4,396.2	4%
None	134.3	0%
Rock	26,863.6	25%
Rock/Concrete	7,338.4	7%
Steel	229.1	0%
Vegetated	64,820.3	60%
Wood	274.0	0%
TOTAL	**108,104.1**	

Table 14. Arcata Bay's shoreline cover types, length, and percentage.

Eureka Bay

Figure 47. Distribution of shoreline cover types on Eureka Bay: vegetated (yellow), fortified (brown), and exposed (red).

The majority of the shoreline cover on Eureka Bay's 15.9 mile shoreline is fortified (8.6 miles, 54%), while there are 7.3 miles (46%) of unfortified shoreline composed of 5.2 miles with vegetative cover (33%), 1.8 miles of exposed or eroding shoreline (11%), and 0.3 miles with no cover (2%)(Table 15). Eureka Bay's shoreline structure is composed of 35% fortified shoreline, 10% railroad grade, 5% roadway, and only 4% dikes. The railroad's 1.7 miles of shoreline has rock revetment covering 66% and 44% in vegetative cover. Roadways occupy 0.7 miles and are 74% rock revetment with 963 feet (25%) exposed. Dikes are on 0.6 miles of shoreline and are entirely unfortified with vegetative cover.

Cover		
Eureka Bay	**Length (ft)**	**Percent (%)**
Concrete	13,978.1	17%
Exposed	9,400.1	11%
None	1,347.8	2%
Rock	29,419.2	35%
Rock/Concrete	119.5	0%
Steel	299.6	0%
Vegetated	27,621.8	33%
Wood	1,717.4	2%
TOTAL	**83,903.4**	

Table 15. Eureka Bay shoreline cover types, length and percentage.

South Bay

Figure 48. Distribution of shoreline cover types on South Bay: vegetated (yellow), fortified (brown), and exposed (red).

The shoreline of South Bay is 21.8 miles long and the dominant shoreline cover is vegetation (12.0 miles, 55%). Fortified cover comprises 6.7 miles of shoreline (36%), and 3.1 miles (14%) is exposed or eroding (Table 16). The dominant artificial shoreline structures on South Bay are: earthen dikes (7.6 miles), fill (2.6 miles), fortified (1.5 miles), and railroad (1.4 miles). A significant length of the dikes has been recently fortified (4.3 miles, 56%), while 2.7 miles are vegetated (12%), and 0.7 miles are exposed (3%). The 2.6 miles of filled shoreline is nearly entirely unfortified (97%): 1.3 miles with vegetative cover (51%), and 1.2 miles exposed (46%). The 1.5 miles of fortified shoreline is nearly entirely composed of revetments (93%) with 522 feet exposed (7%). The 1.4 miles of railroad has 1.1 miles of vegetative cover (80%), and 346 feet exposed (4%).

Cover		
South Bay	**Length (ft)**	**Percent (%)**
Concrete	8,871.9	8%
Exposed	16,558.5	14%
Rock	25,093.6	22%
Rock/Concrete	645.6	1%
Vegetated	63,550.9	55%
Wood	534.3	0%
TOTAL	**115,254.7**	

Table 16. South Bay shoreline cover types, length and percentage.

Mad River Slough

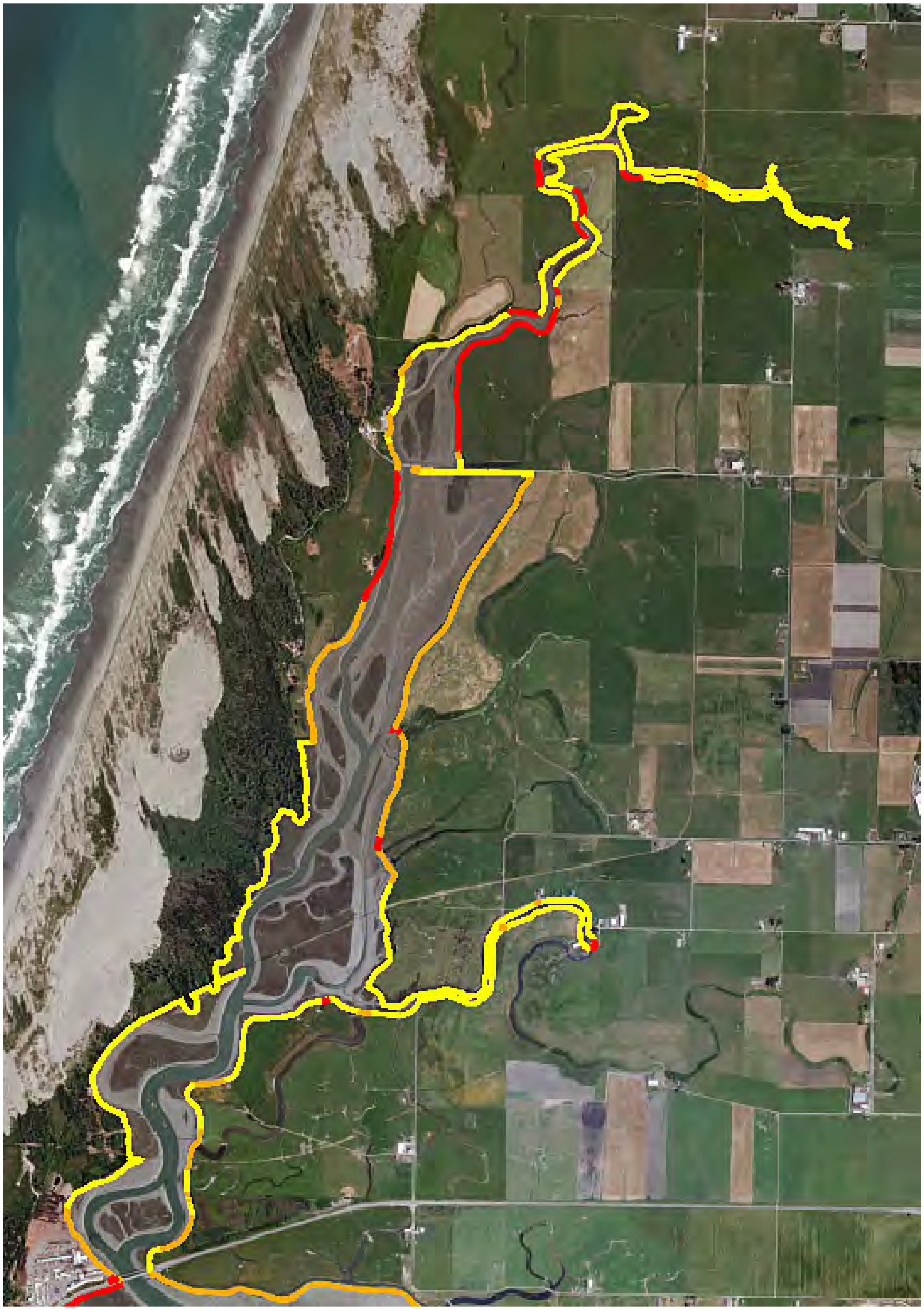

Figure 49. Distribution of shoreline cover types on Arcata Bay: vegetated (yellow), fortified (brown), and exposed (red).

There are 13.7 miles of shoreline on Mad River Slough and the dominant shoreline cover is vegetation (9.2 miles, 67%). Fortified cover comprises 2.9 miles (21.5%), and 1.6 miles is exposed or eroding (11.5%)(Table 17). Dikes are the dominant shoreline structure (9.0 miles), 5.0 miles are vegetated (56%), 2.5 miles are composed of rock and concrete revetment (23%), and 1.5 miles are exposed (17%).

Cover		
Mad River Slough	**Length (ft)**	**Percent (%)**
Concrete	10,805.8	15%
Exposed	8,273.2	11%
Rock	4,373.9	6%
Steel	297.3	0%
Vegetated	48,381.0	67%
TOTAL	**72,131.1**	

Table 17. Mad River Slough shoreline cover types, length and percentage.

Eureka Slough

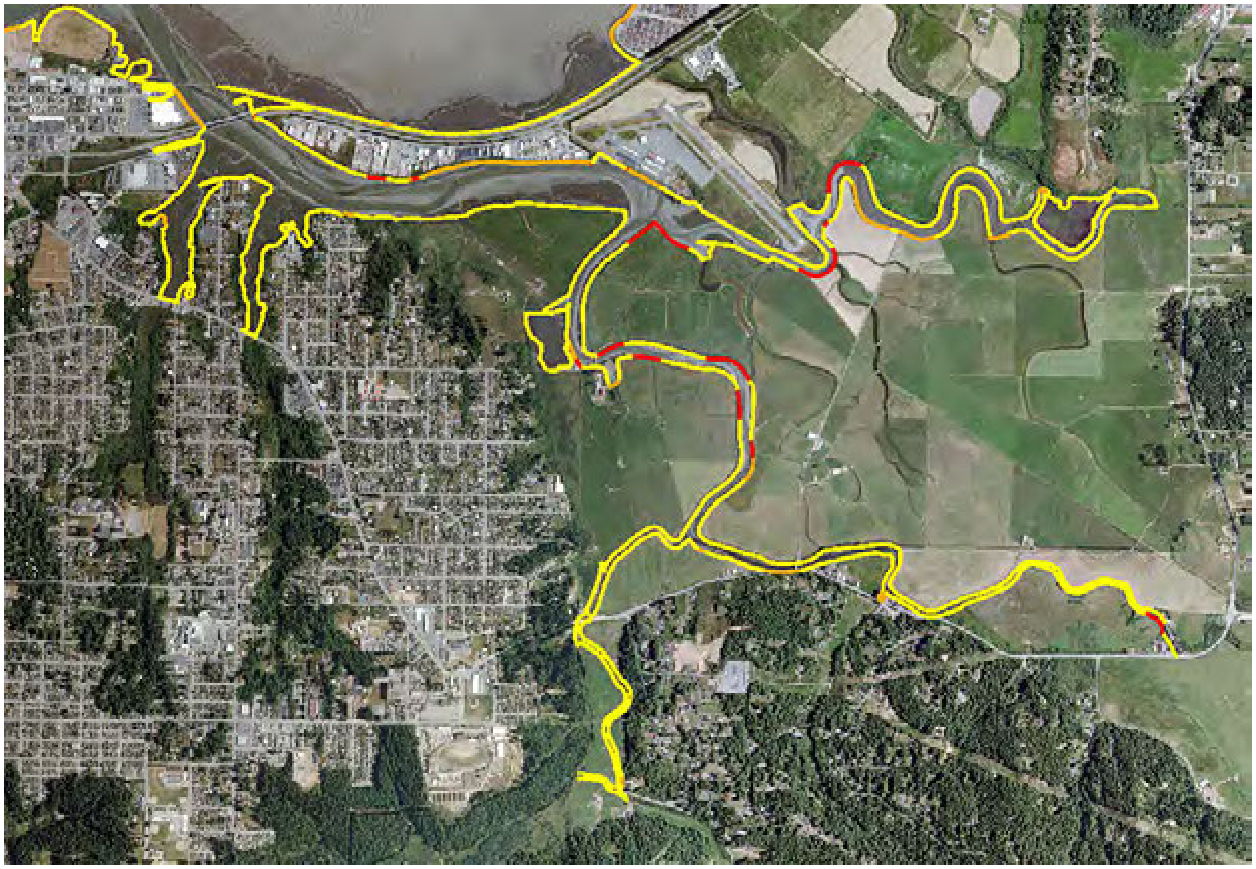

Figure 50. Distribution of shoreline cover types on Eureka Slough: vegetated (yellow), fortified (brown), and exposed (red).

The 20.8 miles of shoreline on Eureka Slough is predominantly artificial (16.6 miles, 80%) with 14.3 miles of earthen dikes. The dominant shoreline cover on Eureka Slough is vegetation (17.8 miles, 86%), fortified cover comprises 1.7 miles (8%), and 1.3 miles is exposed or eroding (6%)(Table 18). The majority of the dikes are un-fortified (13.3 miles, 93%): 12.1 miles are vegetated (85%), 1.1 miles are exposed (8%) while 1.0 miles has rock and concrete revetment (7%).

Cover		
Eureka Slough	**Length (ft)**	**Percent (%)**
Concrete	5,382.7	5%
Exposed	6,760.3	6%
Rock	2,092.6	2%
Rock/Concrete	333.1	0%
Vegetated	94,176.6	86%
Wood	830.3	1%
Asphalt	112.7	0%
TOTAL	**109,688.4**	

Table 18. Eureka Slough shoreline cover types, length and percentage.

Elk River Slough

Figure 51. Distribution of shoreline cover types on Elk River slough: vegetated (yellow), fortified (brown), and exposed (red).

The 9.7 miles of shoreline on Elk River Slough is predominately natural (5.4 miles, 55%). The dominant artificial shoreline structure is earthen dikes covering 2.9 miles (30%) and the dikes are in vegetative cover for nearly their entire length (99.6%)(Table 19). Roadways occupy 0.6 miles of the shoreline and 95% is vegetatively covered, and the railroad along 0.3 miles of shoreline is nearly evenly split between rock revetment and vegetative cover.

Cover		
Elk River Slough	**Length (ft)**	**Percent (%)**
Concrete	1,202.4	2%
Exposed	1,930.3	4%
Rock	1,155.2	2%
Rock/Concrete	98.6	0%
Vegetated	46,839.2	91%
TOTAL	**51,225.7**	

Table 19. Elk River Slough shoreline cover types, length and percentage.

c) Shoreline Elevation

The MMMW elevation of 7.74 feet at the north spit tidal station was used as the baseline from which to measure existing shoreline elevations. NOAA's 2012 LiDAR dataset, which reflects surface elevations in 2010, was used to generate a shoreline elevation profile; an average relative elevation to MMMW elevation was calculated for each one meter shoreline segment and used as the basis for analysis (Figure 52).

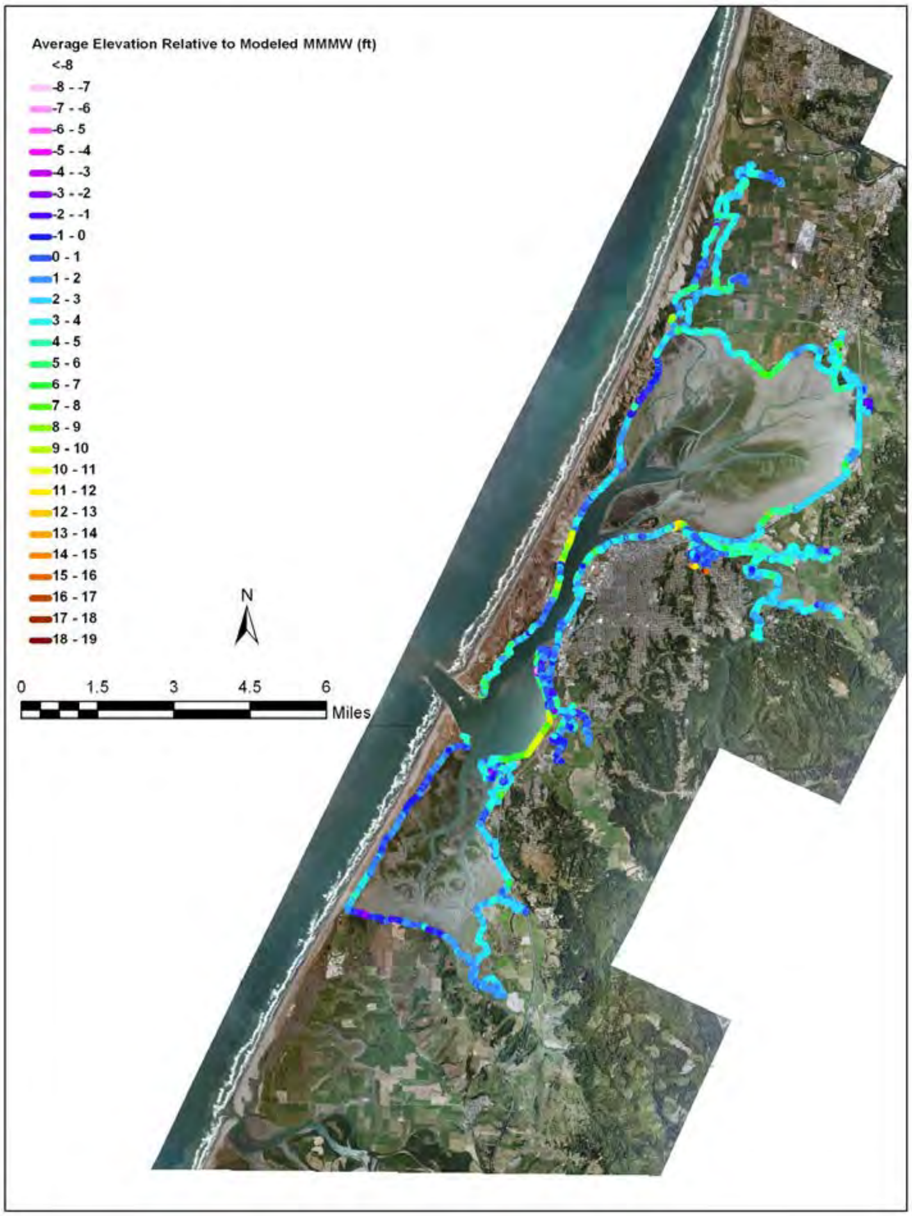

Figure 52. Existing shoreline elevations in relation to the MMMW elevation of 7.74 feet.

Shoreline elevation is an important attribute. While a well fortified dike may not be vulnerable to coastal erosion, if overtopped, a dike may be susceptible to breaching and the lands behind it to flooding. As mentioned earlier, in 2003, during an extreme high tide (EHT) and storm surge, a dike on Mad River Slough experienced a 230 foot breach which flooded approximately 600 acres of former tide lands. It was not until several years later, when Reclamation District 768 received Federal Emergency Management Agency (FEMA) funding to fortify its dikes, that the 2003 breach was repaired. In 2006, a period of heavy precipitation combined with the EHT on New Year's Eve, resulted in a state of emergency being declared on Humboldt Bay. Consequently, California Coastal Commission (CCC) and Humboldt Bay Harbor District issued numerous emergency permits to property owners to repair their overtopped dikes. With 75% of the shoreline on Humboldt Bay composed of man-made structures, it is important to establish the elevation of these structures; this information is necessary for an assessment of the shoreline's vulnerability to overtopping.

Humboldt Bay

The MMMW elevation of 7.74 feet at the North Spit tidal station was used as the baseline from which to measure existing shoreline elevations. Table 20 lists the length of artificial shoreline for each hydrologic unit by elevation; these are not cumulative shoreline lengths.

ARTIFICIAL SHORELINE ELEVATION	ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET	TOTAL PERCENT
7.74'	736	2,289	4,611	443	1,756	2,469	12,304	**3.0%**
8.74'	4,596	5,913	11,357	3,318	5,691	9,339	40,214	**9.9%**
9.74'	19,688	12,522	31,485	13,809	18,899	13,777	110,181	**27.2%**
10.74'	54,061	28,592	57,911	30,841	45,157	17,311	233,872	**57.8%**
13.74'	88,910	45,246	75,158	55,068	85,284	21,585	371,251	**91.7%**
Total (ft)	98,619	59,772	78,132	57,623	87,834	22,829	404,810	**100.0%**

Table 20. Humboldt Bay, hydrologic unit's artificial shoreline length (feet) and percent by shoreline elevation.

Most of the artificial shoreline (91.7%) is less than 13.74 feet in elevation: 2.3 miles are less than or equal to 7.74 feet, 5.3 miles are 7.74 to 8.74 feet, 13.3 miles are 8.74 to 9.74 feet, 23.4 miles are 9.74 to 10.74 feet, and 26 miles are 10.74 and 13.74 feet. The majority (57.8%) of the artificial shoreline elevation is within 3 feet of the MMMW elevation and 33.9% is between 3 and 6 feet of MMMW. Chart 3 illustrates the length of artificial shoreline in miles for each of these elevations.

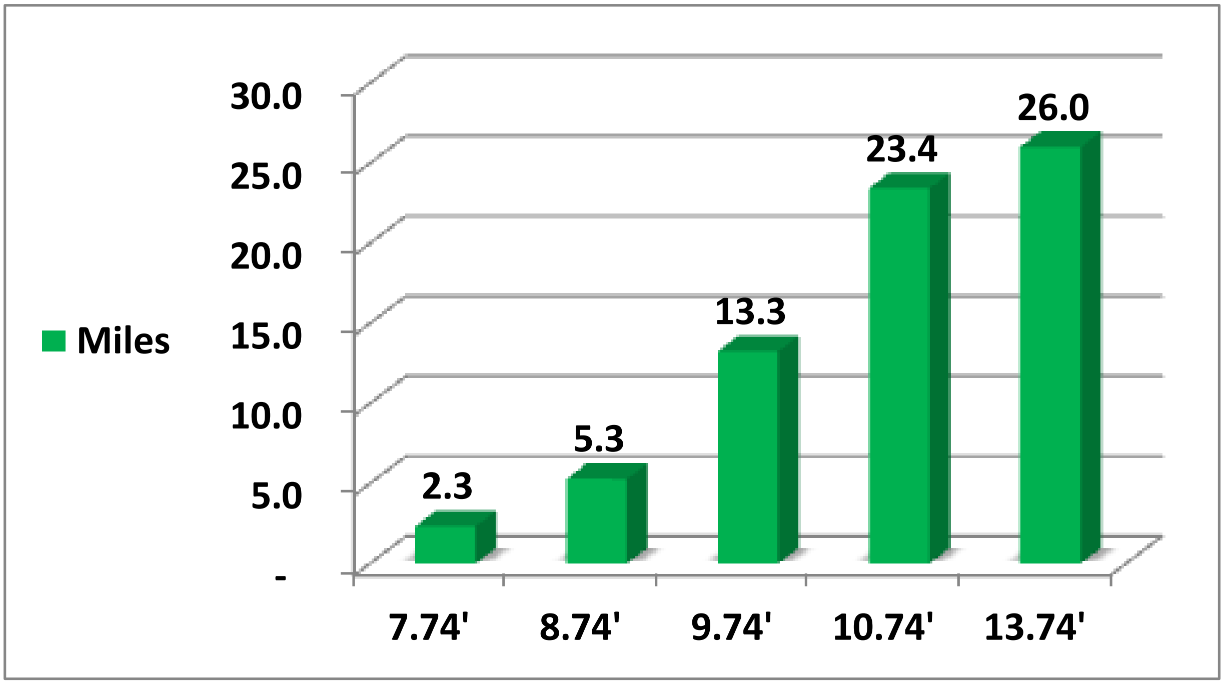

Chart 3. Humboldt Bay, artificial shoreline length in miles by elevation.

The GIS figures below depict the spatial distribution of shoreline segments that are cumulatively less than or equal to: 8.74 feet, 9.74 feet, 10.74 feet, and 13.74 feet.

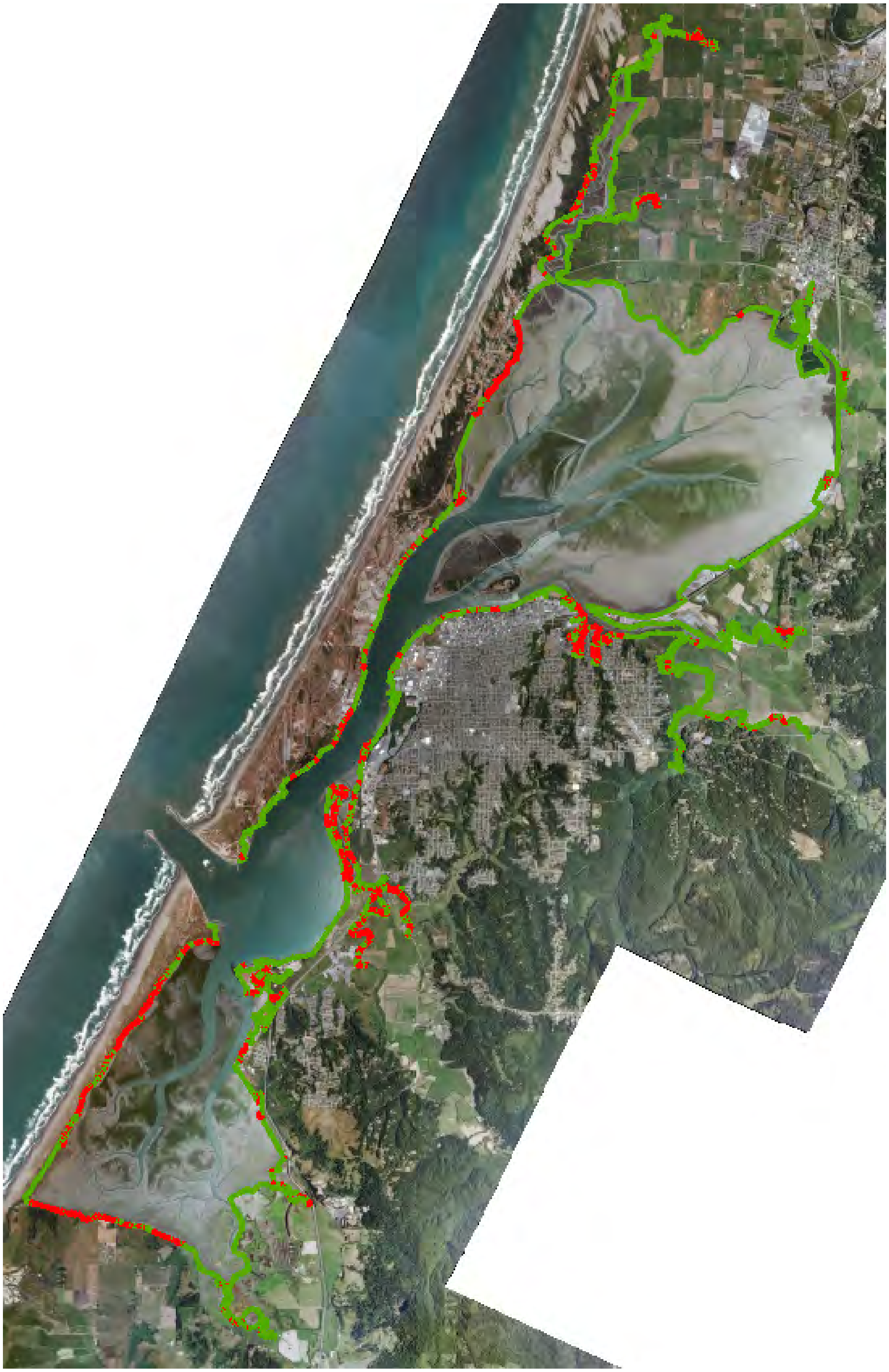

Figure 53. Humboldt Bay shoreline segments with elevations less than or equal to 8.74 feet (red), and segments that are greater than 8.74 feet in elevation (green).

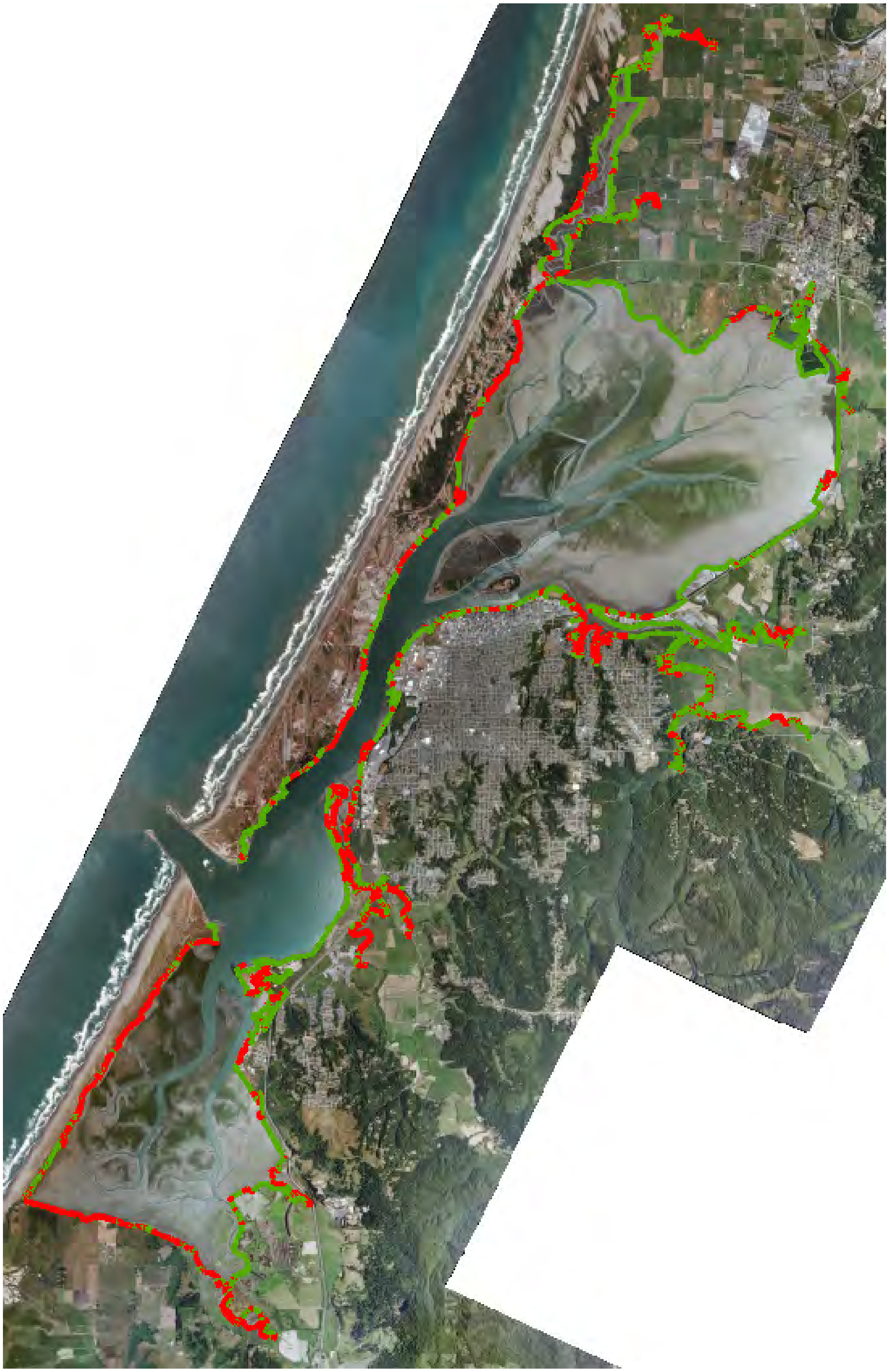

Figure 54. Humboldt Bay shoreline segments with elevations less than or equal to 9.74 feet (red) and segments that are greater than 9.74 feet in elevation (green).

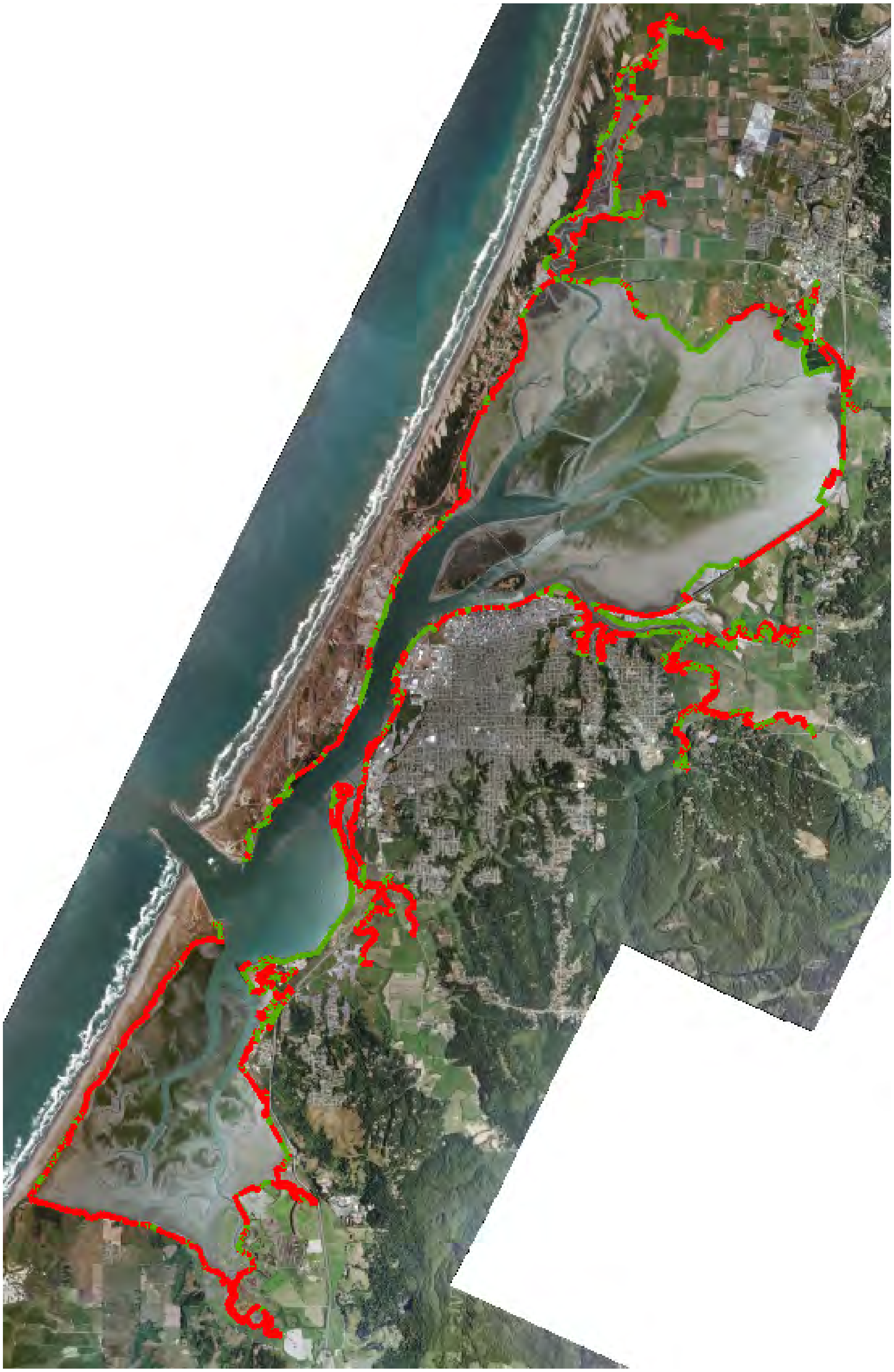

Figure 55. Humboldt Bay shoreline segments with elevations less than or equal to 10.74 feet (red) and segments that are greater than 10.74 feet in elevation (green).

Figure 56. Humboldt Bay shoreline segments with elevations less than or equal to 13.74 feet (red) and segments that are greater than 13.74 feet in elevation (green).

The five most prevalent shoreline structures are: dikes (40.7 miles), railroad (10.5 miles), fill (7.7 miles), fortified (7.6 miles), and roadways (5.0 miles). Table 21 lists shoreline length by elevation for these five structures. One characteristic that these shoreline structures share is that they are flat and of uniform elevation. Almost a third (31.3%) of these structures has a surface elevation between 10 and 11 feet (Chart 4). Cumulatively, 59.3% of these structures are less than or equal to 10.74 feet, and 91.9% of these structures are less than or equal to 13.74 feet.

Dike	4,273	12,899	43,184	63,097	79,331	214,792
Railroad	18	375	7,722	28,378	13,850	55,655
Fill	3,573	5,002	10,113	9,105	8,523	40,543
Fortified	1,465	4,426	5,892	9,188	12,046	40,263
Road	593	2,216	3,856	8,344	9,606	26,405
Percent	**2.6%**	**6.6%**	**18.7%**	**31.3%**	**32.7%**	

Table 21. Shoreline structure length by elevation and the total length of the shoreline for five specific structural types: dike, railroad, fill, fortified, and road.

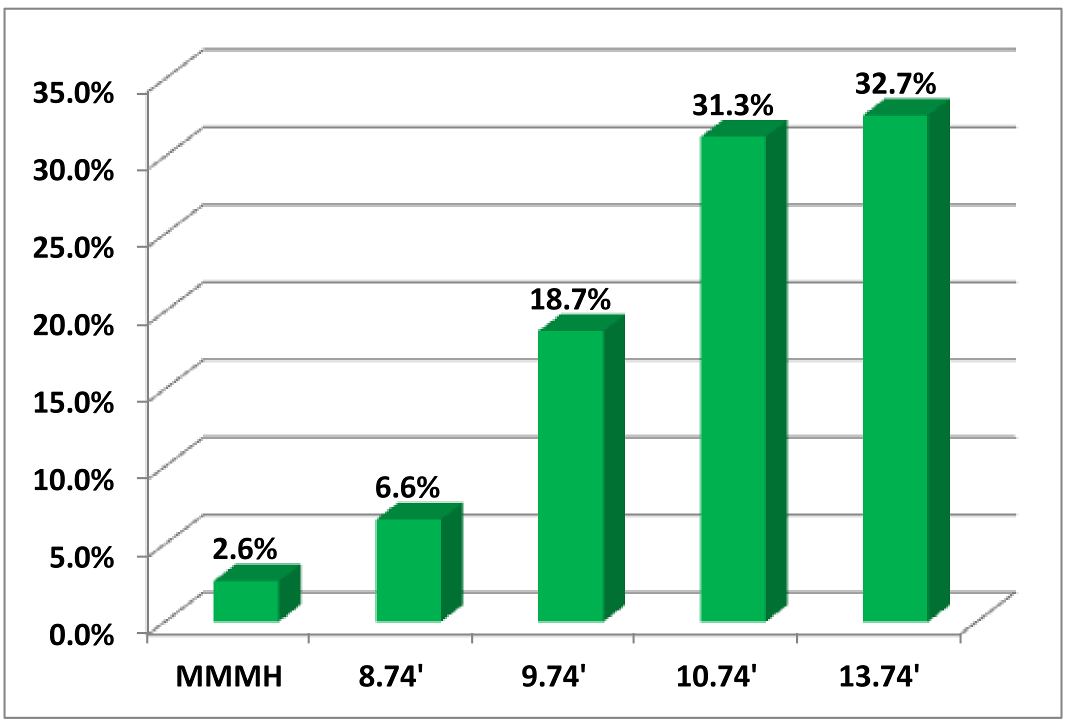

Chart 4. Shoreline structure elevations as a percent of the total length of shoreline for five specific structural types: dike, railroad, fill, fortified, and road.

Arcata Bay:

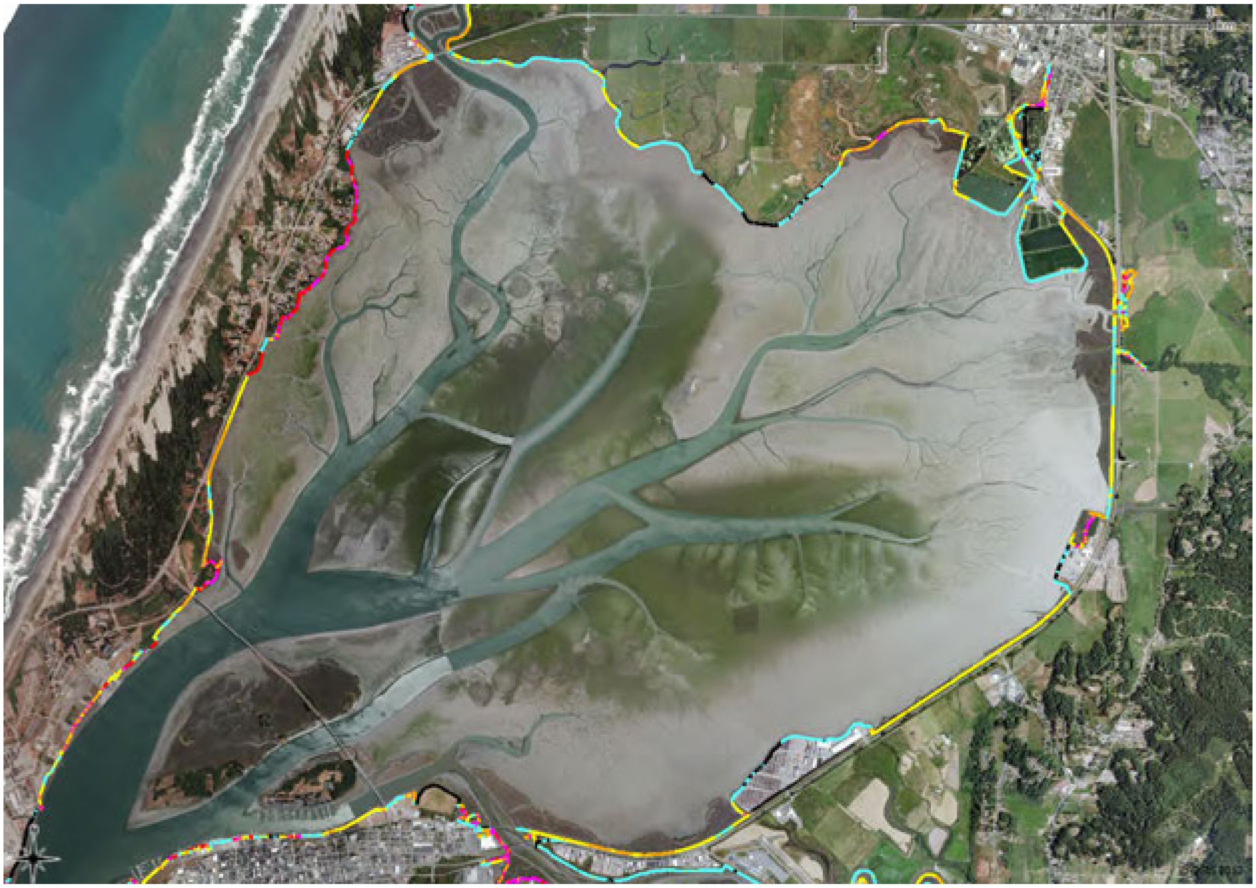

Figure 57. Distribution of shoreline elevations on Arcata Bay: 7.74 feet (red), 8.74 feet (magenta), 9.74 feet (brown), 10.74 feet (yellow), 13.74 feet (turquoise), and greater than 13.74 feet (black).

The shoreline of Arcata Bay is 20.5 miles long; 91% of the shoreline is composed of artificial structures. The two dominant shoreline structures on Arcata Bay are the railroad with 6.5 miles (32%) of the shoreline, and dikes on 6.3 miles (31%) of the shoreline (Table 22). Other types of shoreline structures on Arcata Bay are fill (2.5 miles,12%), the City of Arcata's waste water treatment and marsh ponds (1.9 miles, 9%), and roadways (1.3 miles, 6%). Nearly two thirds (67.4%) of the recently rehabilitated diked shoreline on Arcata Bay is equal to or greater than 13.74 feet in elevation. A significant length, 61.4% of the railroad grade, is at an elevation of 10.74 feet, and 93.9% of the wastewater treatment/marsh pond on Arcata Bay has an elevation of 13.74 feet, although 996 feet is 3 feet lower in elevation.

ARCATA BAY	ELEVATION					TOTAL
Linear (ft)	MMMH	8.74'	9.74'	10.74'	13.74'	FEET
Dike	154	815	4,168	5,645	15,739	33,107
Railroad	-	262	6,939	21,148	5,956	34,431
Fill	468	2,551	2,413	3,065	2,323	12,935
Wastewater Ponds	-	-	-	1,993	9,606	11,599
Road	3	97	1351	996	4,131	6,788
Total	**625**	**3,725**	**14,871**	**32,847**	**37,755**	**98,860**
Percent	**0.6%**	**3.8%**	**15.0%**	**33.2%**	**38.2%**	

Table 22. Arcata Bay shoreline structures and length for each surface elevation class and percentage of shoreline at elevation.

Eureka Bay:

Figure 58. Distribution of shoreline elevations on Eureka Bay: 7.74 feet (red), 8.74 feet (magenta), 9.74 feet (brown), 10.74 feet (yellow), 13.74 feet (turquoise), and greater than 13.74 feet (black).

The shoreline of Eureka Bay is 15.9 miles long; 71% of the shoreline is composed of artificial structures. The dominant artificial shoreline structures on Eureka Bay are fortified (5.6 miles, 35%), railroad (1.7 miles, 10%), fill (1.2 miles, 8%), bulwark (0.7 miles, 5%), and roadways (0.7 miles, 5%)(Table 23).

EUREKA BAY	**ELEVATION**					**TOTAL**
Linear (ft)	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**FEET**
Dike	166	285	537	266	128	3,077
Railroad	-	-	517	3,229	1,112	8,794
Fill	188	521	755	2,293	2,355	6,308
Fortified	1,167	1,985	3,573	6,537	9,280	29,657
Bulwark	463	159	400	785	1,735	3,916
Roads	47	268	229	1,905	892	3,852
Total	**2,030**	**3,218**	**6,011**	**15,015**	**15,502**	**55,604**
Percent	**3.7%**	**5.8%**	**10.8%**	**27.0%**	**27.9%**	

Table 23. Eureka Bay shoreline structures and length for each surface elevation class and percentage of shoreline at each elevation.

South Bay:

Figure 59. Distribution of shoreline elevations on South Bay: 7.74 feet (red), 8.74 feet (magenta), 9.74 feet (brown), 10.74 feet (yellow), 13.74 feet (turquoise), and greater than 13.74 feet (black).

The shoreline of South Bay is 21.8 miles long; 68% of the shoreline is composed of artificial structures. The two dominant artificial shoreline structures on South Bay are earthen dikes (7.6 miles, 35%), fill (2.6 miles, 12%), fortified (1.5 miles, 7%), and railroad (1.4 miles, 6%)(Table 24). A significant portion of the diked shoreline on South Bay is at an elevation of 9.74 feet (39.0%) or at 10.74 feet (39.0%). A significant portion of the railroad grade, 50.4%, is at an elevation of 10.74 feet.

SOUTH BAY	ELEVATION					TOTAL
Linear (ft)	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**FEET**
Dike	653	2,318	15,646	15,655	5,679	40,215
Railroad	-	-	89	3,626	3,503	7,197
Fill	1,972	2,155	2,462	2,710	2,464	13,816
Fortified	1,129	1,106	1,453	2,290	2,400	8,019
Road	313	825	142	**1,133**	**1,260**	3607
Total	**4,067**	**6,404**	**19,792**	**25,414**	**15,306**	**72,854**
Percent	**5.6%**	**8.8%**	**27.2%**	**34.9%**	**21.0%**	

Table 24. South Bay shoreline structures and length for each surface elevation class and percentage of shoreline at each elevation.

Mad River Slough:

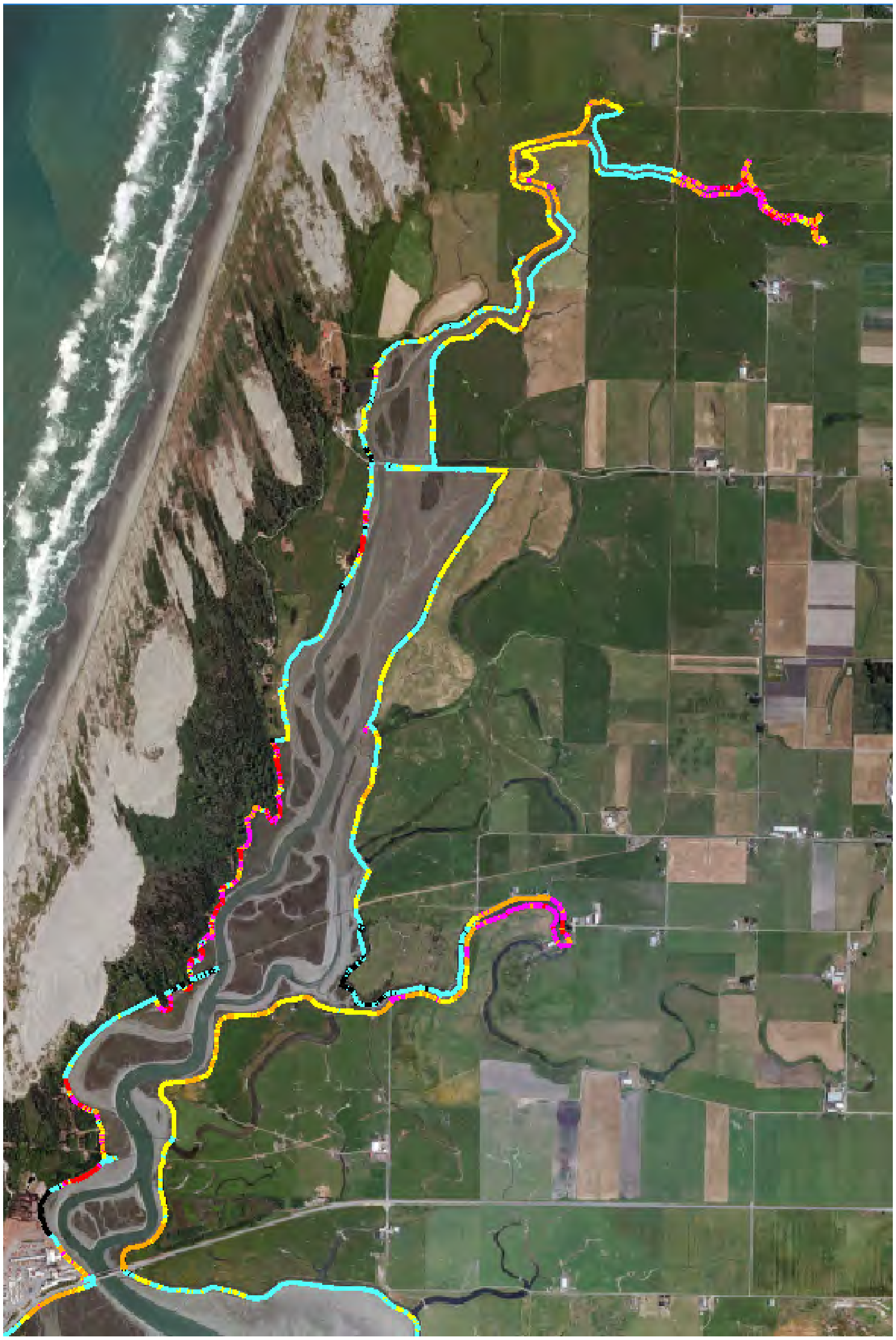

Figure 60. Distribution of shoreline elevations on Mad River Slough: 7.74 feet (red), 8.74 feet (magenta), 9.74 feet (brown), 10.74 feet (yellow), 13.74 feet (turquoise), and greater than 13.74 feet (black).

The shoreline of Mad River Slough is 13.7 miles long; 80% of the shoreline is composed of artificial structures. The dominant artificial shoreline structures are dikes (9.0 miles, 66%), roadway (1.0 miles, 7%), and an abandoned historic Hammond Railroad Grade (0.6 miles, 4%)(Table 25). A significant portion, 42.3%, of the artificial shoreline is at an elevation of 13.74 feet.

MAD RIVER SLOUGH	ELEVATION					TOTAL
Linear (ft)	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**FEET**
Dike	431	2,330	8,636	15,172	19,274	47,471
Railroad	-	-	-	77	2,462	2,968
Fill	3	3	79	52	445	469
Fortified	-	59	396	159	248	1,345
Road	9	477	1,133	1,522	1,795	5,050
Total	**443**	**2,869**	**10,244**	**16,982**	**24,224**	**57,303**
Percent	**0.8%**	**5.0%**	**17.9%**	**29.6%**	**42.3%**	

Table 25. Mad River Slough shoreline structures and length for each surface elevation class and percentage of shoreline at each elevation.

Eureka Slough:

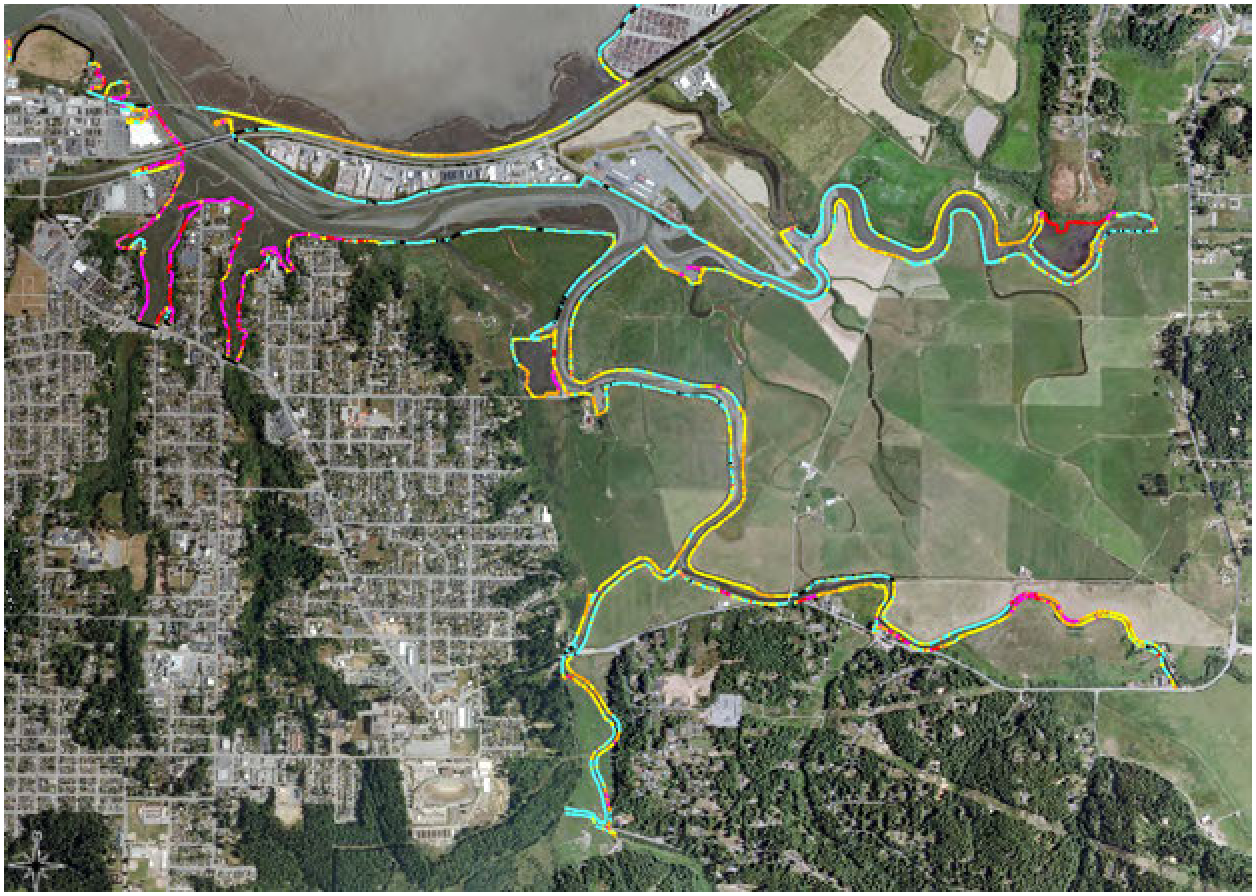

Figure 61. Distribution of shoreline elevations on Eureka Slough: 7.74 feet (red), 8.74 feet (magenta), 9.74 feet (brown), 10.74 feet (yellow), 13.74 feet (turquoise), and greater than 13.74 feet (black).

The shoreline of Eureka Slough is 20.8 miles long; 80% of the shoreline is composed of artificial structures. The dominant shoreline structures are earthen dikes (14.3 miles, 69%), fill (1.2 miles, 6%), and roadway (0.7 miles, 3%) (Table 26). A significant portion, 45.7%, of the artificial shoreline is at an elevation of 13.74 feet.

EUREKA SLOUGH	ELEVATION					TOTAL
Linear (ft)	MMMH	8.74'	9.74'	10.74'	13.74'	FEET
Dike	689	1,465	10,312	23,929	37,332	75,588
Railroad	18	113	164	166	102	551
Fill	828	1,893	1,451	961	924	6,059
Fortified	-	3	66	75	16	163
Road	147	427	866	641	959	3,666
Total	**1,682**	**3,901**	**12,859**	**25,772**	**39,333**	**86,027**
Percent	**2.0%**	**4.5%**	**14.9%**	**30.0%**	**45.7%**	

Table 26. Eureka Slough shoreline structures and length for each surface elevation class and percentage of shoreline at each elevation.

Elk River Slough:

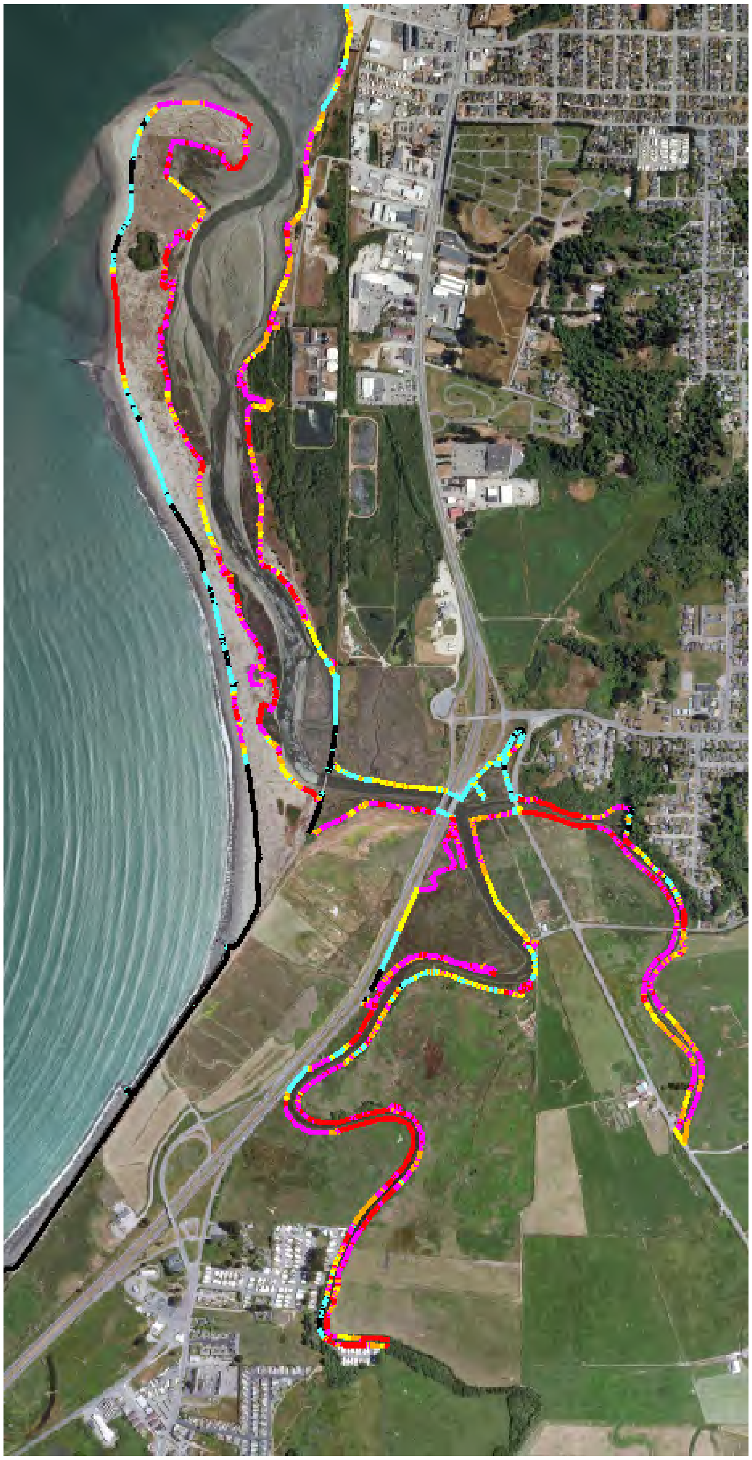

Figure 62. Distribution of shoreline elevations on Elk River Slough: 7.74 feet (red), 8.74 feet (magenta), 9.74 feet (brown), 10.74 feet (yellow), 13.74 feet (turquoise), and greater than 13.74 feet (black).

The shoreline of Elk River Slough is 9.7 miles long; 5.4 miles (55%), of the shoreline is natural and 4.2 miles, (45%) of the shoreline is composed of artificial structures. The three dominant shoreline structures are natural (3.0 miles, 31%), earthen dikes (2.9 miles, 30%), and foredunes (1.7 miles, 18%) (Table 27). Other types of shorelines are roadway (0.6 miles, 7%), and railroad (0.3 miles, 3%). A significant portion, 4,500 feet, of the upper tidal reach of Elk River Slough, has natural channel banks, 31% at an elevation 7.74 feet, and 37.2% at 8.74 feet. 51.3% of the earthen dikes are also at an elevation less than or equal to 8.74 feet.

ELK RIVER SLOUGH	ELEVATION					TOTAL
Linear (ft)	MMMH	8.74'	9.74'	10.74'	13.74'	FEET
Dike	2,180	5,685	3,885	2,420	1,179	15,334
None	4,938	5,916	3,013	1,706	438	15,919
Fore dune	3,000	3,772	1,341	991	147	9,246
Road	75	122	136	829	1,884	3,443
Railroad	-	-	13	131	714	1,714
Total	**10,193**	**15,495**	**8,388**	**6,077**	**4,362**	**45,656**
Percent	**22.3%**	**33.9%**	**18.4%**	**13.3%**	**9.6%**	

Table 27. Elk River Slough shoreline structures and length for each surface elevation class and percentage of shoreline at each elevation.

d) Salt Marsh

The salt marsh habitat present today is less than 900 acres (Pickart 2001), significantly less than the nearly 9,000 acres mapped in 1870 (USCGS) (Figure 63); large areas of salt marsh dissected by tidal tributary channels which were once common around the Bay and in the Sloughs, are now rare.

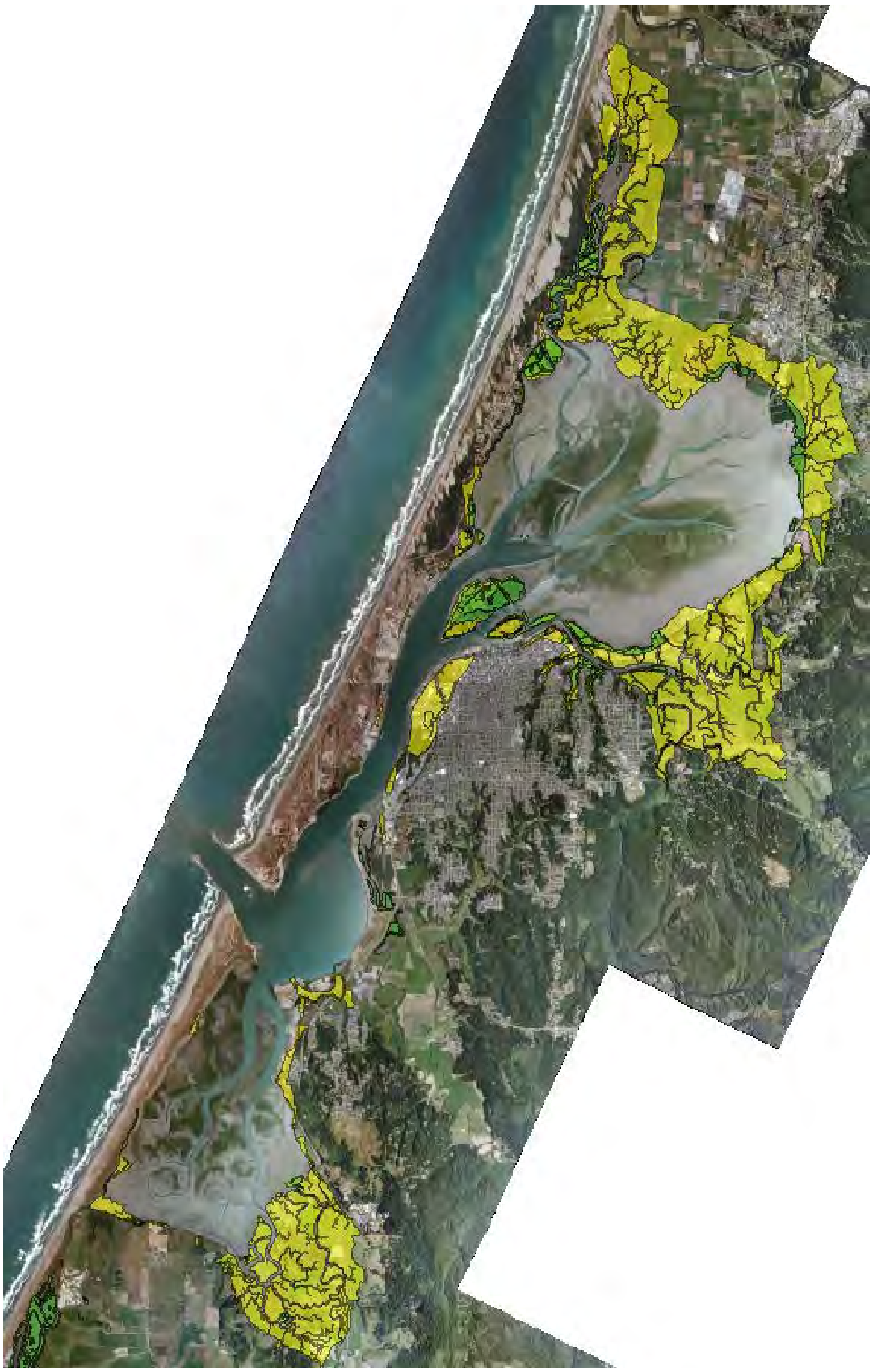

Figure 63. Humboldt Bay, salt marsh distribution and extent; 1870 (yellow) versus 2009 (green).

The presence of salt marsh habitat was one of the attributes used to stratify shoreline into segments. Salt marsh was present on 48.5 miles, brackish marsh occurred on 1.5 miles, and tidal marsh was absent from 52.3 miles of shoreline (Chart 5).

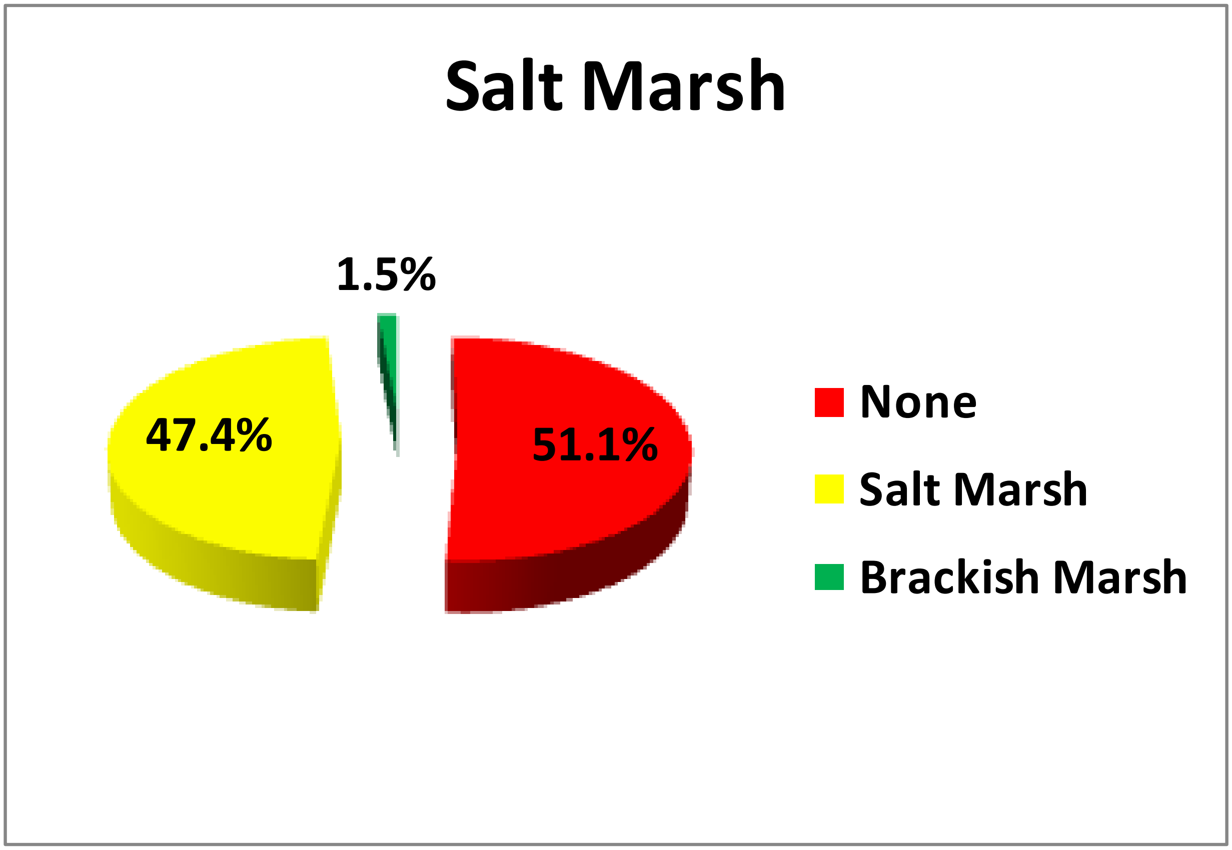

Chart 5. Percentage of shoreline with tidal or brackish marshes.

Salt marsh is spatially associated with several shoreline structures that cover 32.7 miles: building, bulwark, cliff/bluff, jetty, dike, pond, railroad, road, and tidegate (Table 28). Dikes support salt marsh habitats on 18.1 miles, railroad on 7.9 miles, fill on 4.3 miles, roads on 3.0 miles, and cliff/bluffs on 2.2 miles. Salt marsh is present on 10.9 miles of shoreline composed of foredune and natural shoreline with no structure (none).

STRUCTURE	Salt Marsh Present (ft)
Building	256
Bulwark	373
Cliff/Bluff	11,944
Dike	95,798
Fill	22,555
Fore Dune	6,758
Fortified	3,130
Jetty	703
None	50,950
Pond	6,046
Railroad	41,858
Road	15,564
Tidegate	40
TOTAL	**255,975**

Table 28. Shoreline structure and length in feet of associated tidal marshes.

The distribution of tidal marshes on Humboldt Bay is not uniform (Table 29) (Figure 62). Most of the natural shoreline in Arcata Bay has salt marsh present (92%); even the artificial shoreline in Arcata Bay is predominantly associated with salt marsh (59%), and there is a minor component of brackish marsh on Butcher Slough (1%). On Eureka Bay, the majority of the shoreline is without salt marsh (84%), and on South Bay, the greater part of the shoreline is also without salt marsh (59%). Most of the salt marsh in South Bay is associated with South Spit. Salt marsh is prevalent on the natural shoreline of Mad River Slough (76%), and on its artificial shoreline it is evenly split between present (49%) or absent (51%). On Eureka Slough the majority of the shoreline has salt marsh present (53%), as well as brackish marsh (6%). Elk River Slough is also mostly associated with salt marsh (61%).

TIDAL MARSH TYPE (ft)	ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET
None	39,762	70,879	67,826	32,998	45,015	19,846	276,325
Salt Marsh	67,275	13,025	46,907	39,133	58,255	31,380	255,974
Brackish Marsh	1,068	0	522	0	6,418	0	8,008
Total	**108,104**	**83,903**	**115,255**	**72,131**	**109,688**	**51,226**	

Table 29. Shoreline length with tidal marsh by hydrologic unit in feet.

During inventory and mapping, 57 areas were located where salt marsh habitat exists which was not delineated on the 2009 NOAA benthic habitat mapping (Figure 64). These salt marsh areas were found either within the Bay or slough channels or hydrologically connected with the Bay via large diameter culverts or breached dikes. However, the extent of these salt marsh habitats has not been delineated by this project.

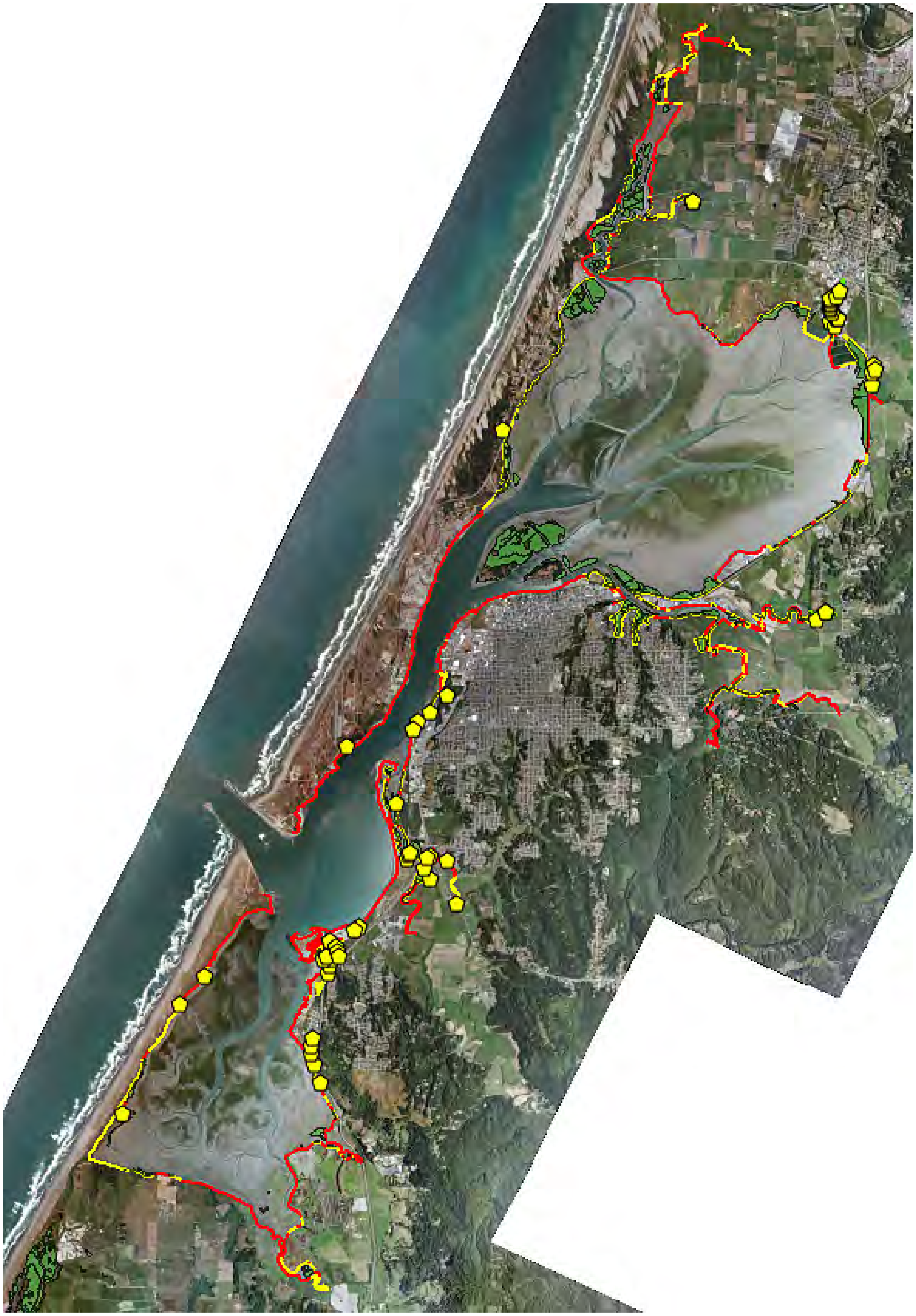

Figure 64. Distribution of shoreline with salt marsh (yellow), without salt marsh (red) and the location of previously un-mapped salt marsh (yellow shield).

e) Water Control Structure

A total of 36 water control structures have been added to USFWS' 2007 water control structures database. The location and type of water control structures have been verified in the field; 18 culverts and 18 tidegates were found at 28 locations (Figure 65).

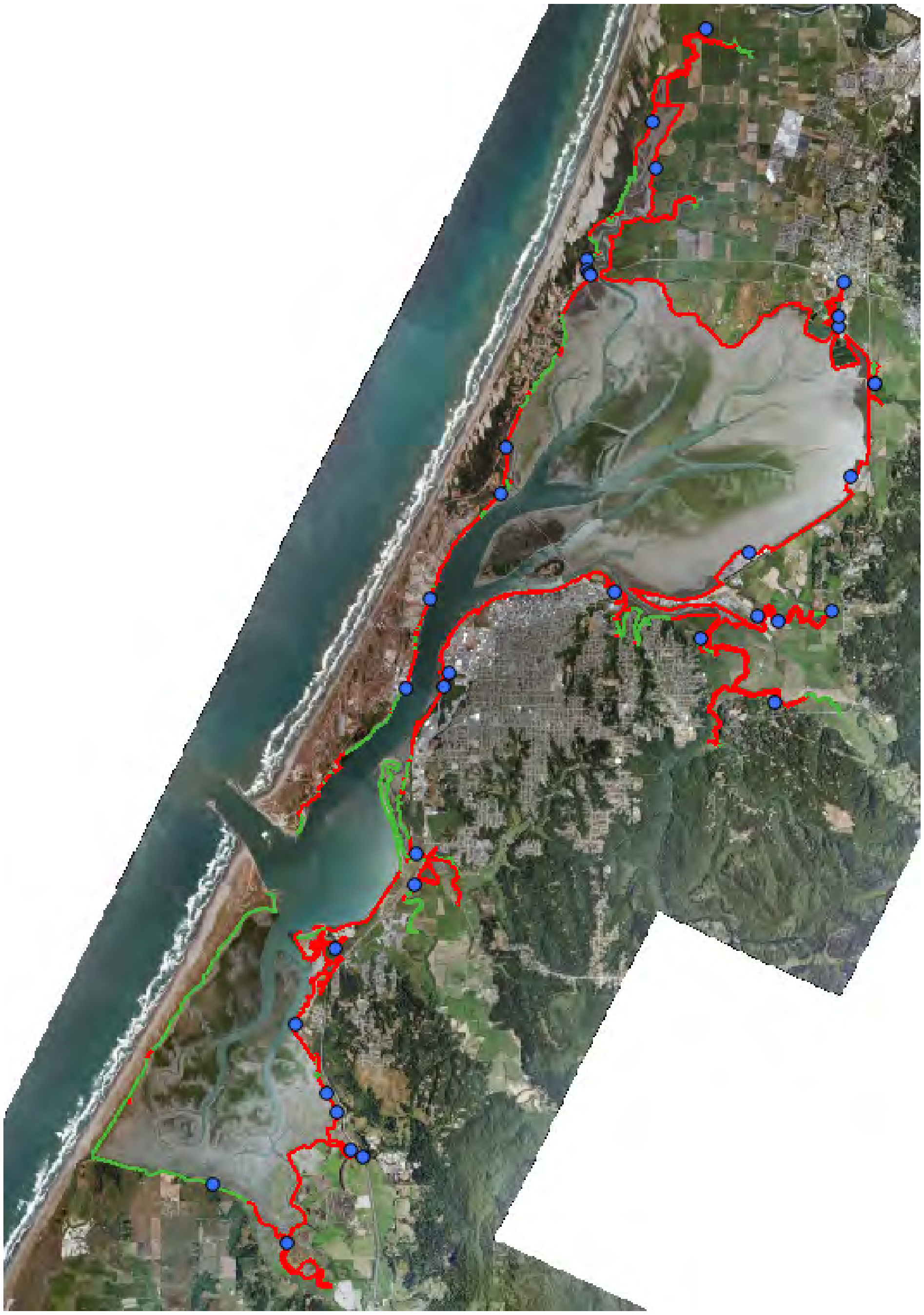

Figure 65. Humboldt Bay, 36 additional water control structures (blue) have been added to USFWS's 2007database.

4 Shoreline Vulnerability Assessment

This chapter will assess the vulnerability of the existing shoreline, to erosion or flooding, under current tidal conditions, and to elevated sea levels. The vulnerability assessment will identify land uses and infrastructure that could be affected if the existing shoreline were to fail to retain the tides. The ability of existing salt marsh habitat areas to migrate with rising sea levels will also be assessed.

This shoreline vulnerability assessment will consider both shoreline structure/cover and shoreline elevations (Figure 66).

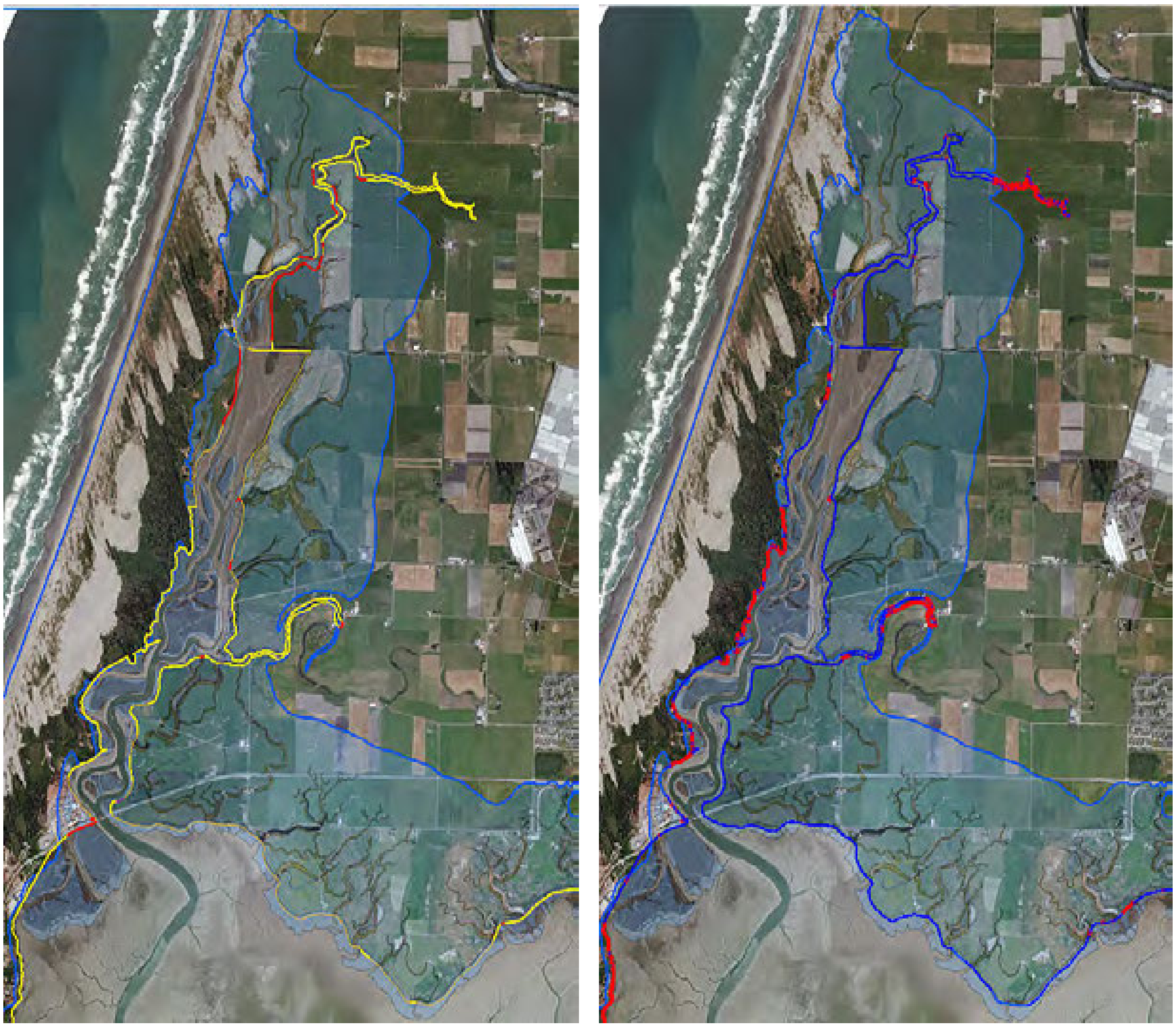

Figure 66. Mad River Slough depicting the location of exposed (red) and unfortified (yellow) shoreline cover on the left versus the location of shoreline elevations that are less than or equal to EHT (red) on the right, and the 1870 tidal inundation footprint.

Shoreline structures such as dikes protect land uses, infrastructure, and resources that reside on former tidelands, from salt water flooding. During the more than 100 years that these former tidelands have been isolated from daily tidal inundation, compaction has lowered their surface elevation, and tectonic subsidence is suspected of also lowering these lands' surfaces. Within the historic tidal footprint, reside land uses, infrastructure, and resources that are important to the Humboldt Bay region. Without a sea level rise inundation model specific to Humboldt Bay, the historic tidal-upland boundary, as surveyed in 1870 by the USCGS, is being used as a minimum or conservative inundation footprint for this shoreline vulnerability assessment (Figures 67 and 68).

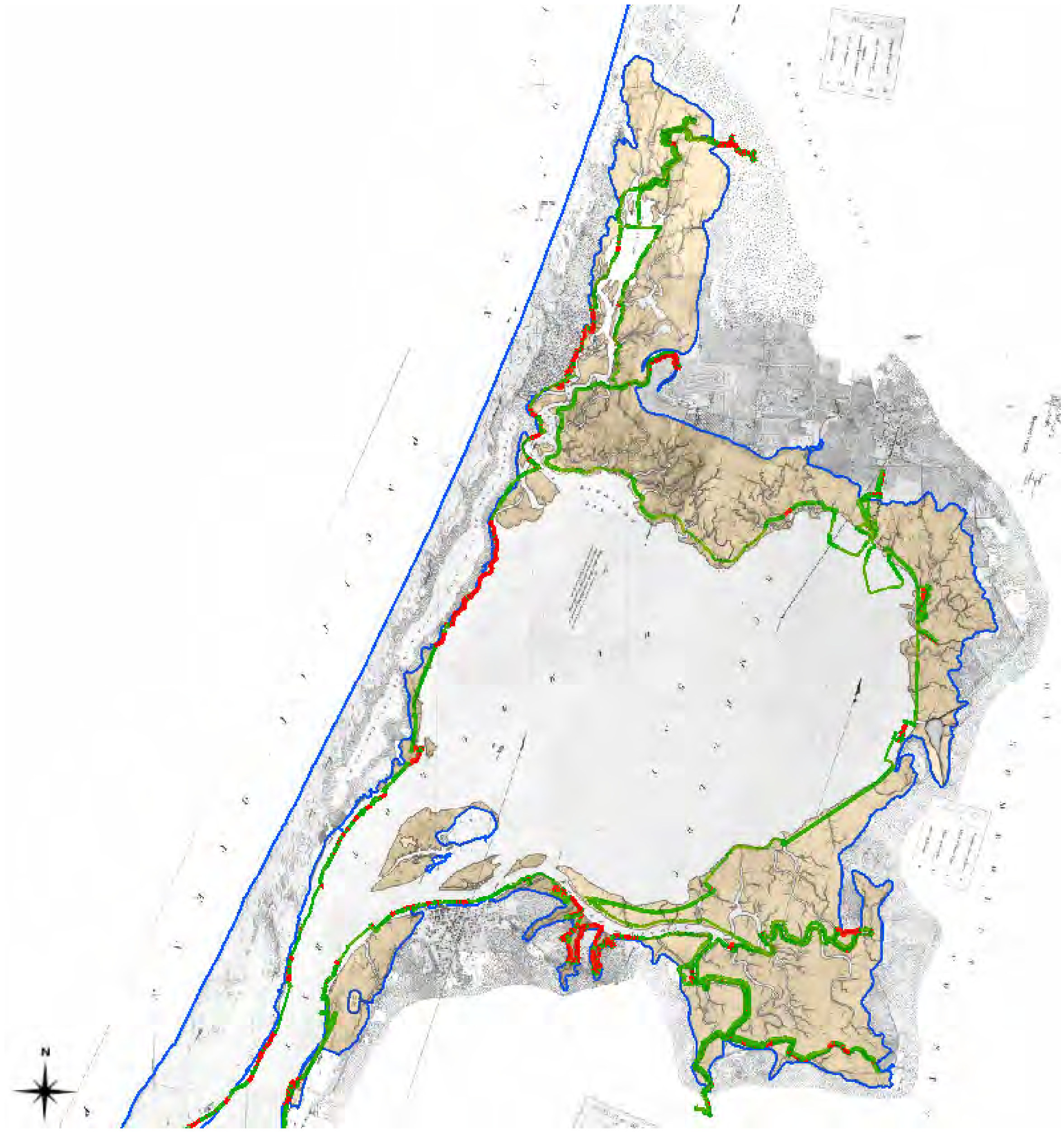

Figure 67. Arcata Bay, Mad River Slough, and Eureka Slough, 2009 shoreline elevations for EHT (red) and shorelines higher in elevation (green) with the 1870 tidal inundation footprint and tidal-upland shoreline (blue) (Laird 2007) on the 1870 USCGS map.

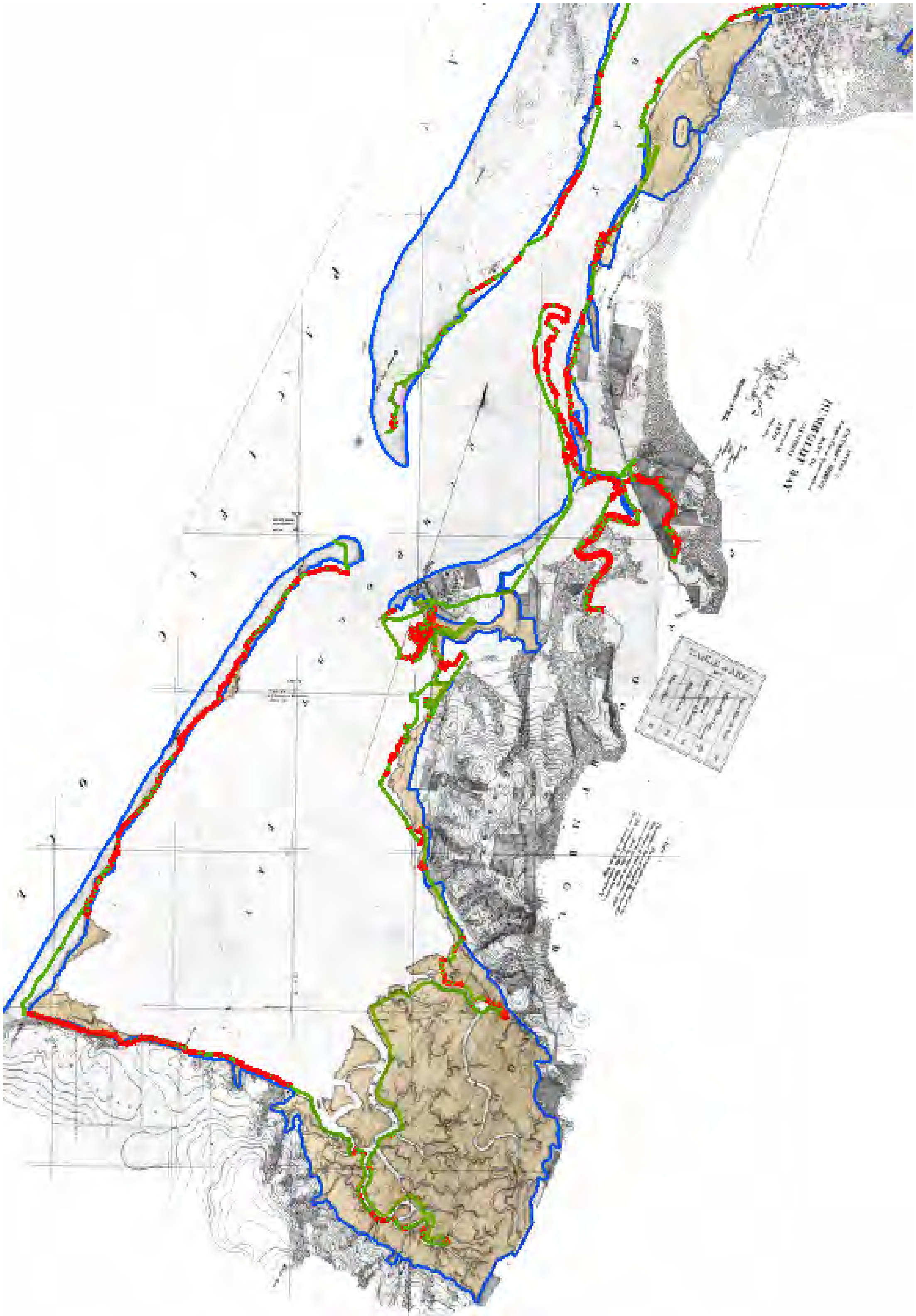

Figure 68. Eureka and South Bays, Elk River Slough, 2009 shoreline elevations for EHT (red) and shorelines higher in elevation (green) with the 1870 tidal inundation footprint and tidal-upland shoreline (blue) (Laird 2007) on the 1870 USCGS map.

This vulnerability assessment describes each hydrologic unit's land uses, infrastructure, and resources that reside in the historic tidal inundation zone that potentially could be flooded if shoreline failure were to occur.

Sea Level Rise

Sea level rise, as used in this vulnerability assessment, is in relation to the MMMW elevation of 7.74 feet measured at the North Spit tidal station. When the Moon is at its closest to Earth, at perigee, and when this occurs during a new or full moon phase, the high tides may be greater than normal. On average each year on Humboldt Bay, we experience one foot of sea level rise during some very high tides. Recently, these very high tides in the winter months have become known as King Tides; otherwise called extreme or annual maximum high tides. King Tides can occur for several days; typically from November through January.

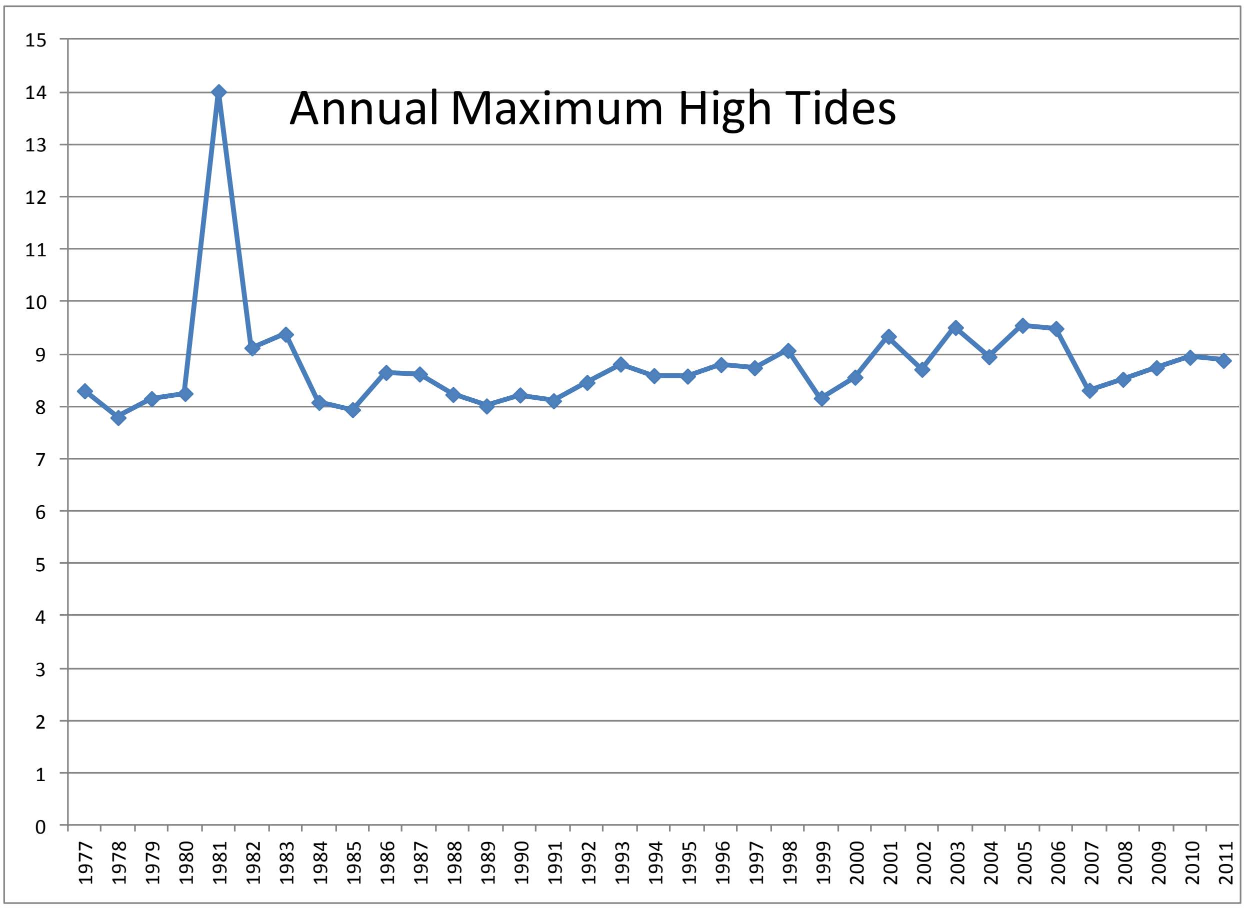

Chart 6. Annual maximum high tide, 1977 through 2011, average annual maximum high tide is 8.79 feet at the north spit tidal datum.

Since 1977, twelve of the annual EHT have exceeded the average annual maximum high tide of 8.79 feet, and since 2000, seven have been greater (Chart 6). El Nino events can also cause elevated tide elevations of 12 inches or more for several months (Griggs 2012). The most recent El Nino events occurred during 1982/1983 and 1997/1998. A combination of King Tides and El Nino event could raise sea levels several feet, even more with storm surges.

During the last 100 years, sea level along California's coast has increased an average of 7 inches (2009 California Climate Adaption Strategy). However, according to the North Spit station records, sea level is rising in Humboldt Bay at a rate of 18.6 inches per century, which is the highest rate in California; Humboldt Bay is subsiding (Russell 2012). The combination of EHT during strong El Nino events or during periods of heavy precipitation can lead to short-term increases in sea level; such as occurred on Humboldt Bay in 2003 and again in 2005/6. A conservative estimation of sea level rise for the coast of California is: 6 inches by 2030, 12 inches by 2050, and 36 inches by 2100. The CCC requires applicants for development permits to evaluate the potential affect of sea level rise on their proposed project, at a minimum of 3 feet and maximum of 6 feet of sea level rise. Relative sea level rise on Humboldt Bay will likely be greater if tectonic subsidence continues to occur. This vulnerability assessment will evaluate the elevation of shoreline structures in one foot increments above MMMH elevation to three feet of sea level rise and at six feet.

a) Humboldt Bay

While overtopping of natural shorelines such as fore dunes on Elk River Spit or South Spit does occur at MMMW and EHT elevations, the dune slope can accommodate a rising tide as the shoreline migrates inland, with little risk to land uses or significant infrastructure. In addition to failing dikes causing flooding of former tidelands, overtopping of natural banks in open tidal channels can also cause flooding of adjacent lands, uses, infrastructure, and resources. There are 7 open tidal channels on Humboldt Bay:

1. Mad River Slough: the uppermost 2,000 feet of channel has natural banks. Overtopping occurs on approximately 500 foot of the south bank at EHT elevation, and at 2 feet of sea level rise both banks will be completely overtopped;
2. Liscom Slough: 1,300 feet of the south bank east of Jackson Ranch is natural ground and is overtopped at EHT elevation;
3. Butcher Slough: is an open channel north of Highway 255 but it is well confined and its banks are higher than 9.74 feet;
4. Jacoby Creek: in the 800 feet of channel east of Highway 101 the south bank currently is overtopped at EHT elevation;
5. Freshwater Creek: the last 2,500 feet of tidal channel has natural banks that are currently over topped at EHT elevation in a few locations. Overtopping increases at 2 feet of sea level rise and complete overtopping occurs with 3 feet of sea level rise,
6. Ryan Slough: is an open channel but it is well confined above the tidal reach south of Mitchell Road;
7. Elk River Slough: the last 4,850 feet of tidal channel has natural banks that are currently overtopped at EHT elevations.

If existing shoreline persist, overbank flooding on Mad River, Liscom, and Elk River, sloughs/ creeks will increase as sea level rises, putting mostly agricultural lands and some roads at risk.

Thousands of acres of former tidelands around Humboldt Bay are primarily protected from tidal flooding by shoreline structures such as dikes and the railroad grade which functions as a dike in most areas. Together, dikes and railroad grade occupy 51.2 miles, which is 66.8% of the artificial shoreline on Humboldt Bay. Currently, there are 17,686 feet (3.3 miles) of exposed dikes, and 896 feet (0.2 miles) of exposed railroad grade. The exposed dike shorelines are predominately located in Mad River Slough (7,969 feet) (Figure 69), Eureka Slough (6,098 feet), and South Bay (3,429 feet). The exposed railroad grade shorelines are located in Arcata Bay (525 feet) and South Bay (346 feet).

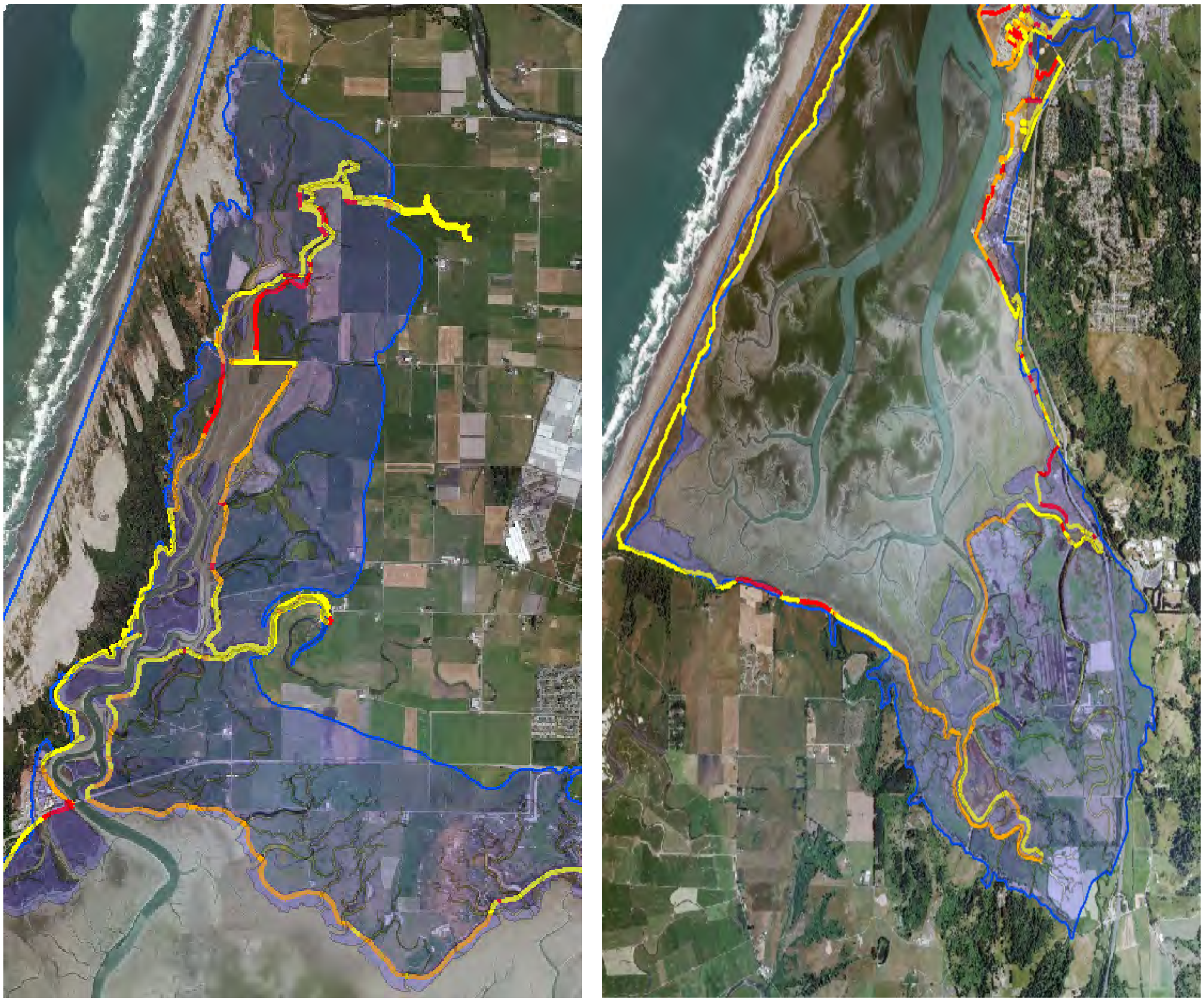

Figure 69. Mad River Slough exposed dikes (red) and South Bay's exposed dikes and railroad grade on the east shore of the Bay, with 1870 tidal inundation area.

On Mad River Slough, the exposed earthen dikes are found on both banks, particularly north of Lanphere Road. There are 12 locations where the dike is exposed, ranging in length from 104 feet to 2,030 feet. Eureka Slough also has exposed dikes on both banks on Fay Slough, Freshwater Slough, and Eureka Slough (Figure 70). There are 15 locations where the dike is exposed, ranging in length from 24 feet to 1,183 feet. South Bay has 7 locations where dikes are exposed, ranging in length from 164 feet to 1,307 feet.

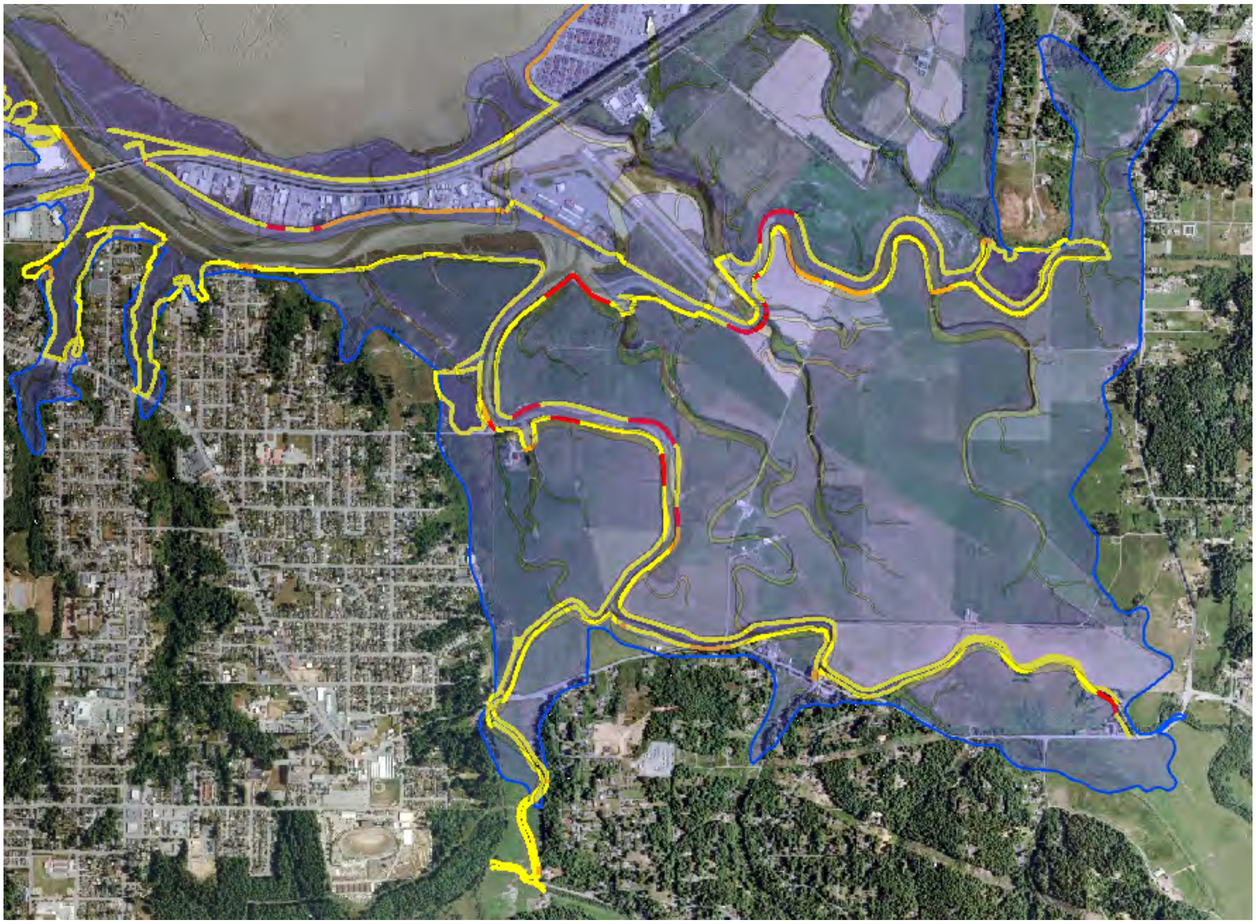

Figure 70. Eureka Slough exposed dikes (red), with 1870 tidal inundation area.

Table 30, lists the length of artificial shoreline in each hydrologic unit that would be overtopped by 1 to 3 feet of sea level rise, and 6 feet of sea level rise. The average EHT elevation, as measured at the north spit, is 8.79 feet and 91% of the artificial shoreline is higher than that elevation, 73% of the artificial shoreline is greater than 9.74 feet, but at 10.74 feet elevation just 42% of the artificial shoreline is higher, and only 8% of the artificial shoreline is greater than 13.74 feet.

	Length (feet) of shoreline at or below specified elevation							
SHORELINE ELEVATION	**ARCATA BAY**	**EUREKA BAY**	**SOUTH BAY**	**MAD RIVER SLOUGH**	**EUREKA SLOUGH**	**ELK RIVER SLOUGH**	**TOTAL FEET**	**TOTAL PERCENT**
7.74' (MMMW)	736	2,289	4,611	443	1,756	2,469	12,304	**3.0%**
8.74' (1' SLR)	4,596	5,913	11,357	3,318	5,691	9,339	40,214	**9.9%**
9.74' (2' SLR)	19,688	12,522	31,485	13,809	18,899	13,777	110,181	**27.2%**
10.74' (3' SLR)	54,061	28,592	57,911	30,841	45,157	17,311	233,872	**57.8%**
13.74' (6' SLR)	88,910	45,246	75,158	55,068	85,284	21,585	371,251	**91.7%**
Total	98,619	59,772	78,132	57,623	87,834	22,829	404,810	

Table 30. Humboldt Bay hydrologic unit's artificial shoreline length (linear feet) by shoreline elevation and percentage of total artificial shoreline length.

South Bay has the most vulnerable artificial shoreline based on 1, 2, and 3 feet of sea level rise. Under existing conditions, approximately 2, 6, and 11 miles of South Bay shoreline would be overtopped. With 6 feet of sea level rise, Arcata Bay has the most vulnerable artificial shoreline, approximately 17 miles would be overtopped, and Eureka Slough would have approximately 16 miles overtopped.

Chart 7 illustrates the cumulative length of shoreline in miles that would be overtopped for each of these elevations. A significant portion of the artificial shoreline, 58%, would be overtopped by 3 feet of sea level rise, and 92% of the artificial shoreline by 6 feet above MMMW.

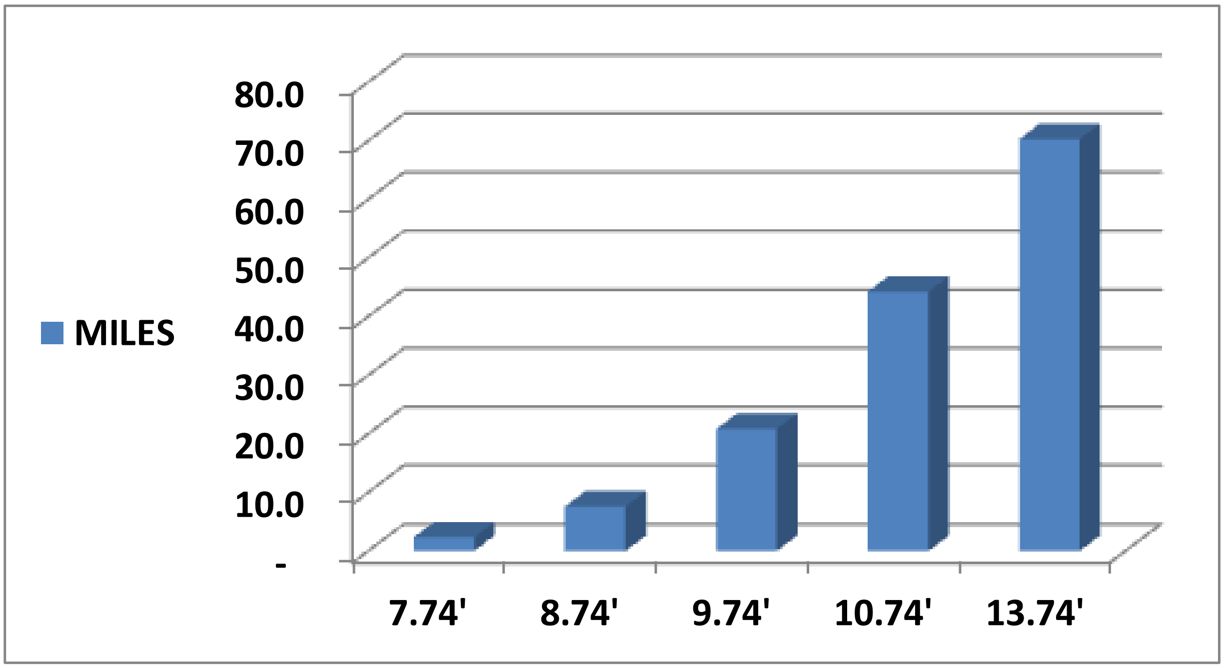

Chart 7. Humboldt Bay artificial shoreline, in miles, that is less than or equal to MMMW (7.74 feet) tide elevation plus 1 through 3 feet and 6 feet of sea level rise.

Significant portions of shoreline structures critical to the protection of thousands of acres of agricultural lands are less than 13.74 feet in elevation: 38.4 miles (94.4%) of the dikes and 9.5 miles (90.5%) of the railroad grade (Table 31). Substantial lengths of these structures are less than 10.74 feet elevation: 23.4 miles (42%) of the dikes and 6.9 miles (34%) of the railroad grade. If existing shoreline elevations persist, there would be two important shoreline overtopping elevation thresholds: 8.74 feet to 9.74 feet, and 9.74 feet to 10.74 feet. The length of dikes that would be overtopped would increase from 3.2 miles to 11.4 miles and then to 23.4 miles, and the length of railroad grade that would be overtopped would increase from 0.7 miles to 1.5 miles and then 6.9 miles. Again, if current shoreline structure elevations persist, when water levels reach 13.74 feet in elevation, 94.4% of the dikes and 90.5% of the railroad grade will be overtopped.

	Length (feet) of shoreline at or below specified elevation					
HUMBOLDT BAY	**ELEVATION**					**TOTAL**
SHORELINE STRUCTURE	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**LENGTH**
Dike	4,273	17,172	60,356	123,453	202,784	214,792
Railroad	18	393	8,115	36,493	50,343	55,655
Fill	3,573	8,575	18,688	27,793	36,316	40,543
Fortified	1,465	5,891	11,783	20,971	33,017	40,263
Total	**9,329**	**32,031**	**98,942**	**208,710**	**322,460**	**351,253**

Table 31. Cumulative length, of critical shoreline structures that would be overtopped by water elevations less than or equal to MMMW plus 1 to 3 feet, and 6 feet of sea level rise.

The two dominant artificial shoreline structures, dikes and railroad grade, cover over 51 miles (66%) of the artificial shoreline.

Dikes

Because dikes are the most prevalent shoreline structure on Humboldt Bay, covering 40.7 miles of shoreline, it is important to assess their current elevation (Table 32). During EHT, water elevations increase above MMMW, on average, 1 foot (8.78 feet). Under current shoreline conditions, overtopping would occur on 8% of the dikes; with the combination of an El Nino event, tidal elevations could increase 1 more foot to 9.74', in which case approximately 28% of the dikes on Humboldt Bay could be overtopped. With a 3 foot rise in water levels, overtopping of dikes increases to 57.5%, and with 6 feet of rise, 94.4% of the dikes will fail to hold back tidewater. If existing dike conditions persist, there is a threshold for significant increases in overtopping between the average EHT elevation and 1 more foot of sea level rise (9.74 feet) which would result in the 3.3 miles overtopped by EHT increasing to 11.4 miles (Chart 8). When sea level rises 2 feet, and if existing dike elevations are not increased, then overtopping of 11.4 miles of dike would cause tidal flooding of a significant amount of former tidelands around Humboldt Bay. A second threshold between 2 and 3 feet of sea level rise could result in a doubling of the number of miles of dikes being overtopped, from 11.4 to 23.4 miles.

	Length (feet) of shoreline at or below specified elevation							
DIKED SHORELINE ELEVATION	**ARCATA BAY**	**EUREKA BAY**	**SOUTH BAY**	**MAD RIVER SLOUGH**	**EUREKA SLOUGH**	**ELK RIVER SLOUGH**	**TOTAL FEET**	**TOTAL PERCENT**
7.74' (MMMW)	154	166	653	431	689	2,180	4,274	**2.0%**
8.74' (1' SLR)	970	450	2,971	2,761	2,155	7,865	17,171	**8.0%**
9.74' (2' SLR)	5,137	988	18,617	11,397	12,467	11,750	60,356	**28.1%**
10.74' (3' SLR)	10,782	1,265	34,272	26,569	36,395	14,170	123,453	**57.5%**
13.74' (6' SLR)	26,521	1,392	39,951	45,843	73,728	15,349	202,783	**94.4%**
Total	33,107	3,077	40,215	47,471	75,588	15,334	214,792	

Table 32. Cumulative length, of diked shoreline that would be overtopped by water elevations less than or equal to MMMW plus 1 to 3 feet, and 6 feet of sea level rise.

With sea level rise of 1 foot, Elk River Slough would experience the greatest amount of overtopping of its diked shoreline sea level rise of 2 feet would result in overtopping of 46% of South Bay's dikes. With 3 feet of sea level rise, 48% of Eureka Slough's dikes would be overtopped, and at 6 feet, nearly all (94%) of the diked shoreline would be overtopped.

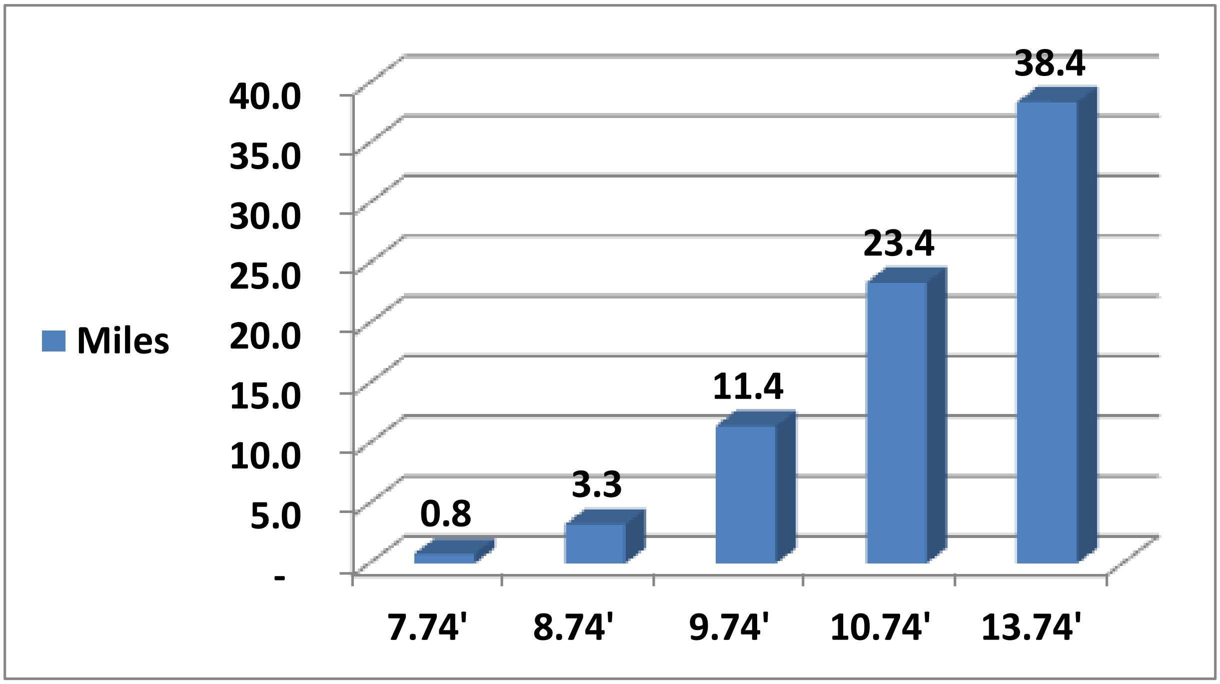

Chart 8. Cumulative length (in miles), of diked shoreline with an elevation that is less than or equal to MMMW, EHT, 2', 3', and 6' of sea level rise.

Railroad

The railroad grade is the second most prevalent artificial shoreline structure on Humboldt Bay; it forms 10.5 miles of shoreline. Based upon existing conditions with sea level rise of 1 foot (EHT), a limited amount (393 feet) of railroad grade would be overtopped. With 2 feet of sea level rise, 15% of the railroad grade would be overtopped mostly on Arcata Bay. With 3 feet of sea level rise, 66% of the entire railroad grade would be overtopped, and at 6 feet, nearly 91% of the railroad would be overtopped (Table 33) (Chart 9). If existing conditions persist there is a threshold between 2 and 3 feet of sea level rise where the length of railroad grade that would be overtopped goes from 1.5 miles (15%) to 6.9 miles (66%).

	Length (feet) of shoreline at or below specified elevation							
RAILROAD SHORELINE ELEVATION	ARCATA BAY	EUREKA BAY	SOUTH BAY	MAD RIVER SLOUGH	EUREKA SLOUGH	ELK RIVER SLOUGH	TOTAL FEET	TOTAL PERCENT
7.74' (MMMW)	-	-	-	-	18	-	18	0.0%
8.74' (1' SLR)	262	-	-	-	131	-	393	0.7%
9.74' (2' SLR)	7,201	517	89	-	295	13	8,115	14.6%
10.74' (3' SLR)	28,349	3,747	3,715	77	461	144	36,493	65.6%
13.74' (6' SLR)	34,305	4,858	7,219	2,540	563	858	50,343	90.5%

Table 33. Cumulative length, of railroad shoreline that would be overtopped by water elevations less than or equal to MMMW plus 1 to 3 feet, and 6 feet of sea level rise.

With sea level rise of 2 feet, 1.4 miles of the railroad grade on Arcata Bay would be flooded, and with 3 feet, 5.4 miles would be flooded. Interstate Highway 101 parallels the railroad grade on Arcata Bay, and in many locations the highway is lower in elevation than the railroad grade. Additionally, sections of State Highway 255 and South G Street also parallel the railroad. Overtopping the railroad shoreline on the eastern shore of Arcata Bay could flood Highway 101 and possibly the former tidelands to the east.

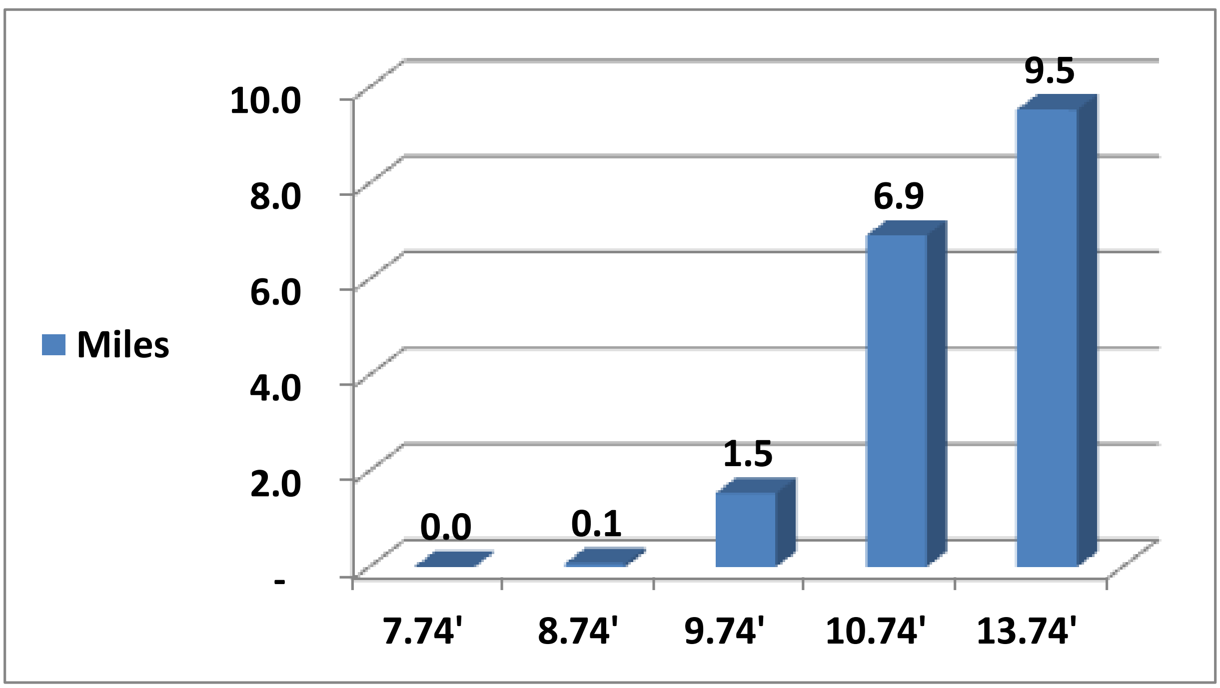

Chart 9. Cumulative length (in miles), of railroad shoreline elevation that is less than or equal to MMMW, EHT, 2’, 3’, and 6’ of sea level rise.

Salt Marsh

Salt marsh habitat can keep pace with rising sea levels if there is a sufficient supply of sediment. If the rate of relative sea level rise exceeds the ability of salt marsh to accrete in place, then these marshes will need to migrate inland in order to maintain this important inter-tidal habitat. Dikes are the dominant shoreline structure in the three sloughs on Humboldt Bay, which are surrounded by thousands of acres of mostly open space currently used for agriculture and waterfowl and wildlife habitat (Figure 71). There are pathways for salt marsh migration in each of these slough areas if dikes were re-located inland or breached. While this may be physically feasible, willing landowners would be necessary to implement this sea level rise adaptation strategy.

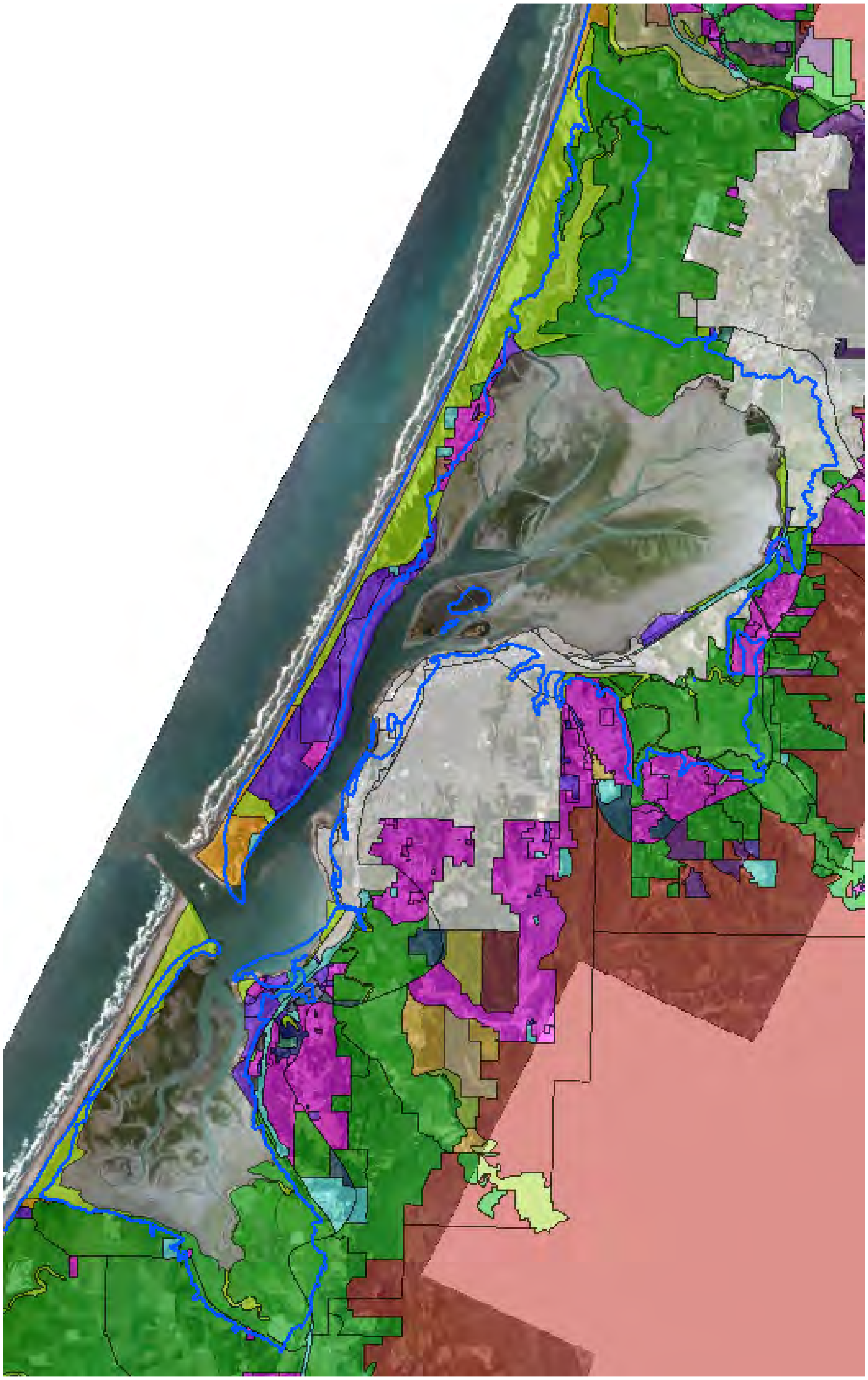

Figure 71. Humboldt County's Humboldt Bay Area Plan land use designations and the 1870 tidal inundation footprint: City of Eureka and Arcata (white), agriculture (dark green), natural resources (light green), public recreation (light brown), timber (brown), residential (pink), manufacturing and commercial (purple), public facilities (light blue).

b) Arcata Bay

The shoreline of Arcata Bay is 20.5 miles long and 91% of the shoreline is composed of artificial structures, but only 4% is exposed (3,605 feet) (Figure 72). The two dominant shoreline structures are the NRCA's railroad grade (32%) and the Reclamation District's dike (31%), which was rehabilitated in 2008. Other types of shorelines are fill (12%), the City of Arcata's wastewater treatment and marsh ponds (9%), which were also rehabilitated in 2008, and roadways (6%). The railroad grade is mostly unfortified (73%); 24,694 feet are vegetated, 525 feet are exposed, and 9,212 feet is fortified (27%). There are 275 feet of exposed railroad grade along Butcher Slough in the Arcata Marsh and the remaining 250 feet of exposed railroad grade are at two locations south of the Indianola cutoff. If the existing exposed condition of the railroad grade at these two locations is allowed to persist, the shoreline has the potential to be breached. A significant length of the dikes on Arcata Bay were recently fortified (20,792 feet, 63%), 12,199 feet are vegetated (37%). Just 116 feet of dike are exposed, which is adjacent to an area that is being restored to tidal functions, so the integrity of the dike is not important here. Highway 255 has 910 feet that are exposed immediately west of the Mad River Slough bridge in front of the Sierra Pacific Lumber Company's operation. The bulk of the remaining exposed shoreline is in fill areas along Butcher Slough and Gannon Slough. Overall, the existing conditions of the artificial shoreline structure and cover in Arcata Bay are not exhibiting any substantial vulnerability.

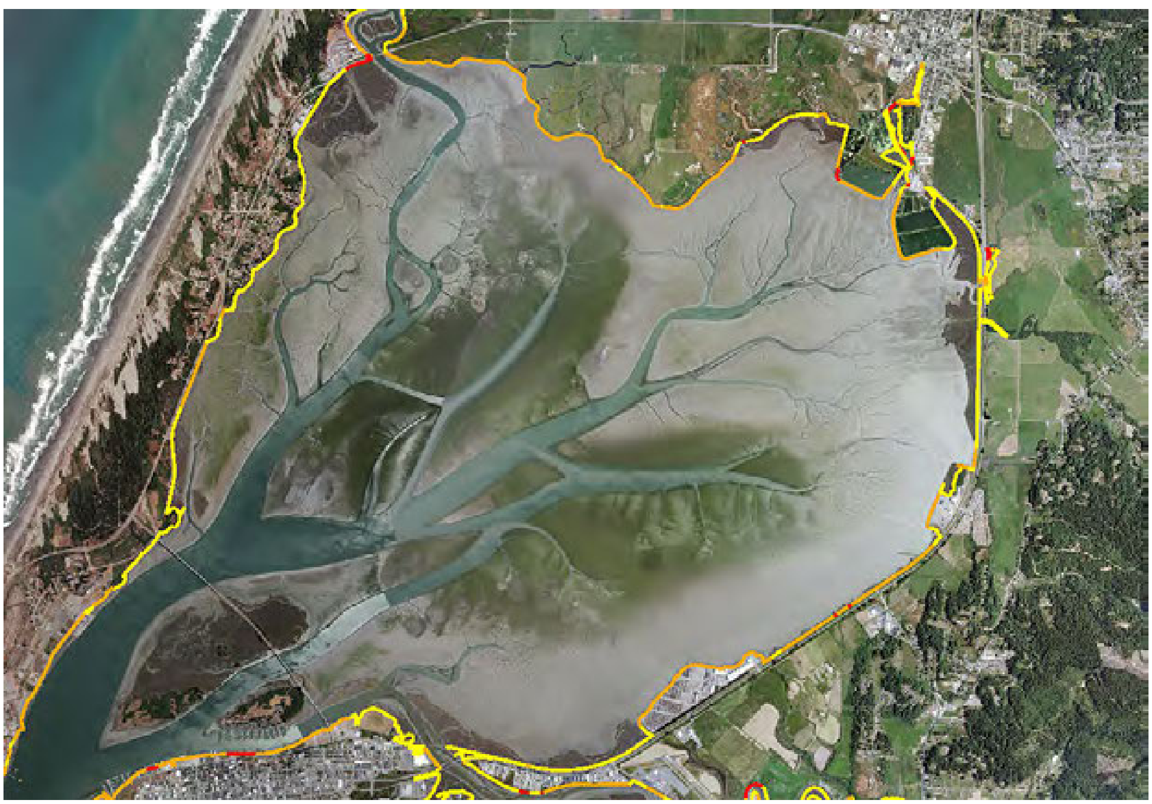

Figure 72. Arcata Bay shoreline cover: fortified (brown), vegetated (yellow), and exposed (red).

While one foot of sea level rise will increase overtopping of filled shorelines significantly (468' to 3,019'), one to two feet of sea level rise will initiate wide spread shoreline overtopping of the railroad grade (262' to 7,201') and dikes (970' to 5,137') (Table 34). While not extensive in regards to shoreline length, the overtopping of the dike on Gannon slough by sea level rise of 1 to 2 feet could flood a large area of former tidelands. Overtopping of Reclamation District 768's dike is in an area that the City of Arcata and DFG have slated for salt marsh restoration. The next increment of sea level rise of two to three feet will overtop a significant length of shoreline: railroad 21.0% to 82.3%, dike overtopping will increase from 15.5% to 32.6%, and fill overtopping will increase from 39.0% to 65.7%. Very little of Arcata Bay's artificial shoreline composed of these four structures, 10.9%, will be above the tides at six feet of sea level rise.

	Length (feet) of shoreline at or below specified elevation					
ARCATA BAY	**ELEVATION**					**TOTAL**
SHORELINE STRUCTURE	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**LENGTH**
Dike	154	970	5,137	10,782	26,521	33,107
Railroad	-	262	7,201	28,349	34,305	34,431
Fill	468	3,019	5,432	8,496	10,819	12,935
Fortified	48	89	144	215	303	330
Total	**670**	**4,340**	**17,914**	**47,843**	**71,948**	**80,803**

Table 34. Cumulative lengths of shoreline by structure at increasing sea level elevations, and the total length of shoreline structure.

Breaching or overtopping of the shoreline on Arcata Bay has the potential to flood the following land uses, infrastructure, and resources that are located within the historic tidal inundation footprint of 1870:

Land Uses:

- Agricultural: predominately grazing and wildlife management on a substantial amount of acreage,
- Natural resource: predominately open space, and wildlife management,
- Residential: in Manila along the Bay, and at Jacobs Avenue in Eureka,
- Commercial: at the Indianola Cutoff east of Highway 101, Harper Motors east of Highway 101, and on Jacobs Avenue in Eureka,
- Industrial/ Manufacturing: at the Sierra Pacific Company mill, along south G Street in Arcata, Bracut, and the California Redwood Company mill,
- Public facilities: park in Manila, waste water treatment plant at South G Street Arcata, radio station at South G Street Arcata, and Murray Field County airport in Eureka.

Infrastructure:

- Transportation: Interstate Highway 101, State Highway 255, County Roads, service streets in Arcata and Eureka, and NCRA railroad, County airport at Murray Field, and 8 bridges.
- Utilities: City of Eureka's water transmission pipes, PG&E gas transmission pipes, PG&E electrical transmission towers,
- Drainage: numerous tidegates and culverts,
- City of Arcata's waste water treatment facility.

Resources:

- Wiyot Tribe's Tuluwat ceremonial site on Indian Island,
- Department of Fish and Game's (DFG) Mad River Slough and Fay Slough wildlife reserves,
- City of Arcata's Marsh and Wildlife area.

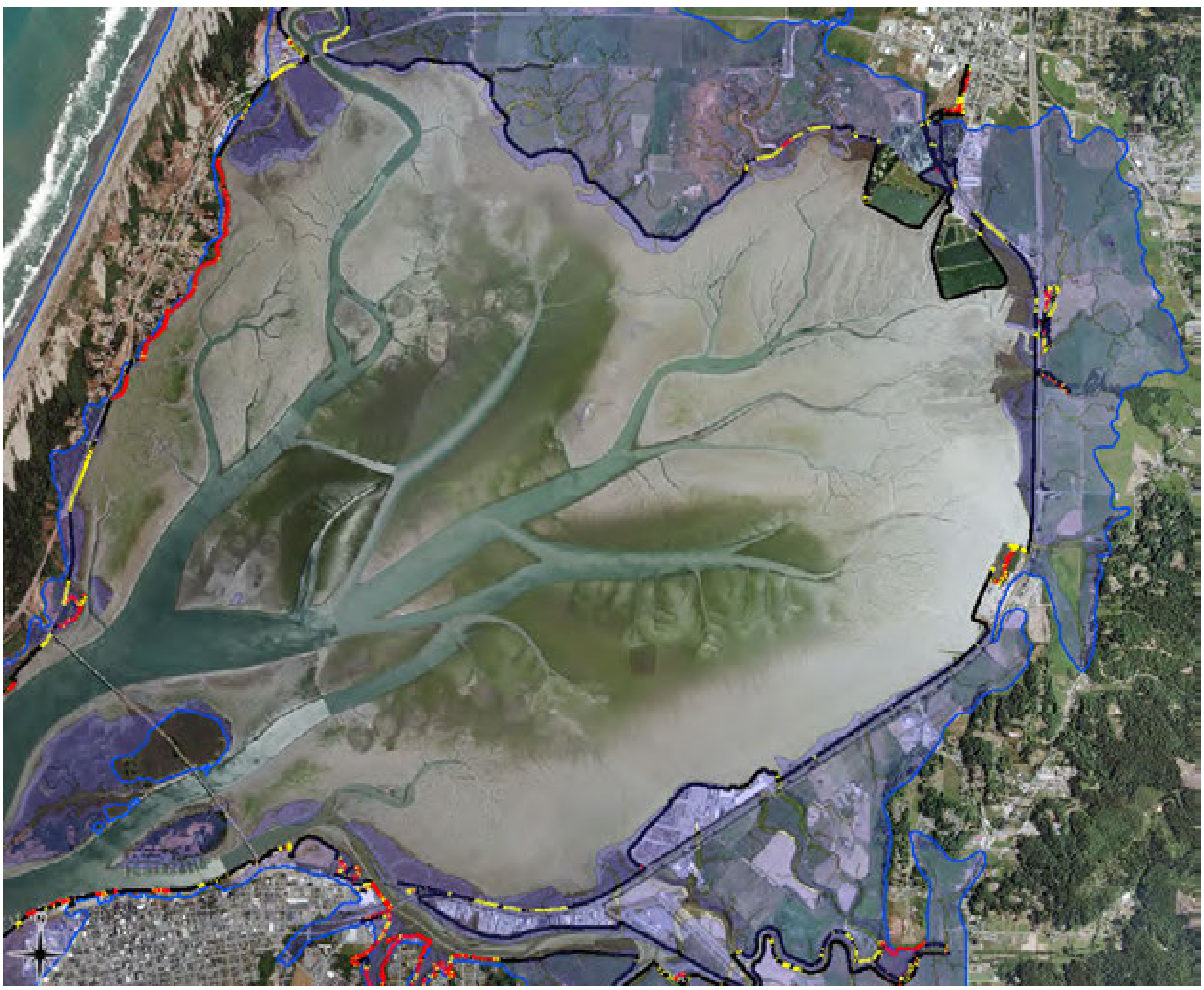

Figure 73. Arcata Bay, shoreline areas overtopped by 1 foot of sea level rise (red), and 2 feet (yellow), and the 1870 tidal inundation footprint (blue).

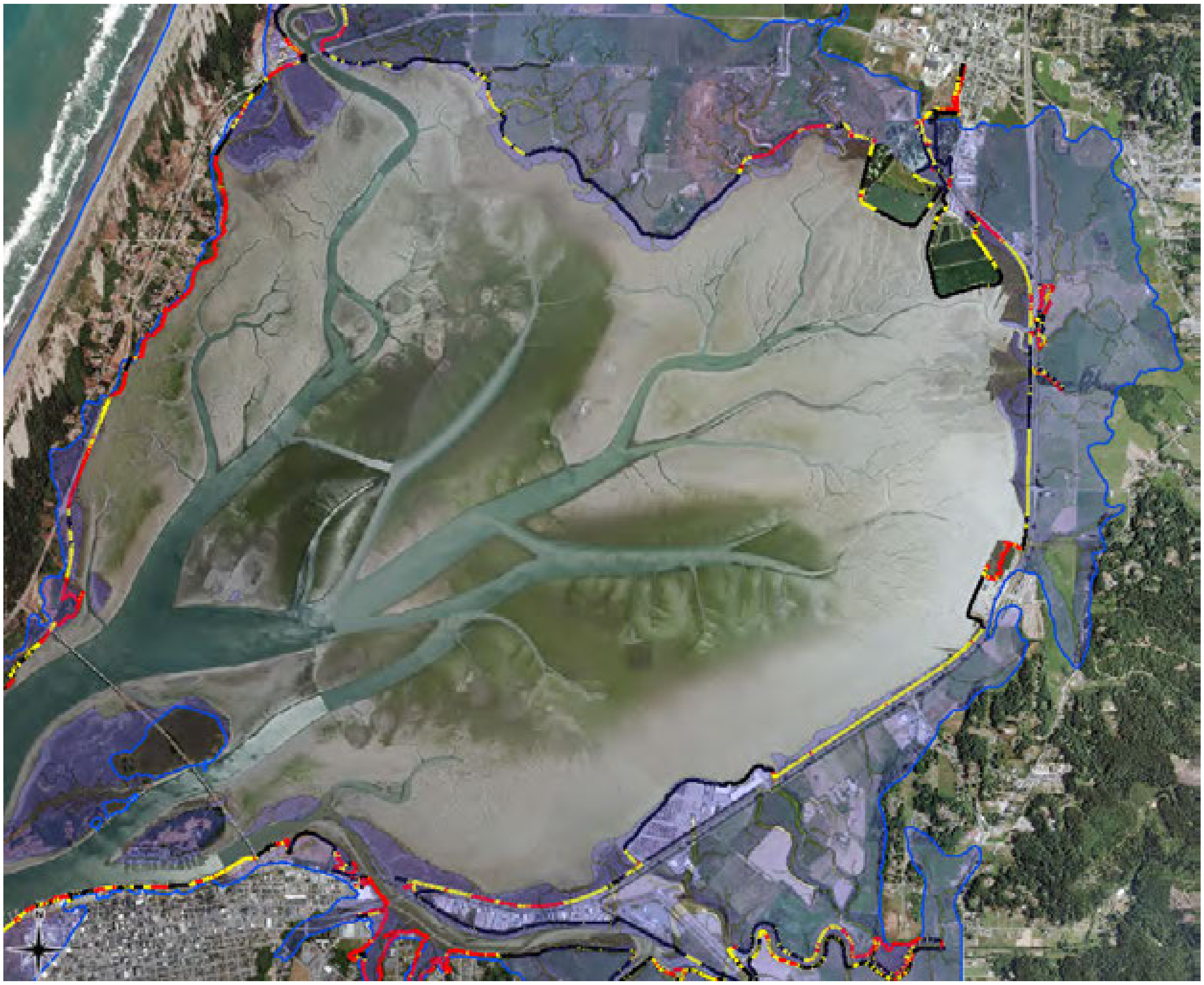

Figure 74. Arcata Bay, shoreline areas overtopped by 2 feet of sea level rise (red), and 3 feet (yellow), and the 1870 tidal inundation footprint (blue).

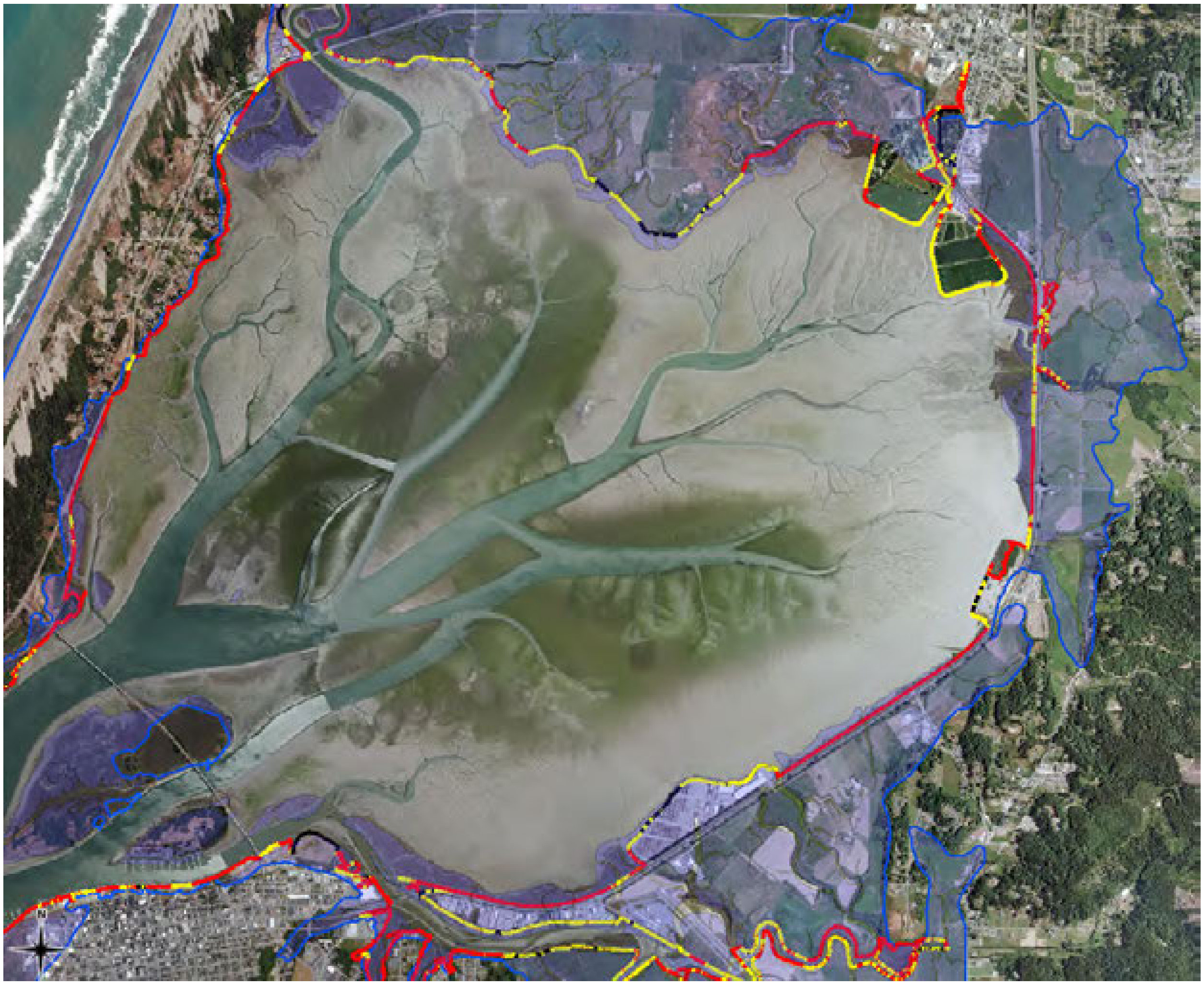

Figure 75. Arcata Bay, shoreline areas overtopped by 3 feet of sea level rise (red), and 6 feet (yellow), and the 1870 tidal inundation footprint (blue).

c) Eureka Bay

The shoreline of Eureka Bay is 15.9 miles long and 71% of the shoreline is composed of artificial structures, but only 6% of the artificial shoreline is exposed (3,587 feet) (Figure 76). The two dominant artificial shoreline structures are fortified shoreline segments (49%, 29,657 feet) and the NCRA's railroad grade (15%, 8,794 feet). Other types of artificial shorelines are fill (10%), bulwarks (6 %), and roadways (6%). The railroad grade is mostly fortified (66%), 2,980 feet are vegetated, and none is exposed. There are 2,015 feet of exposed fill and 963 feet of exposed road way. The 963 feet of exposed County road is on the North Spit facing the Bay south of the Coast Guard station. The bulk of the 2,015 feet of exposed shoreline fill areas are along the eastern shore of the Bay mostly in abandoned waterfront areas. There are 2,600 feet of exposed natural shoreline on the Bayside of the Elk River Spit and 1,200 feet of exposed fore-dune between the Jetties at King Salmon. Existing artificial shoreline conditions of structure and cover in Eureka Bay are not exhibiting any substantial vulnerability.

Figure 76. Eureka Bay shoreline cover: fortified (brown), vegetated (yellow), and exposed (red).

Eureka Bay's existing shoreline elevations are vulnerable to overtopping: one foot of sea level rise will increase overtopping of fortified shorelines significantly (1,167' to 3,152'). One to two feet of sea level rise will initiate shoreline overtopping of the railroad grade (0’ to 517’), will increase bulwark overtopping from 622 feet to 1,022 feet, roadway overtopping from 315 feet to 543 feet, and double the overtopping of dikes (450’ to 988’) and fortified shorelines from 3,152 to 6,725 feet (Table 35). Sea level rise of two to three feet will significantly increase overtopping of the railroad grade (517’ to 3,747’) and roadways from 543 feet to 2,448 feet. Dike overtopping will increase from 988 feet to 1,265 feet, and a substantial increase in overtopping of bulwark shoreline will occur from 13,262 feet to 22,542 feet. Sea level rise of three to six feet overtops 75% of these artificial shoreline structures.

	Length (feet) of shoreline at or below specified elevation					
EUREKA BAY	**ELEVATION**					**TOTAL**
SHORELINE STRUCTURE	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**LENGTH**
Dike	166	450	988	1,265	1,392	3,077
Railroad	-	-	517	3,747	4,858	8,794
Fill	188	709	1,465	3,757	6,113	6,308
Fortified	1,167	3,152	6,725	13,262	22,542	29,657
Bulwark	463	622	1,022	1,806	3,541	3,916
Roads	47	315	543	2,448	3,340	3,852
Total	**2,030**	**5,248**	**11,260**	**26,285**	**41,786**	**55,604**

Table 35. Cumulative lengths of shoreline by structure at increasing sea level elevations, and the total length of shoreline structure.

Breaching or overtopping of the shoreline on Eureka Bay has the potential to flood the following land uses, infrastructure, and resources that are located within the historic tidal inundation footprint of 1870:

Land Uses:

On the Western Shoreline

- Natural resources,
- Public recreation,
- Public facility, Coast Guard station,
- Coastal dependent industrial,
- Residential, in Fairhaven (Indian Island).

On the Eastern Shoreline

- Coastal waterfront commercial,
- Coastal dependent industrial,
- Public facilities, wastewater treatment facility, community center,
- Natural resources,
- Public recreation,
- Agricultural,

<u>Infrastructure:</u>

- Transportation: County roads, service streets in Eureka and Fairhaven, and NCRA railroads;
- Harbor: Eureka and Woodley Island Marinas, docks, three boat launches, Coast Guard station, and NOAA weather station on Woodley Island;
- Utilities: Humboldt Bay Municipal Water District's (HBMWD) water transmission pipe, fuel depot
- Drainage: Numerous tidegates and culverts
- City of Eureka's wastewater treatment facility.

<u>Resources:</u>

- Wiyot Tribe village site on Indian Island,
- Egret Rookery on Indian Island.

Figure 77. Eureka Bay, shoreline areas overtopped by 1 foot of sea level rise (red), and 2 feet (yellow), and the 1870 tidal inundation footprint (blue).

Figure 78. Eureka Bay, shoreline areas overtopped by 2 foot of sea level rise (red), and 3 feet (yellow), and the 1870 tidal inundation footprint (blue).

Figure 79. Eureka Bay, shoreline areas overtopped by 3 feet of sea level rise (red), and 6 feet (yellow), and the 1870 tidal inundation footprint (blue).

d) South Bay

The shoreline of South Bay is 21.8 miles long. 68% (78,132 feet) of the shoreline is composed of artificial structures, and 15% (11,936 feet) of the artificial shoreline is exposed (Figure 80). The four dominant artificial shoreline structures are dikes covering 35% (40,215 feet), and fill (12%, 13,816 feet), along with fortified shoreline segments (7%, 8,019 feet), and the NCRA's railroad grade at 6% (7,197 feet). The diked shoreline on South Bay is mostly fortified (56%, 22,424 feet), 35.7% (14,362 feet) is vegetated, and 8.5% (3,429 feet) is exposed. There is 6,353 feet (46%) of exposed fill, and 346 feet (4.8%) of exposed railroad grade.

The majority of the exposed dike shoreline (3,028 feet) is located on the HBNWR in the White Slough area that fronts Highway 101; the remaining exposed dikes are south of King Salmon in an area that has several breaches. There is 3,185 feet of exposed fill in the Fields Landing area and the remainder is in the community of King Salmon. The entire exposed railroad grade is south of Fields Landing. Existing shoreline conditions of structure and cover make the waterfront of Fields Landing vulnerable to erosion and the residential and commercial areas of King Salmon vulnerable to flooding.

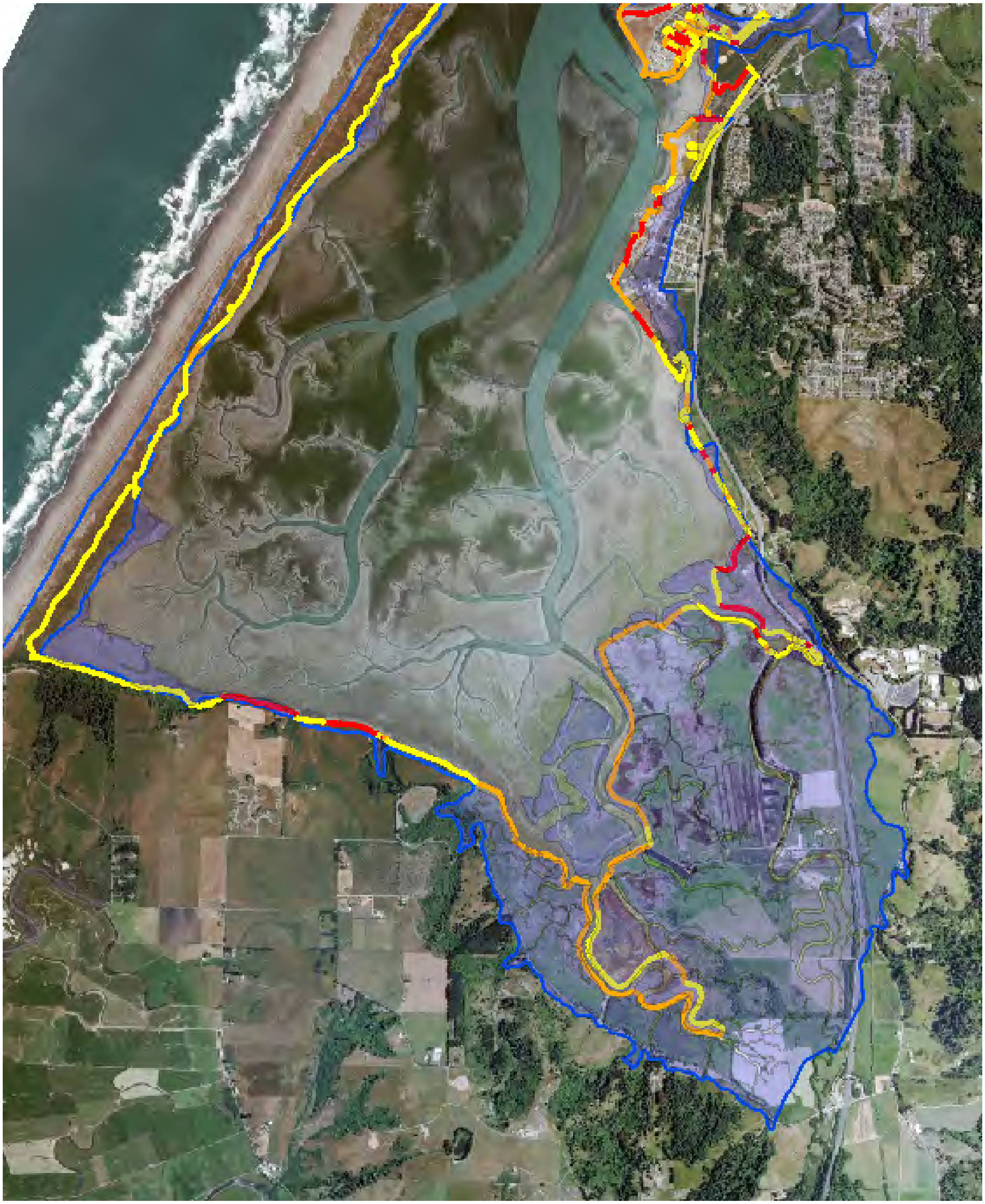

Figure 80. South Bay shoreline cover: fortified (brown), vegetated (yellow), and exposed (red).

With one foot of sea level rise, the length of shoreline of these four dominant structures that will be overtopped will more than double (3,754’ to 9,333’). Overtopping of diked shorelines will increase substantially (653’ to 2,971’), and overtopping of fill shorelines will more than double (1,972 to 4,127 feet) (Table 36). With one foot of sea level rise, overtopping of dikes is limited in extent to the White Slough and Hookton Slough units of the HBNWR. One to two feet of sea level rise will initiate wide spread shoreline overtopping (1.8 to 5.5 miles) particularly of dikes (2,971’ to 18,617’). On the HBNWR, one to two feet of sea level rise will overtop the entire length of the Hookton Slough unit and nearly the entire length of the White Slough unit, and initiate overtopping of the Salmon Creek unit as well. The next increment of sea level rise of two to three feet will overtop a significant length of shoreline 5.5 to 10.1 miles (28,982’ to 53,264’); this will particularly affect the railroad grade (89’ to 3,715’) and dikes (18,617 to 34,272 feet).

The existing HBNWR dikes, while fortified against wave induced erosion, would be overtopped with three feet of sea level rise, which would result in flooding of Highway 101 as it traverses former tidelands. At six feet of sea level rise, 96% of the artificial shoreline in South Bay would be overtopped.

	Length (feet) of shoreline at or below specified elevation					
SOUTH BAY	**ELEVATION**					**TOTAL**
SHORELINE STRUCTURE	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**LENGTH**
Dike	653	2,971	18,617	34,272	39,951	40,215
Railroad	-	-	89	3,715	7,219	7,197
Fill	1,972	4,127	6,589	9,299	11,762	13,816
Fortified	1,129	2,234	3,687	5,977	8,378	8,019
Total	**3,754**	**9,333**	**28,982**	**53,264**	**67,309**	**69,247**

Table 36. Cumulative lengths of shoreline by structure at increasing sea level elevations, and the total length of shoreline structure.

Breaching or overtopping of the shoreline on South Bay has the potential to flood the following land uses, infrastructure, and resources that are located within the historic tidal inundation footprint of 1870:

<u>Land Uses:</u>

<u>On the Western and Southern Shorelines</u>

- Natural resources: HBNWR, and South Spit,
- Agricultural.

<u>On the Eastern Shoreline</u>

- Agricultural,
- Natural resources: HBNWR, and King Salmon,
- Public recreation: county boat launch at Fields Landing,
- Public facilities: NCRA railroad, Highway 101,

- Industrial: Coastal dependent and resource related in King Salmon and Fields Landing, general in Fields Landing,
- Commercial: General and recreational in King Salmon,
- Residential: north of Hookton Road, Fields Landing and King Salmon.

Infrastructure:

- Recreational: HBNWR's visitor center operations complex, boat launches at Hookton Slough and Fields Landing,
- Transportation: Interstate Highway 101, county roads, service streets in Fields Landing and King Salmon, and NCRA railroad,
- Harbor: King Salmon canals/marina, HBHRCD dry dock in Fields Landing, commercial docks in Fields Landing,
- Utilities: PG&E power plant in Fields Landing, PG&E gas transmission line,
- Drainage: numerous tidegates and culverts.

Resources:

- Wiyot Tribe historical and archeological village sites on South Spit,
- HBNWR South Bay units,
- Bureau of Land Management's Mike Thompson Wildlife area on South Spit.

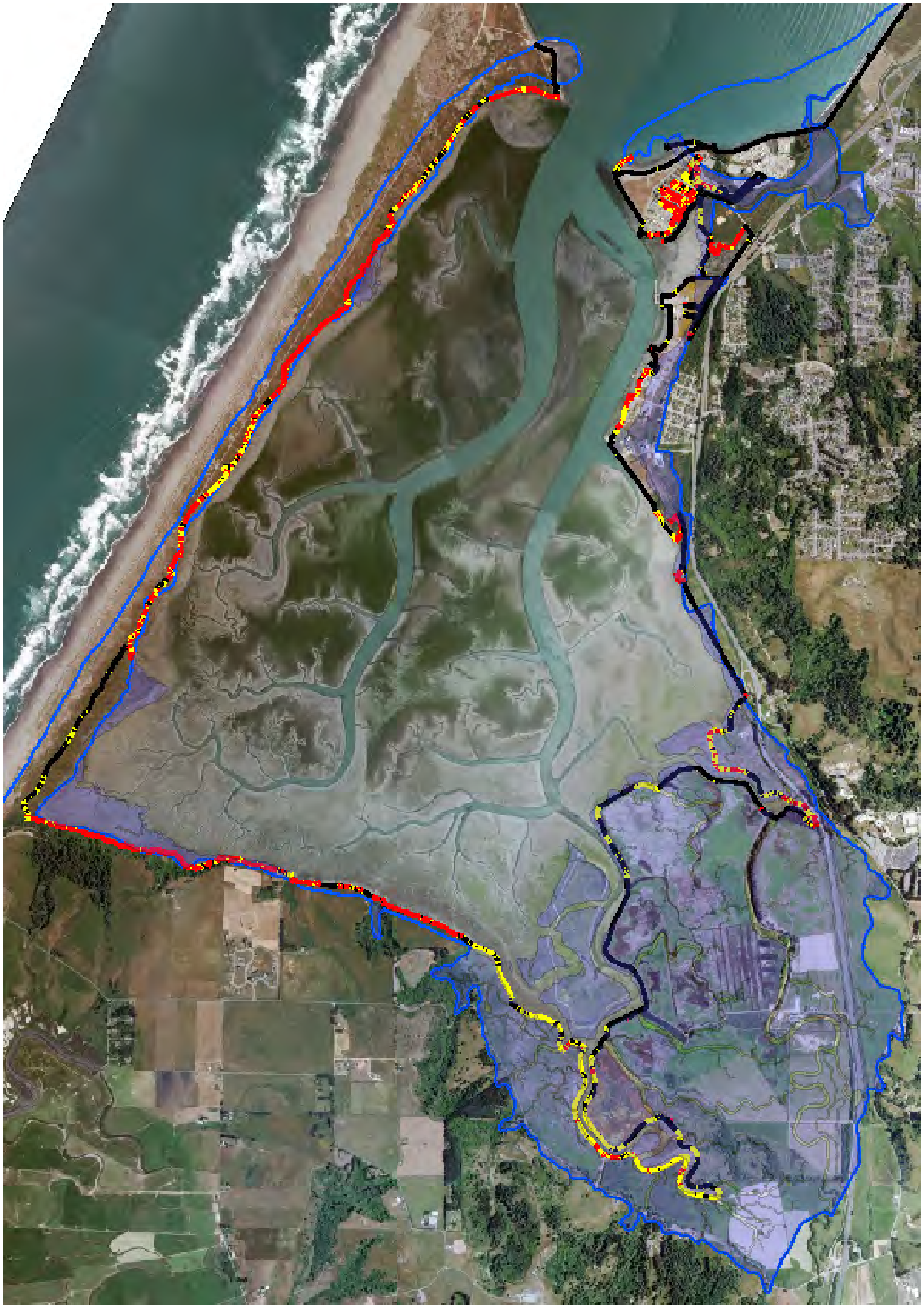

Figure 81. South Bay, shoreline areas overtopped by 1 foot of sea level rise (red), and 2 feet (yellow), and the 1870 tidal inundation footprint (blue).

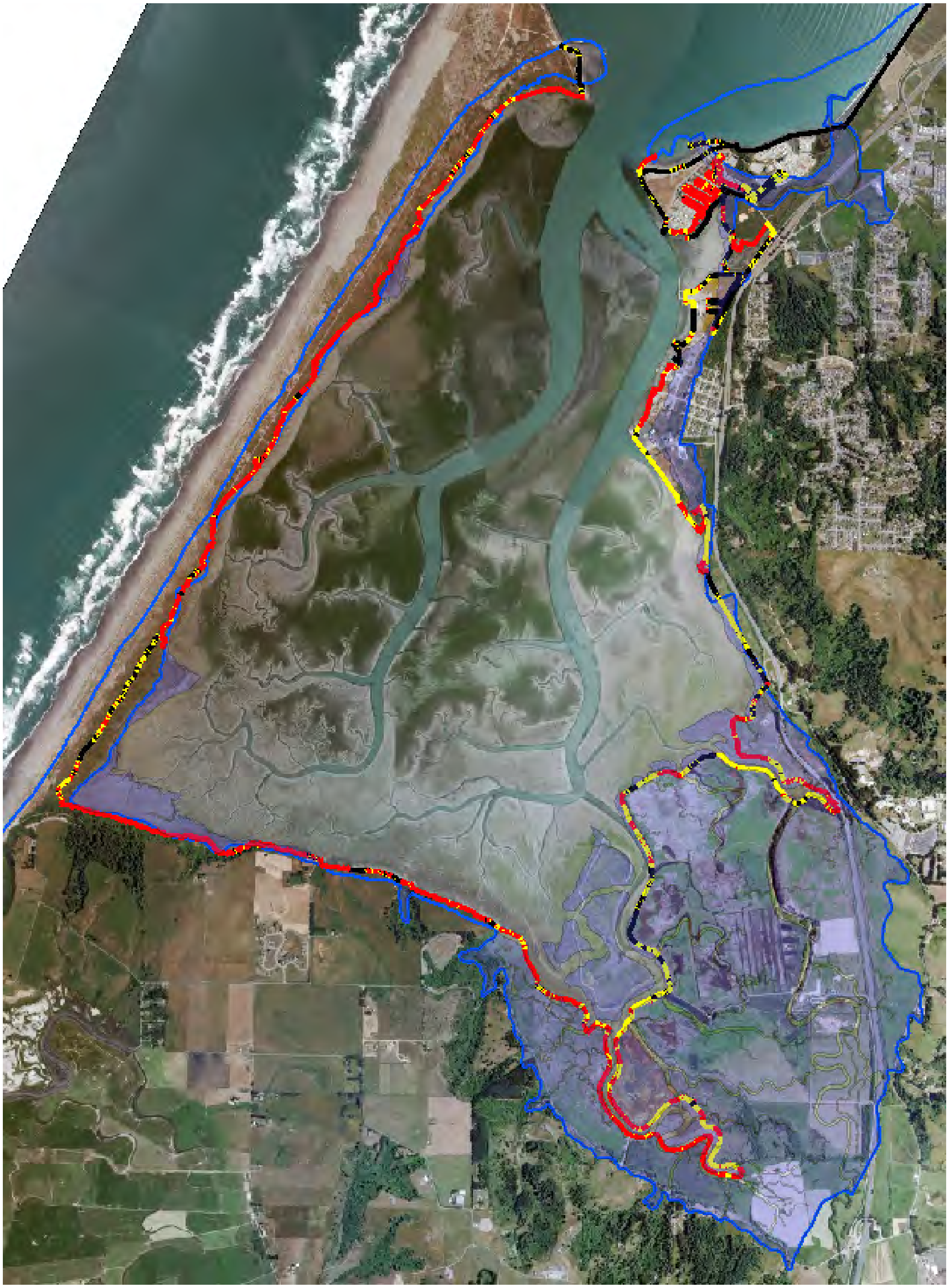

Figure 82. South Bay, shoreline areas overtopped by 2 foot of sea level rise (red), and 3 feet (yellow), and the 1870 tidal inundation footprint (blue).

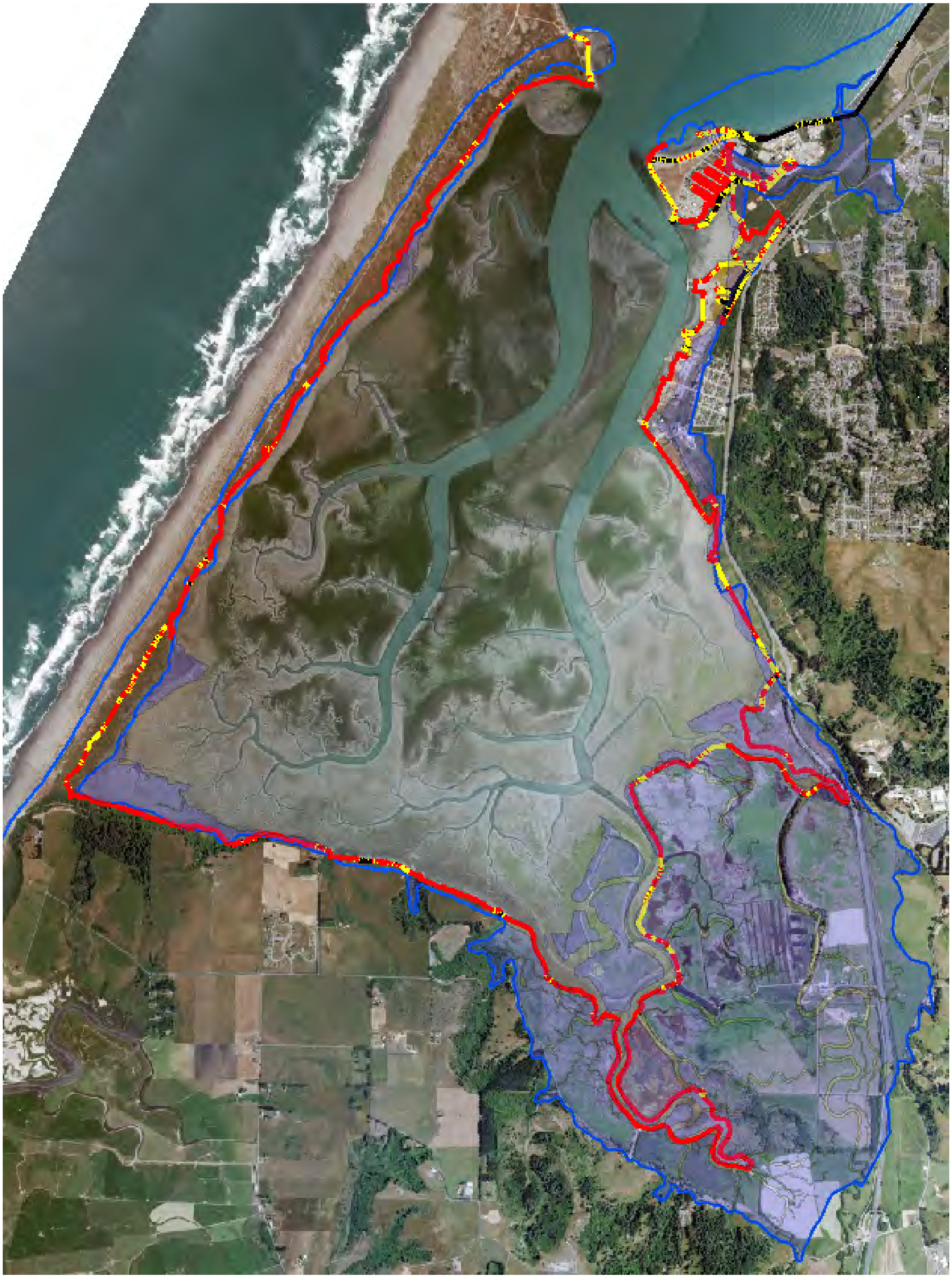

Figure 83. South Bay, shoreline areas overtopped by 3 feet of sea level rise (red), and 6 feet (yellow), and the 1870 tidal inundation footprint (blue).

e) Mad River Slough

The shoreline of Mad River Slough is 13.7 miles long and 80% (57,623 feet) of the shoreline is composed of artificial structures, 14% (8,189 feet) of the artificial shoreline is exposed (Figure 84). The two dominant artificial shoreline structures are dikes (66%, 47,471 feet) and roadway (7%, 5,050 feet). The diked shoreline is 53.7% (25,518 feet) vegetated, and 16.8% (7,968 feet) exposed. There are also 469 feet of exposed fill and 104 feet of exposed roadway.

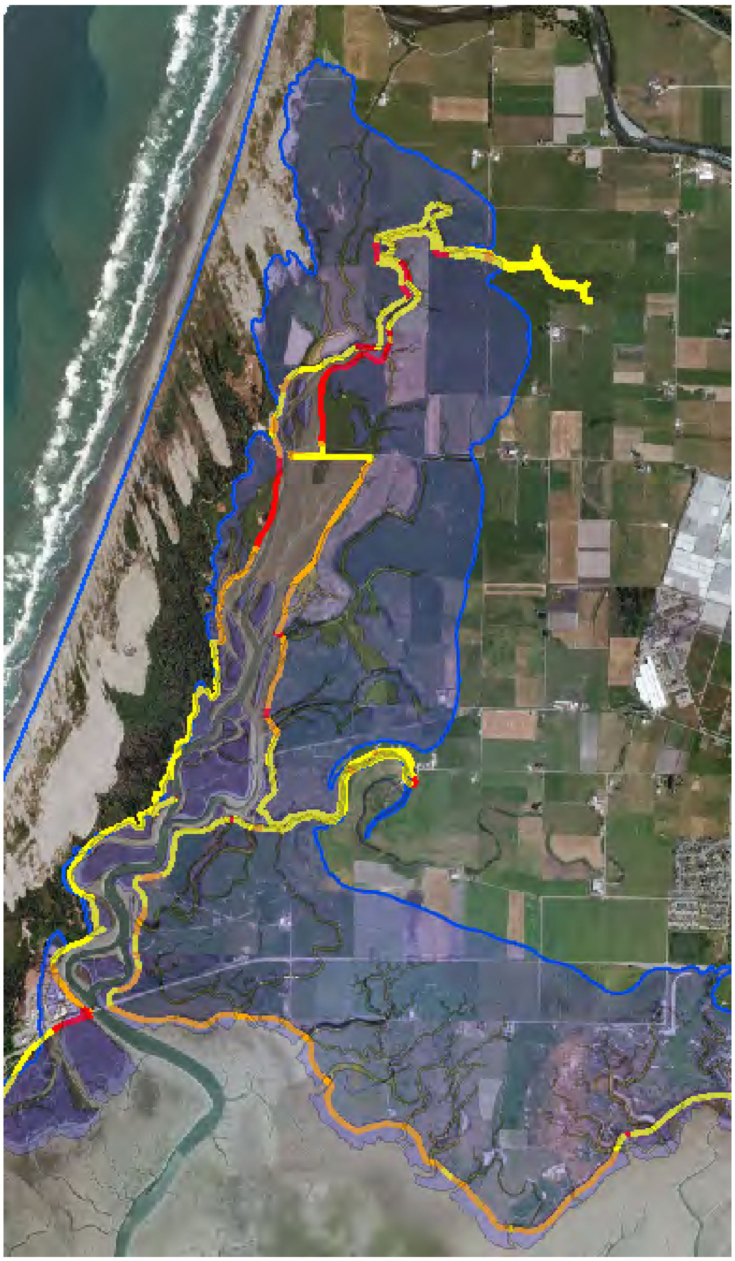

Figure 84. Mad River Slough shoreline cover: fortified (brown), vegetated (yellow), and exposed (red), with the 1870 tidal inundation area (blue).

On the west shoreline of Mad River Slough, there is 1,031 feet of eroded dike below Lanphere Bridge. Above Lanphere Bridge on the West shoreline, there are two units of eroding dike totaling 965 feet (453 and 412 feet in length). If the two units on the Western shoreline were to fail, a large area of agricultural land to the west and north would be flooded. There is a total of 2,418 feet of eroding dike on the eastern shoreline (4 units ranging from 140 to 1,484 feet) above Lanphere Road. If these units above Lanphere Road on the eastern shore were to fail, the agricultural land south and west of the Slough would likely flood to the east to the historical Hammond Railroad grade and south to Lanphere Road. If tidewater were to overtop the road, a large agricultural area south to Liscom Slough could be flooded. This threat illustrates why shoreline fortification needs to occur on a hydrologic basis and not parcel by parcel, as the eastern shoreline of the Slough below Lanphere Road is well fortified but flooding would occur from breaches farther up the Slough. On Liscom Slough, there are 105 feet of eroding dike that, if breached, could flood a large agricultural area to the south and west down to Highway 255. Another 104 feet of eroded shoreline exists on the eastern shoreline of Mad River Slough below Liscom Slough. If this shoreline were to breach, the agricultural area that flooded in the 2003 breach could be flooded again down to Highway 255.

One foot of sea level rise on Mad River Slough will increase the length of diked shoreline that is overtopped from 431 to 2,761 feet (Table 37). The dike on the western shoreline below Lanphere Bridge will be overtopped at one foot of rise, and flood the former tidelands behind the dike. With one foot of rise, the south bank of Mad River Slough, at its terminus, will be overtopped; flooding would extend south to Lanphere Road and possibly beyond to Jackson Ranch road. At the same time, the south bank of Liscom Slough, at its eastern end, will be overtopped with flooding south to Highway 255. One to two feet of sea level rise will initiate widespread dike overtopping, from 2,761 to 11,397 feet in the upper reach above Lanphere Road on both the west and eastern shores. On a few eastern shore segments of Mad River Slough south of Lanphere Road, one to two feet of sea level rise would flood a large agricultural area between Lanphere Road and Jackson Ranch Road. Along Liscom Slough, and the eastern shoreline of Mad River Slough in Reclamation District 768, flooding caused by one to two feet of sea level rise could occur in the same area as the 2003 breach, down to Highway 255. The next increment of sea level rise of two to three feet will more than double the length of shoreline (11,937’ to 27,397’) being overtopped on both sides of Mad River Slough and Liscom Slough, and at six feet, 95% of the shoreline would be overtopped.

	Length (feet) of shoreline at or below specified elevation					
MAD RIVER SLOUGH	**ELEVATION**					**TOTAL**
SHORELINE STRUCTURE	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**LENGTH**
Dike	431	2,761	11,397	26,569	45,843	47,471
Railroad	-	-	-	77	2,540	2,968
Fill	3	6	84	136	581	469
Fortified	-	59	456	615	862	1,345
Total	**434**	**2,826**	**11,937**	**27,397**	**49,827**	**52,253**

Table 37. Cumulative lengths of shoreline by structure at increasing sea level elevations, and the total length of shoreline structure.

Breaching or overtopping of the shoreline on Mad River Slough has the potential to flood the following land uses, infrastructure, and resources that are located within the historic tidal inundation footprint of 1870:

Land Uses:

On the Western Shoreline

- Natural resources,
- Agricultural,
- Maricultural,
- Industrial.

On the Eastern Shoreline

- Agricultural,
- Natural resources.

Infrastructure:

- Recreational: HBNWR's Ma-le'l Dunes and Lanphere units,
- Transportation: State Highway 255, county roads, and NCRA railroad,
- Utilities: HBMWD's water transmission pipes, and PG&E electrical transmission towers, MCSD's wastewater transmission pipe right-of-way,
- Drainage: numerous tidegates and culverts.

Resources:

- Wiyot Tribe historical and archeological village sites on the western shore,
- Historical Hammond Railroad grade and bridge trestles.

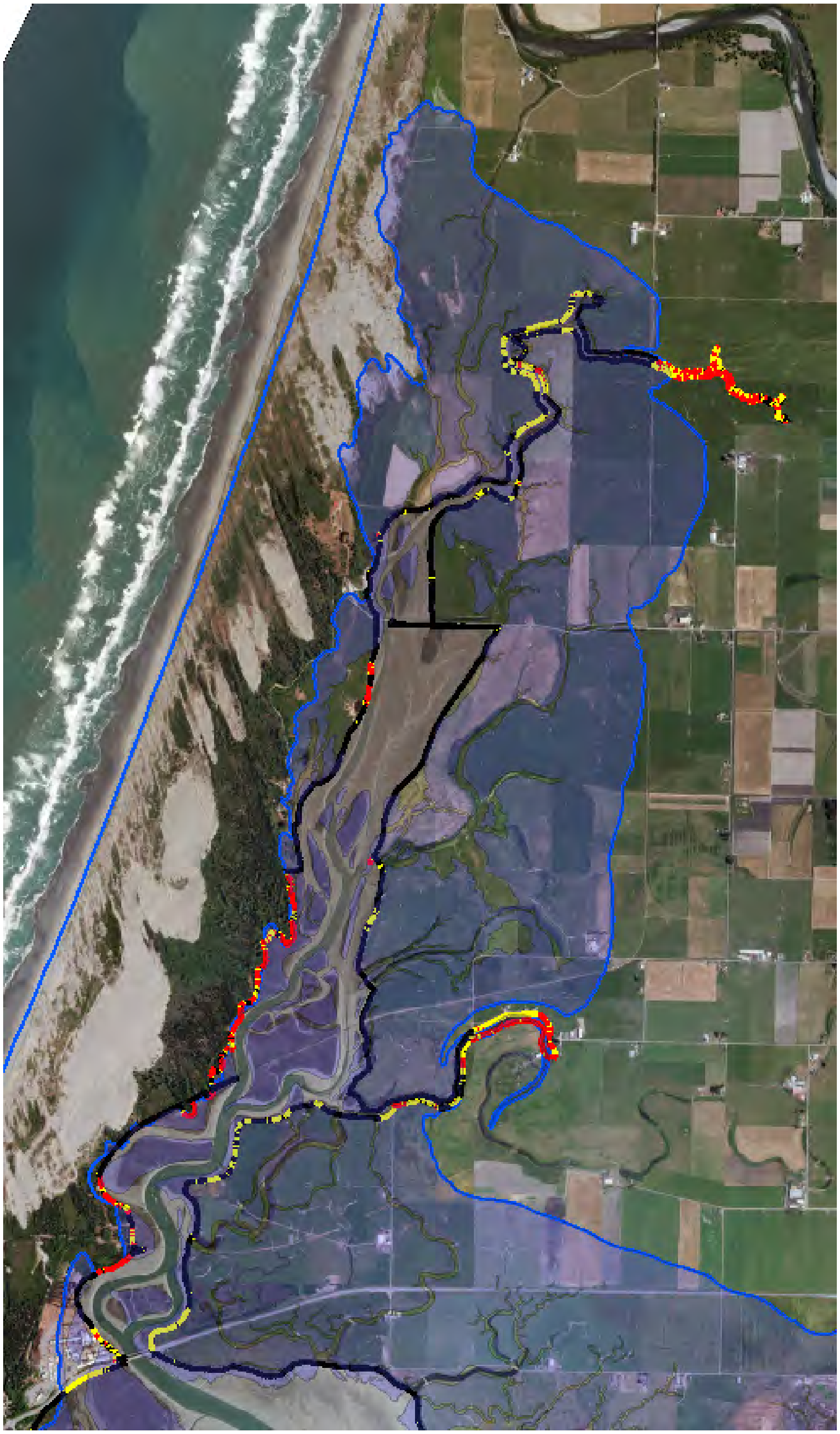

Figure 85. Mad River Slough, shoreline areas overtopped by 1 foot of sea level rise (red), and 2 feet (yellow), and the 1870 tidal inundation footprint (blue).

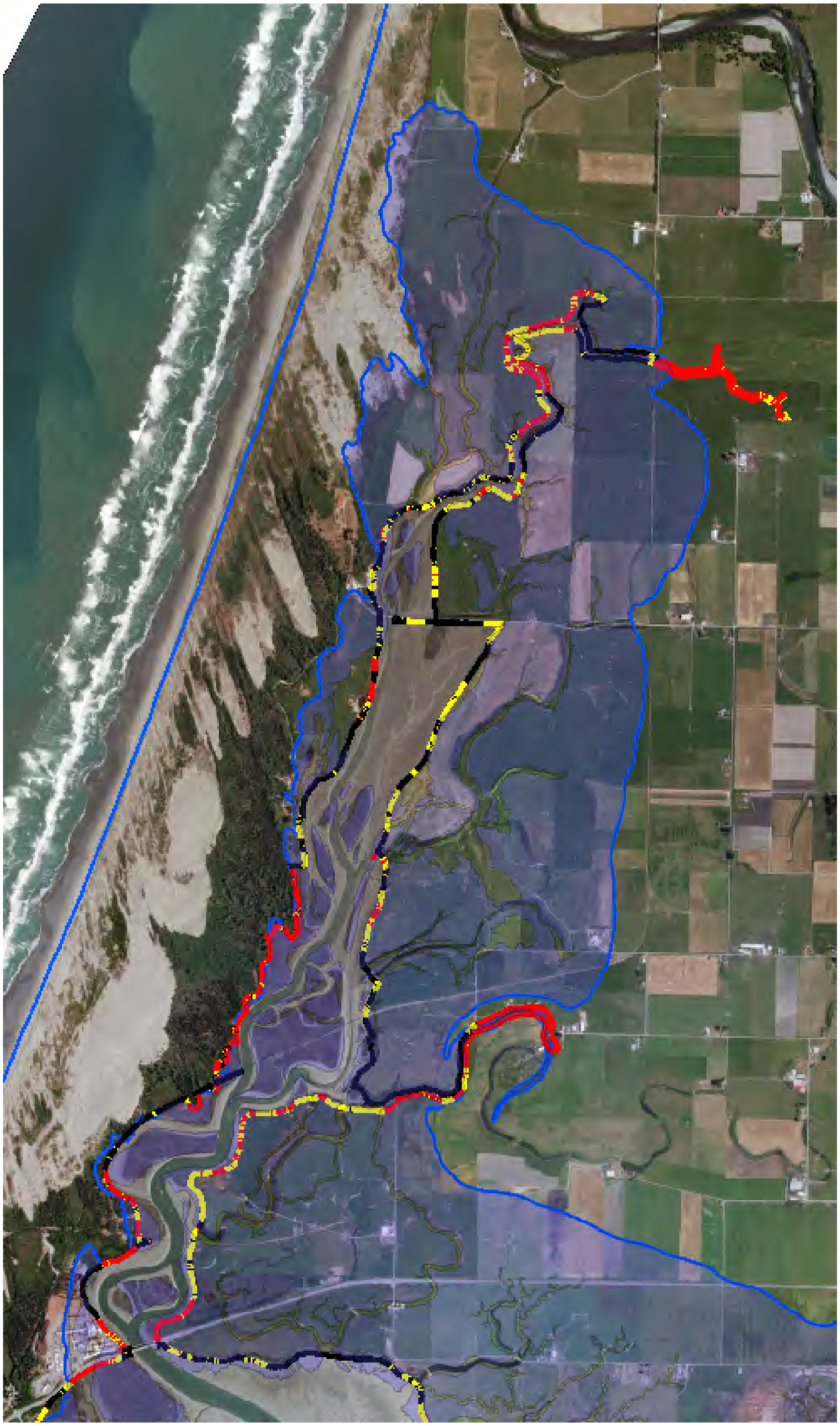

Figure 86. Mad River Slough, shoreline areas overtopped by 2 foot of sea level rise (red), and 3 feet (yellow), and the 1870 tidal inundation footprint (blue).

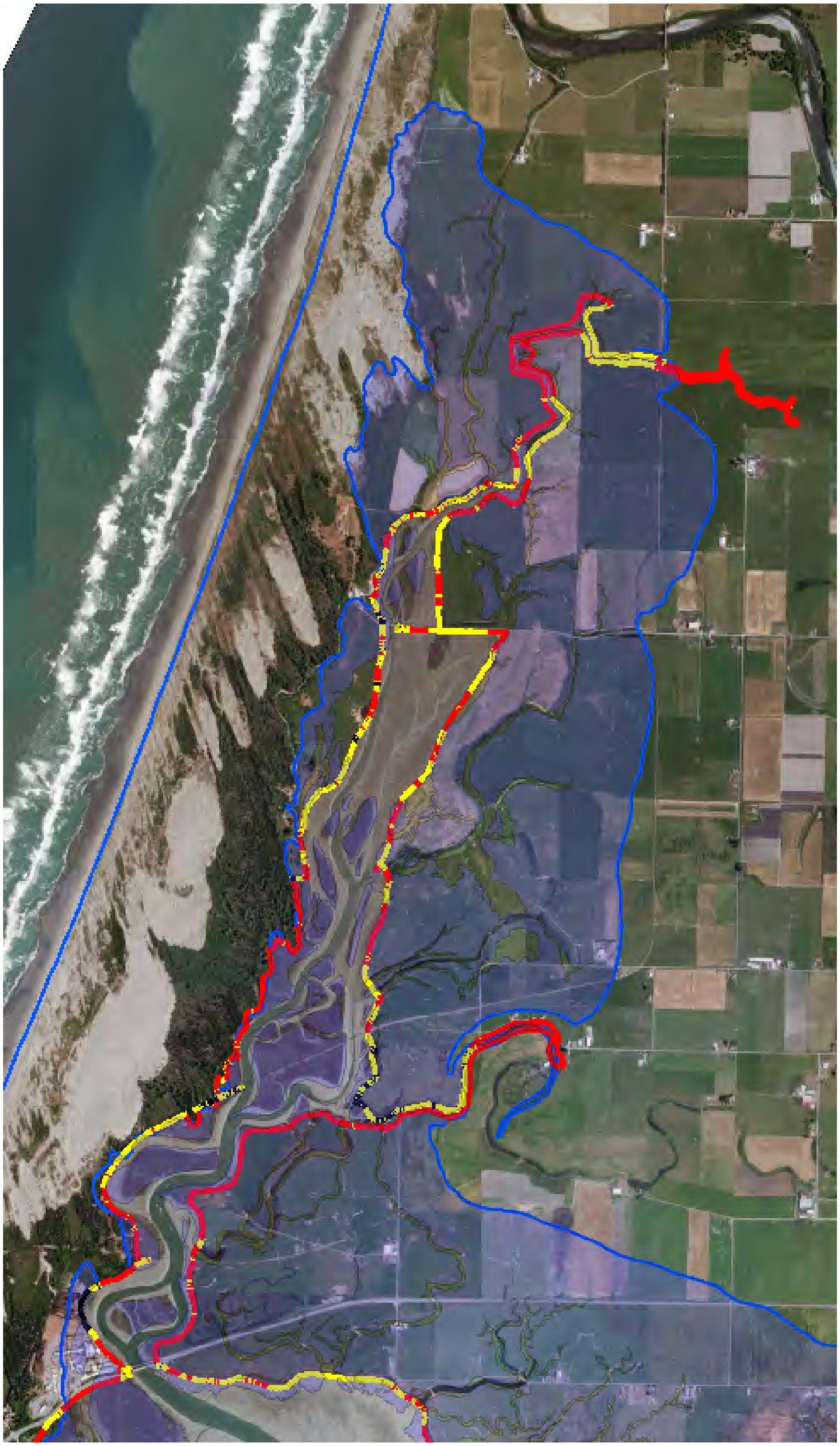

Figure 87. Mad River Slough shoreline areas overtopped by 3 feet of sea level rise (red), and 6 feet (yellow), and the 1870 tidal inundation footprint (blue).

f) Eureka Slough

The shoreline of Eureka Slough is 20.8 miles long. 80% (87,834 feet) of the shoreline is composed of artificial structures, and 7.0% (6,166 feet) of the artificial shoreline is exposed (Figure 88). The dominant artificial shoreline structures are dikes (69%, 75,588 feet) and roadway (3%, 3,666 feet). The diked shoreline is 84.7% (64,029 feet) vegetated, and 8.1% (6,098 feet) exposed.

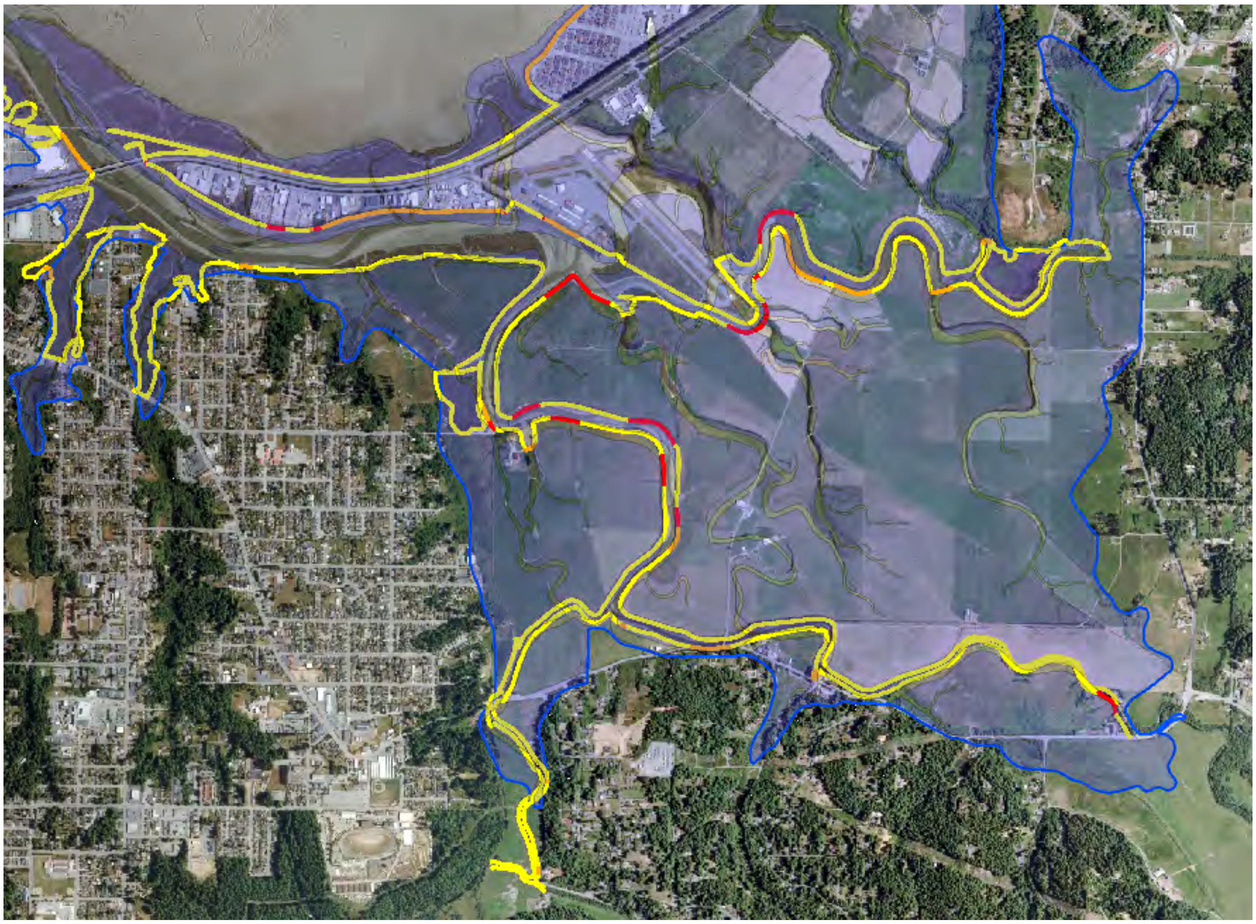

Figure 88. Eureka Slough shoreline cover: fortified (brown), vegetated (yellow), and exposed (red), with the 1870 tidal inundation area (blue).

Segregating Eureka Slough and the bottom land surrounding the slough into hydrologically connected areas will facilitate assessment of what land uses, infrastructure, or resources, may be at risk if the exposed shoreline were to fail to hold back tide water. On the north shoreline of Eureka Slough, three units (210, 113, and 21 feet in length) are exposed on the Jacobs Avenue dike, and on the airport dike, one unit of 98 feet is exposed. Continuing on the north shoreline, now in Fay Slough, there is one unit of 826 feet that is exposed. The land north of these shorelines was historically tidally interconnected and sloped towards the Bay. Shoreline failure on Fay Slough could flood agricultural and wildlife refuge lands to Highway 101, quite possibly the highway, towards commercial land at Indianola Cut-off, the airport and adjoining commercial area, and commercial and residential land in the Jacobs Avenue area. A breach in the airport dike could affect the airport and Jacobs Avenue area. A breach in the Jacobs Avenue dike may flood just that area.

On the south shoreline of Fay Slough, there are three dike units (95, 888, and 1,183 feet in length) that are exposed. On the north shoreline of Freshwater Slough, there are three dike units (402, 869, and 265 feet in length) that are exposed. Failure of any of these dike units would lead to flooding of a large agricultural area and a few residences. The City of Eureka's water transmission pipe traverses this area as does PG&E's gas transmission pipe and electrical transmission towers.

On the south shoreline of Freshwater Slough, there is one dike unit of 442 feet that is exposed. If this shoreline unit were to fail, flooding of agricultural land and Myrtle Avenue could occur.

On the west shoreline of Freshwater Slough, there are three dike units (451, 432, and 154 feet in length) that are exposed. If these dike units are breached, the agricultural area and a few residences north of Ryan Slough and south of Parks Street could flood.

One foot of sea level rise will increase the length of diked shoreline that is overtopped from 689 to 2,155 feet (Table 38). One to two feet of sea level rise will initiate wide spread dike overtopping; from 2,155 to 12,467 feet. The next increment of sea level rise of two to three feet will nearly triple the length of overtopped diked shoreline (12,467' to 36,395'). Six feet of sea level rise will overtop 97.5% of the diked shoreline. South of Eureka Slough are First, Second, and Third Sloughs, interspersed with residential and commercial uses, mostly on upland slopes. At the Slough shoreline, overtopping will occur but, due to the topography, there is little area to flood.

	Length (feet) of shoreline at or below specified elevation					
EUREKA SLOUGH	**ELEVATION**					**TOTAL**
SHORELINE STRUCTURE	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**LENGTH**
Dike	689	2,155	12,467	36,395	73,728	75,588
Railroad	18	131	295	461	563	551
Fill	828	2,720	4,172	5,133	6,057	6,059
Fortified	-	3	69	145	161	163
Total	**1,535**	**5,009**	**17,003**	**42,134**	**80,509**	**82,361**

Table 38. Cumulative lengths of shoreline by structure at increasing sea level elevations, and the total length of shoreline structure.

Breaching or overtopping of the shoreline on Eureka Slough has the potential to flood the following land uses, infrastructure, and resources, that are located within the historic tidal inundation footprint of 1870:

Land Uses:

North of Eureka and Fay Slough Shorelines

- Natural resources: DFG Fay Slough Wildlife Reserve,
- Agricultural,
- Commercial,
- Residential,
- Public facility: county airport

South of Fay Slough and East of Freshwater Slough Shorelines

- Agricultural,
- Natural resources,

South of Freshwater Slough

- Agricultural,
- Residential,
- Commercial

West of Freshwater Slough

- Agricultural,
- Natural Resources,

South of Eureka Slough

- Agricultural,
- Natural Resources,
- Residential,
- Commercial,
- Public Facility,

Infrastructure:

North of Eureka and Fay Slough Shorelines

- Recreational: DFG Fay Slough Wildlife Reserve, trails,
- Transportation: Interstate Highway 101, county roads, Jacobs Avenue, county airport,
- Drainage: numerous tidegates and culverts.

South of Fay Slough and East of Freshwater Slough Shorelines

- Transportation: County road,
- Utilities: City of Eureka water transmission pipes, PG&E gas transmission line, and PG&E electrical transmission towers,
- Drainage: numerous tidegates and culverts.

South of Freshwater Slough

- Transportation: County road,
- Drainage: tidegates, culverts, and causeway.

West of Freshwater Slough

- Transportation: County roads, service streets in Eureka and HCSD,

- Utilities: HCSD wastewater pump station,
- Drainage: numerous tidegates and culverts.

South of Eureka Slough

- Transportation: service streets in Eureka and HCSD,
- Utilities: HCSD wastewater pump station,
- Drainage: numerous tidegates and culverts.

Cultural Resources:

- Wiyot Tribe historical and archeological village sites.

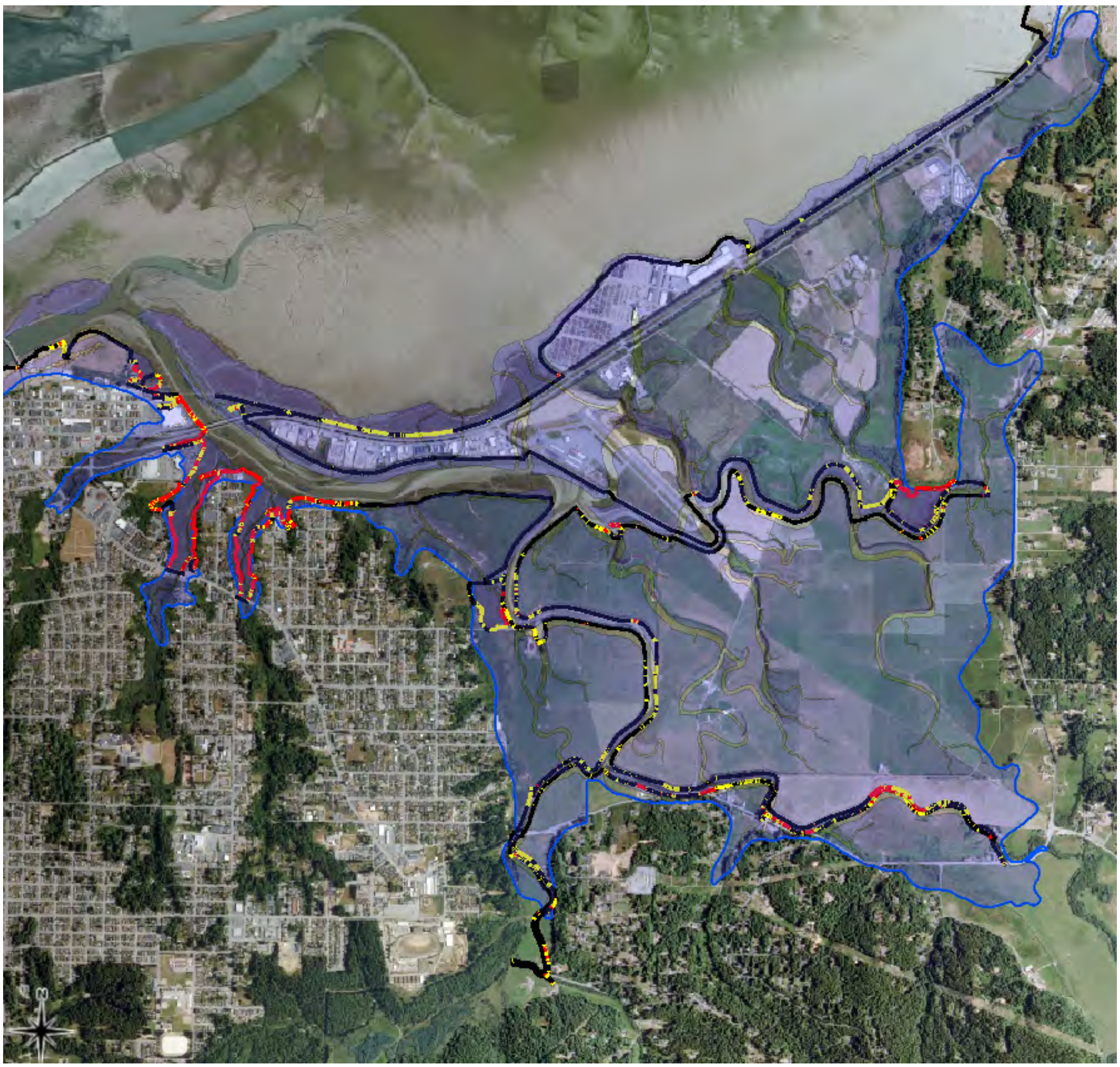

Figure 89. Eureka Slough, shoreline areas overtopped by 1 foot of sea level rise (red), and 2 feet (yellow), and the 1870 tidal inundation footprint (blue).

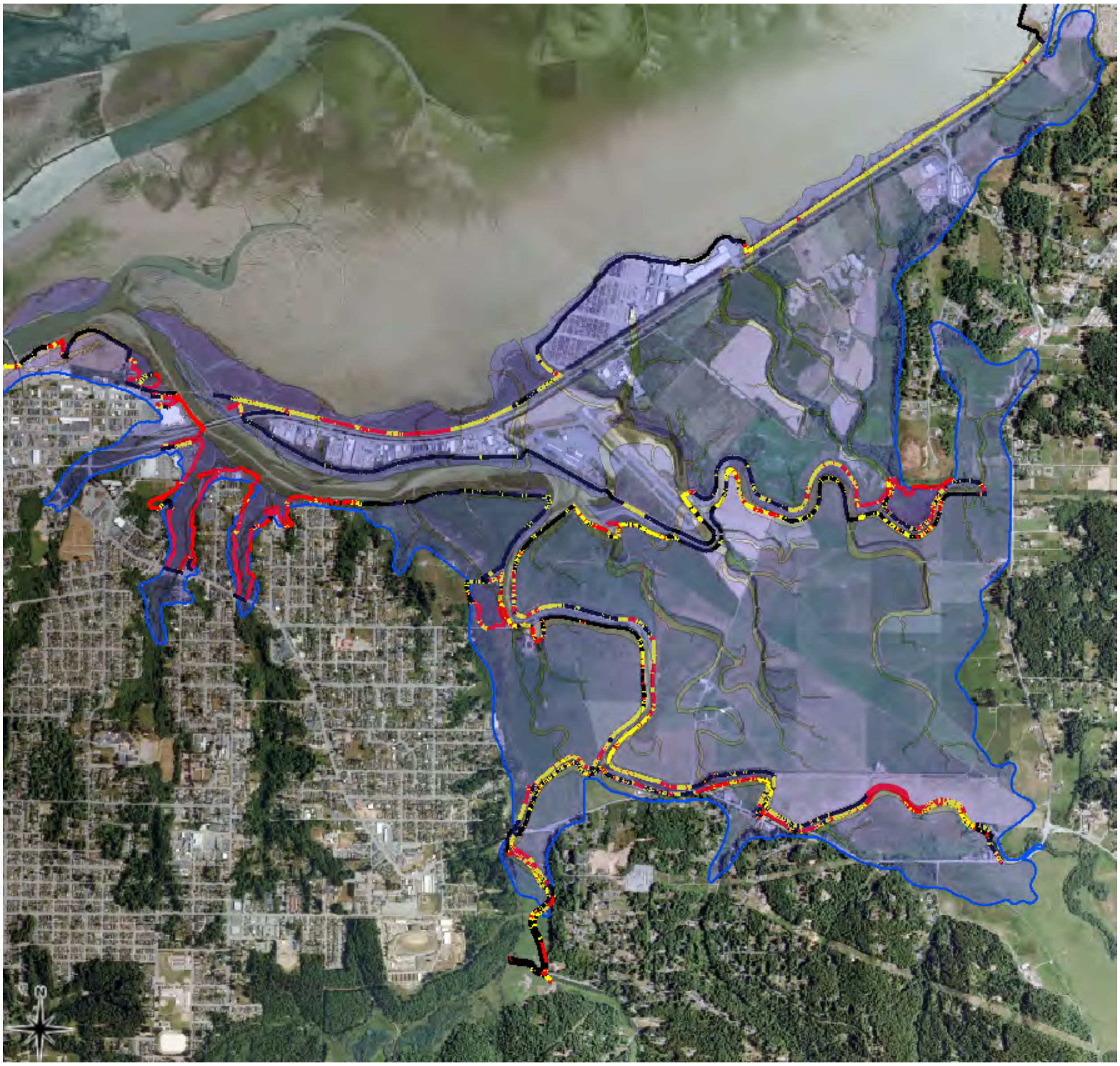

Figure 90. Eureka Slough, shoreline areas overtopped by 2 foot of sea level rise (red), and 3 feet (yellow), and the 1870 tidal inundation footprint (blue)..

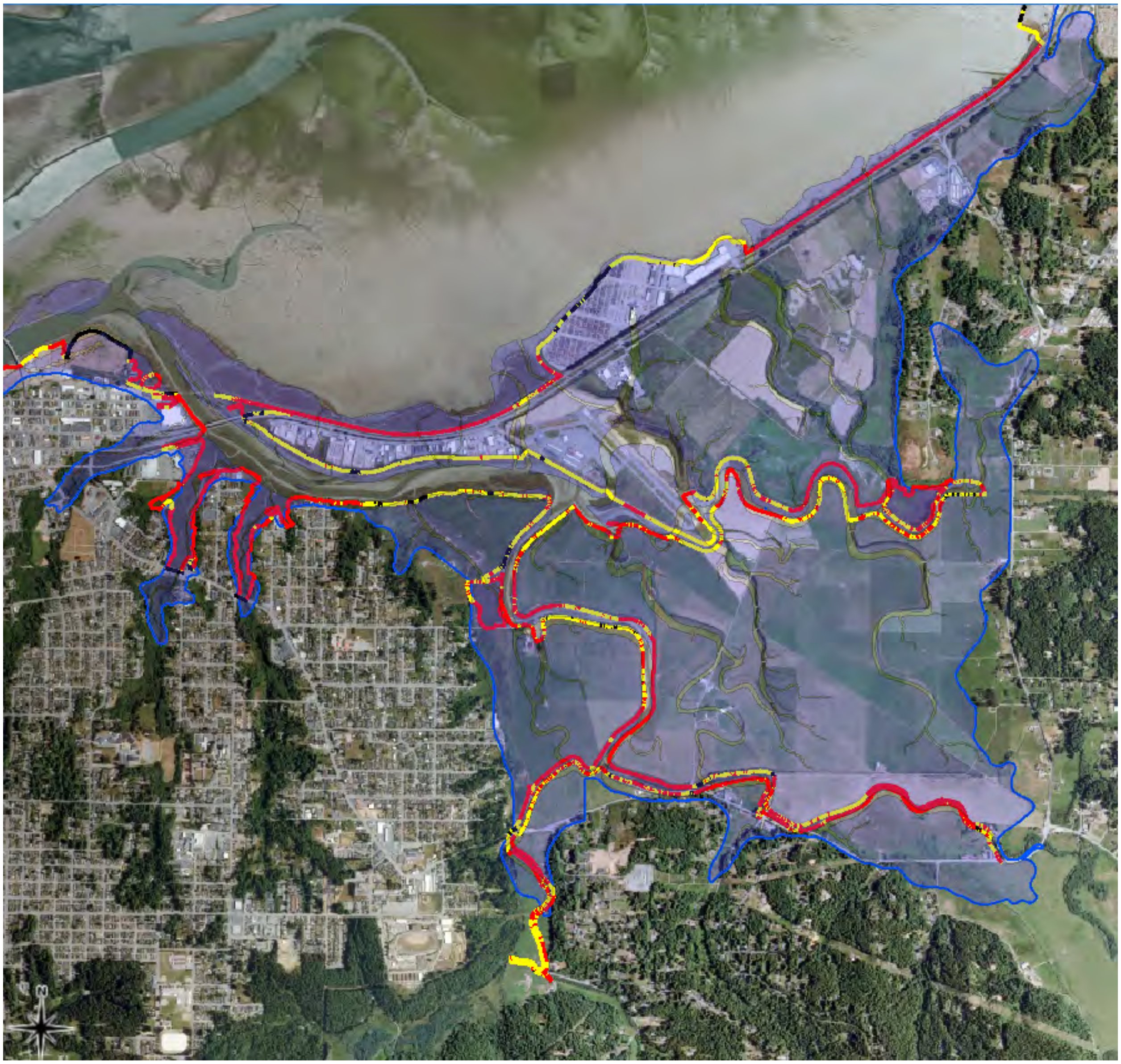

Figure 91. Eureka Slough, shoreline areas overtopped by 3 feet of sea level rise (red), and 6 feet (yellow), and the 1870 tidal inundation footprint (blue).

g) Elk River Slough

The shoreline of Elk River Slough is 9.7 miles long. 45% (35,306 feet) of the shoreline is composed of artificial structures, and only 100 feet of the artificial shoreline are exposed (Figure 92). The dominant artificial shoreline structures are dikes (43.4%, 15,334 feet) and roadway (9.7%, 3,443 feet). The diked shoreline is 57.4% (20,273 feet) vegetated, and only 74 feet are exposed. The majority of the shoreline on Elk River Slough, 55%, is made of natural channel banks. The upper 4,850 feet of the tidal reach of Elk River Slough is a natural channel that traverses the floodplain.

Figure 92. Elk River Slough shoreline cover: fortified (brown), vegetated (yellow), and exposed (red).

Nearly the entire length of Martin Slough, which is diked, and a substantial length of the diked shoreline on Elk River Slough (2,180 feet) are overtopped by MMMW of 7.74 feet. In addition, 4,938 feet of natural shoreline (no structure) on the west and east banks of Elk River, at the upper reach of tidal influence, are also overtopped at MMMW elevation. Flooding at this tidal stage affects predominantly agricultural lands. One foot of sea level rise (EHT) will substantially increase overtopped diked shoreline from 2,180 to 7,865 feet (Table 39), and will overtop the remaining 3,747 feet of the east bank of the natural channel in the upper tidal reach. Flooding of the agricultural lands in Martin Slough and lower Elk River Valley, as well as Pine Hill Road, occurs regularly at EHT. At two feet of sea level rise, 11,750 feet (76.6%) of diked shoreline is overtopped, and flooding on both sides of Highway 101, NCRA right-of-way, and Elk River Road, will occur south of Elk River and Martin Sloughs. Overtopping of the fore dunes of Elk River Spit is extensive (87.7%) at two feet. It is not known how sediment circulation in Humboldt Bay, particularly across from the entrance, will change with rising sea levels or what impact that might have on Elk River Spit. Much of the shoreline fronting Hilfiker Lane and City of Eureka wastewater treatment facility is overtopped at two feet and the entire shoreline at three feet. At three feet of sea level rise, the dike on the north bank of Elk River Slough between Highway 101 and the NCRA Bridge south of the City of Eureka's Wastewater Treatment Facility, is overtopped; and 92.4% of the diked shoreline on Elk River and Martin Sloughs is overtopped.

	Length (feet) of shoreline at or below specified elevation					
ELK RIVER SLOUGH	**ELEVATION**					**TOTAL**
SHORELINE STRUCTURE	**MMMH**	**8.74'**	**9.74'**	**10.74'**	**13.74'**	**LENGTH**
Dike	2,180	7,865	11,750	14,170	15,349	15,334
None	4,938	10,854	13,867	15,573	16,010	15,919
Fore dune	3,000	6,772	8,113	9,104	9,251	9,246
Road	75	196	332	1,162	3,046	3,443
Railroad	-	-	13	144	858	1,714
Total	**10,193**	**25,687**	**34,075**	**40,152**	**44,514**	**45,656**

Table 39. Cumulative lengths of shoreline by structure at increasing sea level elevations, and the total length of shoreline structure.

Breaching or overtopping of the shoreline on Elk River Slough has the potential to flood the following land uses, infrastructure, and resources that are located within the historic tidal inundation footprint of 1870:

<u>Land Uses:</u>

<u>West of Highway 101</u>

- Natural resources,
- Agricultural,
- Public recreation.
- Public facility.

- Industrial

East of Highway 101

- Agricultural,
- Residential.

Infrastructure:

West of Highway 101

- Recreational: City of Eureka's Hiksari Trail,
- Transportation: Interstate Highway 101, county roads and City of Eureka service streets, and NCRA railroad,
- Utilities: City of Eureka Wastewater Treatment Facility, PG&E's gas transmission line,
- Drainage: numerous tidegates and culverts.

East of Highway 101

- Transportation: Interstate Highway 101, county roads,
- Utilities: PG&E's gas transmission line, PG&E electrical transmission towers,
- Drainage: numerous tidegates and culverts.

Resources:

- Wiyot Tribe historical or archeological village sites.

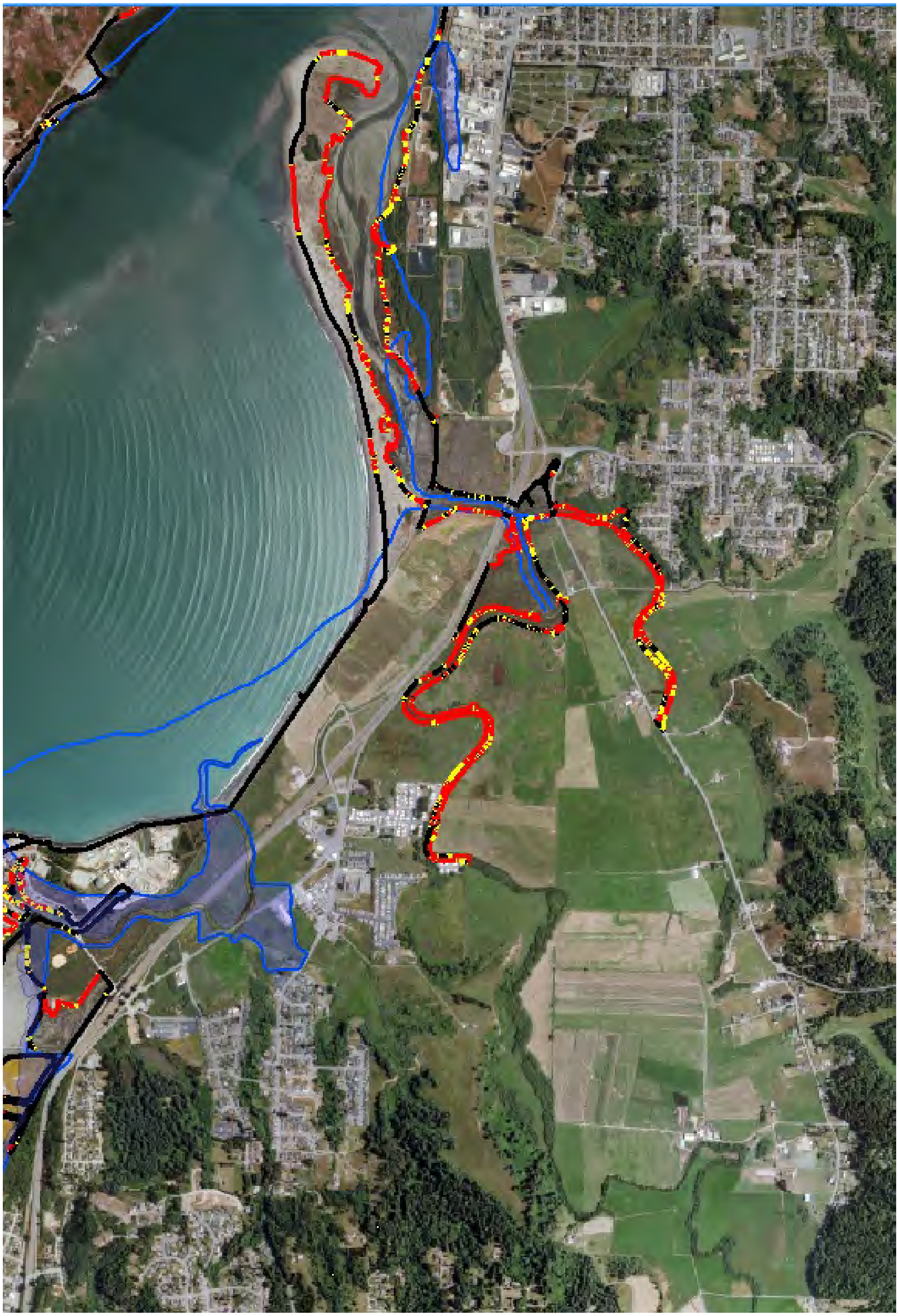

Figure 93. Elk River Slough shoreline areas overtopped by 1 foot of sea level rise (red), and 2 feet (yellow).

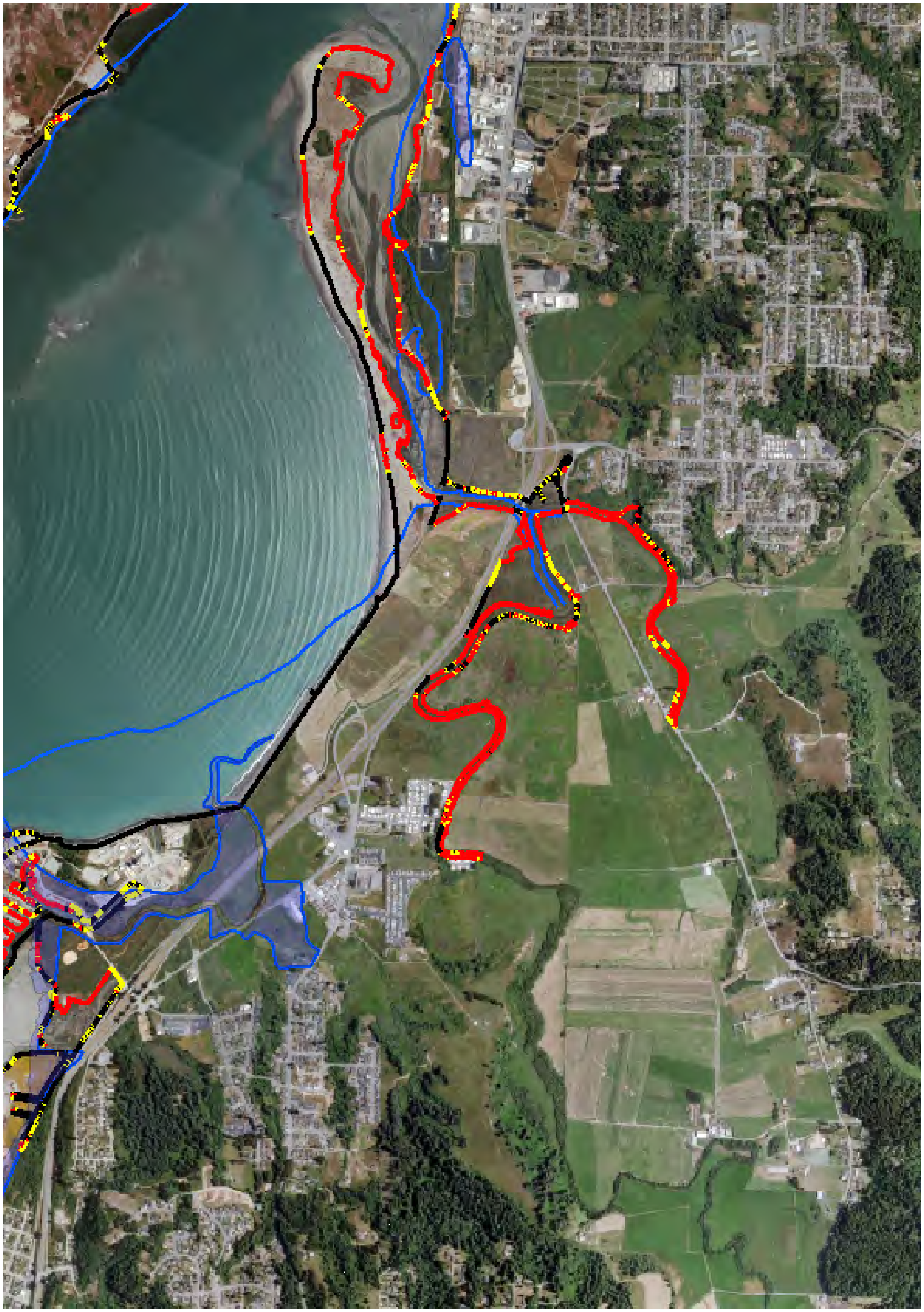

Figure 94. Eureka Slough shoreline areas overtopped by 2 foot of sea level rise (red), and 3 feet (yellow).

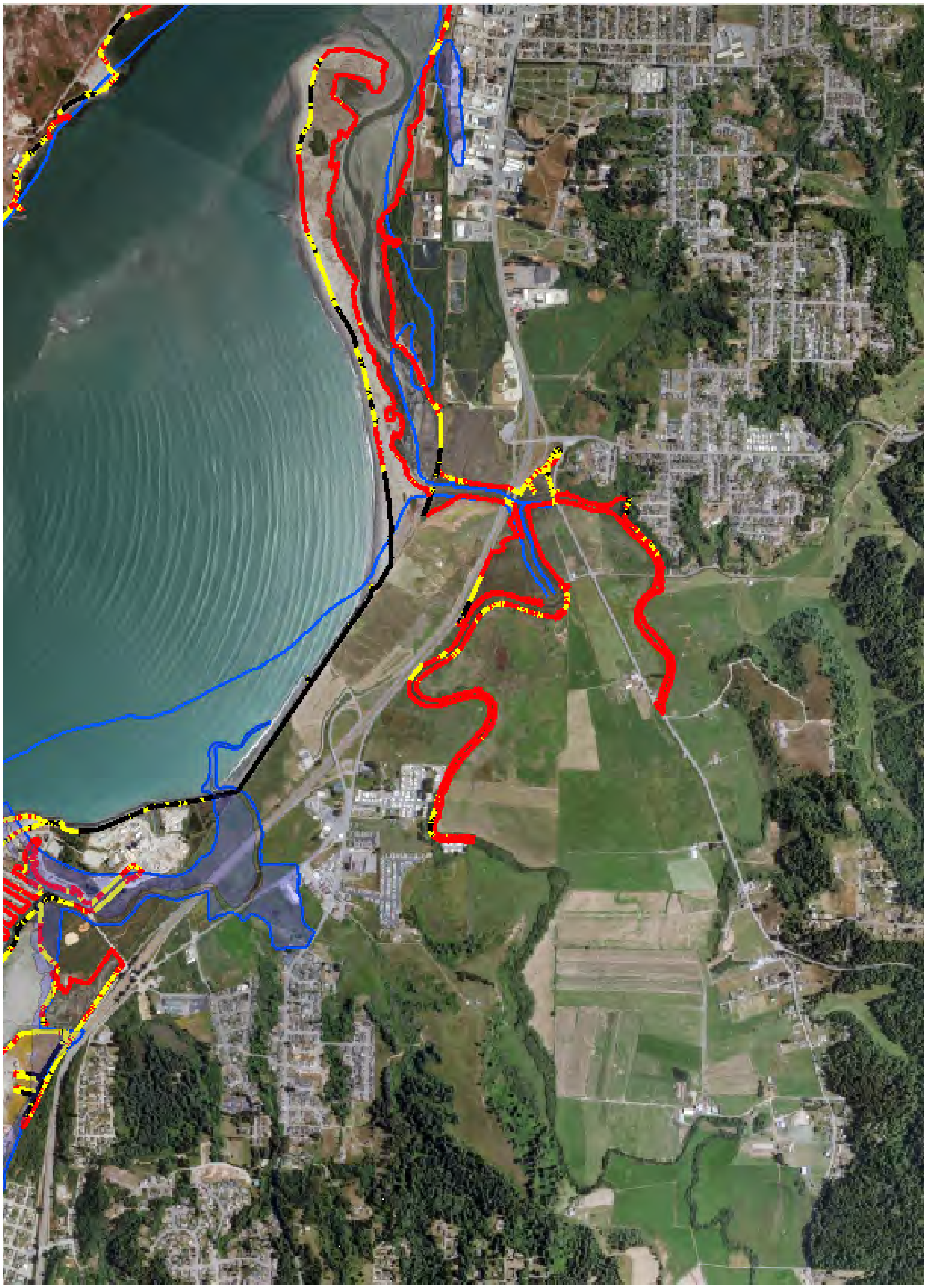

Figure 95. Eureka Slough shoreline areas overtopped by 3 feet of sea level rise (red), and 6 feet (yellow).

5 Conclusions

This project created the first comprehensive geo-spatial database of Humboldt Bay's shoreline. The database is based upon physical shoreline attributes of structure, cover, elevation, and the presence of salt marsh habitat. This database serves as a useful baseline to measure future changes in these shoreline attributes. NOAA's 2009 benthic habitat mapping of Humboldt Bay has been augmented to include the location of 57 additional areas of salt marsh habitat. This project also added 36 structures, 18 culverts, and 18 tidegates at 28 locations, to the USFWS's 2007 water control structure database.

Since the 1880s, Humboldt Bay has had a historical legacy of diking and "reclaiming" nearly 9,000 acres of tidelands. There currently are reaches of earthen dikes on Humboldt Bay that are actively eroding, unmaintained, or with surfaces that are overtopped by MMMW or EHT elevations; these reaches are vulnerable to coastal hazards of erosion and flooding. Since 2000, Humboldt Bay has experienced periods of rising water elevations on the order of 1 to 1.75 feet during annual EHTs and when combined with either stormwater runoff or storm surges. Vulnerable shoreline structures, such as dikes, put land uses, infrastructure, and property that may be lower in elevation than the Bay, at risk from flooding. At great expense, fortification of diked shorelines has been a common response to recently breached or overtopped dikes, during EHTs that have flooded formerly protected lands. Unfortunately, for example, fortification and rehabilitation of dikes, at the cost of $900,000.00 to $2,000,000.00 per mile, on Arcata Bay by the City of Arcata and Reclamation District 768, did not significantly increase their dike's surface elevations. These recently repaired dikes now range in elevation from 10.74 to 13.74 feet, and would not offer protection from rising sea levels above 3 or 6 feet.

Increasing the elevation of a dike generally requires expanding the width of the dike's base, or footprint. The California Coastal Act (Act) does allow shoreline armoring to protect "existing structures" (Public Resource Code (PRC) Section 30235). Existing, is interpreted to mean those structures built before 1976, the date of the Act. However, increasing the height of a dike by expanding its base generally would require placing fill in a tidal wetland or coastal water, which under the Act, is not one of the allowable reasons for placing fill in a wetland or coastal water (Section 30233). Therein is the conundrum! While it may be physically feasible for dikes to be modified to retain higher tide elevations, it may not be, per regulations, feasible to fill coastal wetlands or waters in order to fortify and expand a dike's footprint and height. With artificial shorelines covering 75% of Humboldt Bay (76.7 miles), only 36% is fortified (27.6 miles). Increasing the amount of shoreline that is fortified is not likely to conform to coastal resource protection policies addressing sediment recruitment and the continued existence of benthic habitats like salt marsh. Former tidelands have been and continue to be productive areas for agriculture, but at some time in the future, rising tides or continued subsidence of the land will elevate groundwater and existing tidegates will no longer fully drain on ebbing tides. Eventually, rising tides and subsiding land may reclaim some of the nearly 9,000 acres of former tidelands as the Bay returns to its original footprint.

With rising sea levels, all tidal datums such as mean low water and mean high water, will increase; when the MMMW elevation rises 1 foot, then so too will EHT increase 1 foot to an average elevation of nearly 10 feet at the North Spit tide station (equivalent now to 2 feet of sea level rise), and the risk of flooding will become an annual event. Based upon existing conditions, a sea level rise of 1 foot plus EHT would expose approximately 11 miles of dikes (28%) to overtopping in all six hydrologic units of Humboldt Bay. A conservative estimate for California is that we could see 1 foot of sea level rise by 2050. Unfortunately, based upon the North Spit tide record, Humboldt Bay is also subsiding, resulting in the highest rate of sea level rise in California. Because of the effect of subsidence, Humboldt Bay could realize a relative sea level rise of 1 foot sooner than 2050. On Elk River, EHT events regularly flood the lower valley reaches that Martin, Swain, and Elk River Sloughs traverse. In 2003, during EHT and a storm surge that elevated water elevations 1.77 feet above MMMW, a breach of 230 feet of dike on Mad River Slough flooded approximately 600 acres of agricultural land. During the 2005/2006 New Years storms and EHT, with water elevations of 1.75 to 1.81 feet, overtopping of Reclamation District 768's dikes on Arcata Bay occurred in several locations, which led to FEMA granting the District 11 million dollars to fortify and rehabilitate 4.9 miles of their dikes.

While it is not known if sea level rise or subsidence will continue at the same rate as has been recorded at the North Spit tide station, it would be prudent for the Humboldt Bay region to initiate adaptation plans before water levels reach the two to three foot threshold when wide-spread shoreline failure of approximately 21 to 44 miles could occur, and land uses, infrastructure, and resources, currently protected, will be at risk of permanent flooding. In the long-term, with a 6 foot rise in water levels, nearly 94% of the dikes would fail to hold back rising tidewater. It is important for the land use authorities on Humboldt Bay who have the capability, to pro-actively adapt to sea level rise in an effort to reduce the risk from flooding of land uses, infrastructure, and resources.

There is time to plan and adapt to sea level rise, but the more time we wait, the more likely we will have to deal with extensive emergency flooding. This project constitutes the first phase of a multi-phase sea level rise adaptation planning effort for Humboldt Bay. To develop a sea level rise adaptation plan, it is necessary to understand the vulnerability to and risk from sea level rise (Russell 2012). In preparing a vulnerability assessment for Humboldt Bay, the local tidal record from the North Spit station should be utilized to develop relative rates of sea level rise that incorporate local rates of tectonic subsidence. The SCC is funding Phase 2 of the sea level rise adaptation planning effort, which will complete the vulnerability assessment begun in Phase 1 with the development of surface and ground water models to assess changes in water levels from anticipated increases in sea level. In Phase 2, maps will be produced of areas under existing conditions that are vulnerable to inundation from Humboldt Bay and from groundwater, and for different rates of sea level rise. Phase 1 identifies structures that are vulnerable and Phase 2 will identify areas that are currently at risk from coastal hazards such as erosion and overtopping of dikes and flooding of low lying areas as well as identifying areas at risk due to sea level rise.

Subsequent adaptation planning phases should include:

- conducting a risk analysis of the sensitivity of the region's land uses, infrastructure, and resources,
- conducting an economic assessment of at risk regional assets,
- conducting an assessment of the adaptive capacity of land use or land management authorities to respond to or cope with the effects of sea level rise,
- developing, vetting, and authorizing adaption strategies and plans,
- implementing adaptation strategies and plans,

6 References

Anderson, Jeffrey K. 2012. Technical Memorandum: Estimates of Mean Monthly Maximum Water Surface Elevations in Humboldt Bay, Humboldt County, CA. Northern Hydrology and Engineering, McKinleyville, CA.

Barnhart, Roger A. 1992. The Ecology of Humboldt Bay, California: An Estuarine Profile. U.S. Fish and Wildlife Office, Arcata, CA.

Goldsmith, Greg. 2007. Humboldt Bay Water Control Structure Inventory, Assessment, and Mapping Project, Final Report. U.S. Fish and Wildlife Office, Arcata, CA.

Griggs, Gary. 2012. Symposium on Sea-Level Rise in California, San Francisco, CA. Western Governors Alliance on Ocean Health: California, Oregon, and Washington. Personal Communications.

Laird, Aldaron. 2007. Historical Atlas of Humboldt Bay and Eel River Delta. Humboldt Bay Harbor, Recreation and Conservation District, Eureka CA.

National Research Council. 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Committee on Sea Level Rise in California, Oregon, and Washington; Board on Earth Sciences and Resources; Ocean Studies Board; Division on Earth and Life Studies; National Research Council.

Pickart, Andrea. 2001. The distribution of *Spartina densiflora* and two rare salt marsh plants in Humboldt Bay, 1998-1999. U.S. Fish and Wildlife Office, Arcata, CA.

Pickart, Andrea. 2006. Vegetation of Diked Herbaceous Wetlands of Humboldt Bay National Wildlife Refuge: Classification, Description, and Ecology. U.S. Fish and Wildlife Office, Arcata, CA.

Russell, Nicole, Gary Griggs. 2012. Adapting to Sea Level Rise: A Guide for California's Coastal Communities. University of California, Santa Cruz.

Van Kirk, Susie. 2007. Fay Slough Tributaries Enhancement Project Historic Resources Report. Redwood Community Action Agency, Eureka, CA.

Watson, E.B. 1925. Soil Survey of the Eureka Area, California. U.S. Department of Agriculture, Bureau of Soils. Washington, D.C.

Winzler, John. 2012. Personal communications on the origin of the Elk River Spit. Winzler and Kelly, Eureka, CA.

Humboldt Bay
Shoreline Inventory, Mapping
and
Sea Level Rise
Vulnerability Assessment

Addendum:

Shoreline Vulnerability Ratings

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Introduction

The Humboldt Bay shoreline vulnerability rating is a quantitative measure of vulnerability that was developed as an addendum to the Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment (Laird 2013). The vulnerability rating uses combinations of shoreline attributes (cover type and relative elevation to modeled mean monthly maximum high water) to rank a shoreline segment's vulnerability to erosion and/or overtopping due to extreme tides, storm surges, and future sea level rise. Shoreline segments were given a rating between 2 and 10, 2 being the least vulnerable and 10 being highly vulnerable. Ranking shoreline vulnerability will assist in identifying assets at risk of flooding in the near-term from existing coastal hazards of shoreline erosion or overtopping.

Methodology

The 2013 inventory and mapping of existing shoreline conditions on Humboldt Bay contain three elements: structure, cover, and elevation. A GIS database containing spatial data of existing shoreline conditions has been created for these three attributes. These attributes were selected to quantify existing shoreline conditions and to support a vulnerability assessment of existing shoreline and tidal conditions and under various sea level scenarios (Laird 2013).

Structure types of dikes and railroads were extracted from the shoreline mapping dataset for the vulnerability rating analysis because they are the most prevalent structures and most vulnerable to extreme tides, storm surges, and sea level rise. If these structures fail, they will expose thousands of acres of former tidelands to risk from flooding. Dike and railroad shoreline segments were given a value between 1 and 3 based on their cover type (0). Fortified shoreline segments are considered to be the least vulnerable to erosion and exposed segments are considered to be the most vulnerable.

Cover	Index Value
Fortified	1
Vegetated	2
Exposed	3

Table 1. Vulnerability index values based on cover type.

As a product of the Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment, relative elevations to the modeled mean monthly maximum tidal water surface (MMMW) were assigned to 1 meter segments of the bay shoreline.

Using these relative elevations we rated each segment of shoreline using the values in Table 2.

Relative Elevation (ft)	Index Value
<1	7
1-2	6
2-3	5
3-4	4
4-5	3
5-6	2
>6	1

Table 2. Vulnerability index values based on relative elevation to MMMW.

Shoreline cover and relative elevation values were added together to assign a final rating between 2 and 10 to each individual 1 meter shoreline segment in Table 3. Relative shoreline elevations of <1 to 2 feet have been given high vulnerability rating because they are within current tidal elevations during annual extreme high tides and storm surges on Humboldt Bay. Relative shoreline elevations of 2 to 4 feet are rated moderately vulnerable at this time as they represent extreme high tide elevations with 1 to 2 feet of sea level rise, which is not expected until 2050 or later. Relative shoreline elevations of 4 to >6 feet are considered the least vulnerable at this time. Shoreline elevations of <1 to 2 feet are ranked highly vulnerable regardless of the shoreline cover conditions, with a vulnerability index of 7 to 10. Relative shoreline elevations of 2 to 4 feet are ranked moderately vulnerable but shoreline conditions of vegetated and exposed at relative elevations of 2 to 3 attain a combined vulnerability ratings of 7 and 8, which is a high vulnerability ranking, likewise at the relative elevation of 3 to 4 feet the exposed shoreline cover condition results in a highly vulnerable rating of 7. The same staggered vulnerability ranking occurs at 4 to 5 feet and 5 to 6 feet due to shoreline cover conditions causing higher vulnerability ranking than what would be if we just considered relative elevation.

Relative Elevation	Index Value	Cover Index Value	Vulnerability Rating
<1	7	1-2-3	8-9-10
1-2	6	1-2-3	7-8-9
2-3	5	1-2-3	6-7-8
3-4	4	1-2-3	5-6-7
4-5	3	1-2-3	4-5-6
5-6	2	1-2-3	3-4-5
>6	1	1-2-3	2-3-4

Table 3. Combined shoreline vulnerability index values create high-moderate-low vulnerability ratings.

Dike and Railroad Grade Shoreline Vulnerability Ratings

Shoreline vulnerability rating results for dike and railroad shoreline segments are shown in Tables 4 through 6 below.

Sum of Length (miles)	Vulnerability Rating									
	Low								High	
Area	2	3	4	5	6	7	8	9	10	Total
Arcata Bay	0.68	0.88	0.98	1.41	2.82	3.38	1.88	0.26	0	12.3
Eureka Bay	0.67	0.41	0.03	0.14	0.4	0.34	0.19	0.09	0	2.26
South Bay	0.01	0.07	0.15	0.82	2.25	3.81	1.34	0.43	0.12	9
Mad River Slough	0.04	0.34	0.68	1.68	2.43	1.9	1.74	0.62	0.12	9.54
Eureka Slough	0	0.46	0.98	1.85	3.93	4.63	1.98	0.58	0.03	14.44
Elk River Slough	0.08	0.13	0.06	0.05	0.2	0.48	0.74	1.49	0	3.23
Total	1.48	2.28	2.88	5.94	12.03	14.54	7.87	3.47	0.28	50.78

Table 4. Dike and railroad shoreline vulnerability rating for Humboldt Bay summarized as length in miles.

The total length of diked and railroad shoreline that is rated highly vulnerable is 26.2 miles. Eureka Slough has the greatest length of shoreline ranked highly vulnerable 7.2 miles; South Bay 5.7 miles, Arcata Bay 5.5 miles, Mad River Slough 4.4 miles, Elk River Slough 2.7 miles, and Eureka Bay 0.6 miles.

Percent of Length	Vulnerability Rating									
	Low								High	
Area	2	3	4	5	6	7	8	9	10	Total
Arcata Bay	5.60%	7.20%	8.00%	11.50%	23.00%	27.40%	15.30%	2.10%	0.00%	100.00%
Eureka Bay	29.70%	18.00%	1.40%	6.10%	17.60%	15.10%	8.40%	3.80%	0.00%	100.00%
South Bay	0.10%	0.80%	1.70%	9.10%	25.00%	42.30%	14.90%	4.80%	1.40%	100.00%
Mad River Slough	0.40%	3.50%	7.20%	17.60%	25.40%	19.90%	18.20%	6.50%	1.30%	100.00%
Eureka Slough	0.00%	3.20%	6.80%	12.80%	27.30%	32.10%	13.70%	4.00%	0.20%	100.00%
Elk River Slough	2.50%	4.10%	1.70%	1.70%	6.20%	14.90%	22.80%	46.10%	0.10%	100.00%
Total	2.90%	4.50%	5.70%	11.70%	23.70%	28.60%	15.50%	6.80%	0.60%	100.00%

Table 5. Dike and railroad shoreline vulnerability rating for Humboldt Bay summarized as percent of total.

The total length of diked and railroad shoreline that is rated highly vulnerable is 51.5 %. Elk River Slough has the greatest percentage, 83.9%, of diked and railroad shoreline ranked highly vulnerable; South Bay 62.0%, Eureka Slough 49.8%, Mad River Slough 45.9%, Arcata Bay 44.8%, and Eureka Bay at 27.3%.

Sum of Length (miles)	Vulnerability Rating									
	Low								High	
	2	3	4	5	6	7	8	9	10	Total
Arcata Bay										
Dike	0.68	0.86	0.9	1.15	0.67	0.59	0.73	0.2	0	5.78
Railroad	0	0.02	0.08	0.26	2.15	2.78	1.16	0.06	0	6.52
Eureka Bay										
Dike	0	0.32	0.01	0	0.01	0.05	0.1	0.09	0	0.58
Railroad	0.67	0.09	0.02	0.13	0.39	0.29	0.09	0	0	1.68
South Bay										
Dike	0.01	0.06	0.11	0.69	1.65	3.28	1.28	0.43	0.12	7.63
Railroad	0	0.01	0.04	0.13	0.61	0.53	0.06	0	0	1.38
Mad River Slough										
Dike	0.04	0.27	0.52	1.51	2.29	1.88	1.74	0.62	0.12	8.99
Railroad	0	0.07	0.16	0.17	0.13	0.01	0	0	0	0.55
Eureka Slough										
Dike	0	0.46	0.98	1.84	3.92	4.6	1.95	0.55	0.03	2.91
Railroad	0	0	0	0	0.02	0.03	0.03	0.02	0	0.32
Elk River Slough										
Dike	0	0.01	0.01	0.05	0.16	0.46	0.73	1.49	0	14.33
Railroad	0.08	0.13	0.04	0.01	0.04	0.02	0	0	0	0.11
Total	1.48	2.28	2.88	5.94	12.03	14.54	7.87	3.47	0.28	50.78

Table 6. Dike and railroad shoreline vulnerability rating for Humboldt Bay summarized as length in miles by structure type.

The total length of diked shoreline that is rated highly vulnerable is 21.0 miles and for railroad shoreline 5.1 miles. Eureka Slough has the greatest length of diked shoreline rated highly vulnerable, 7.13 miles; South Bay 5.1 miles, Mad River Slough 4.4 miles, Elk River Slough 2.7 miles, Arcata Bay 1.5 miles, and Eureka Bay 0.3 miles. Arcata Bay has the greatest length of railroad shoreline rated highly vulnerable, 4.0 miles; South Bay 0.6 miles, Eureka Bay 0.4 miles, Eureka Slough 0.01 miles, and Elk and Mad River Sloughs negligible lengths of railroad bridge ramps that are vulnerable. The distribution of shoreline vulnerability ratings is depicted in Figure 1.

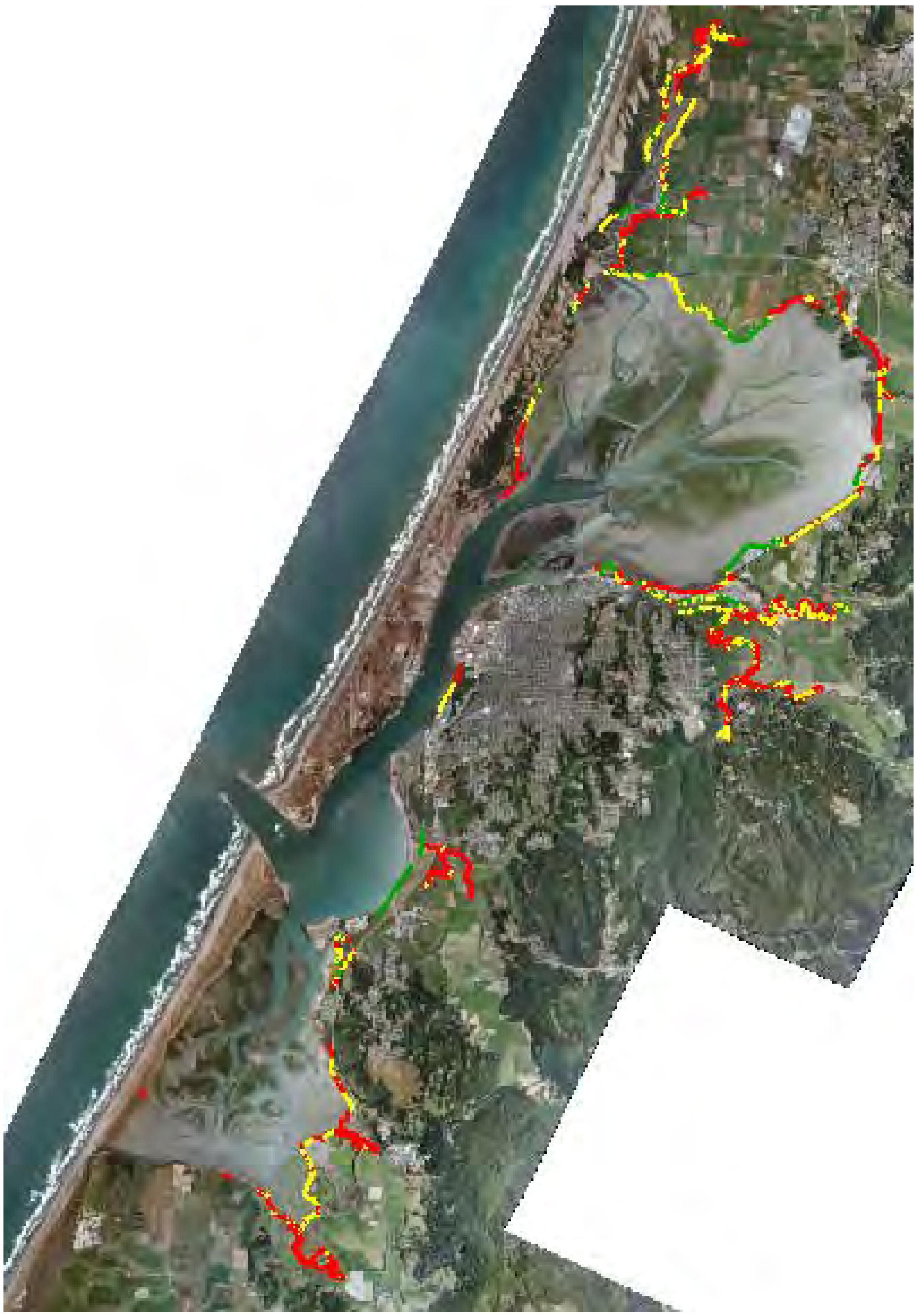

Figure 1. Diked and railroad shoreline vulnerability rating for Humboldt Bay; red-high, yellow-moderate, and green-low.

The vulnerability ratings have also been charted as column graphs below.

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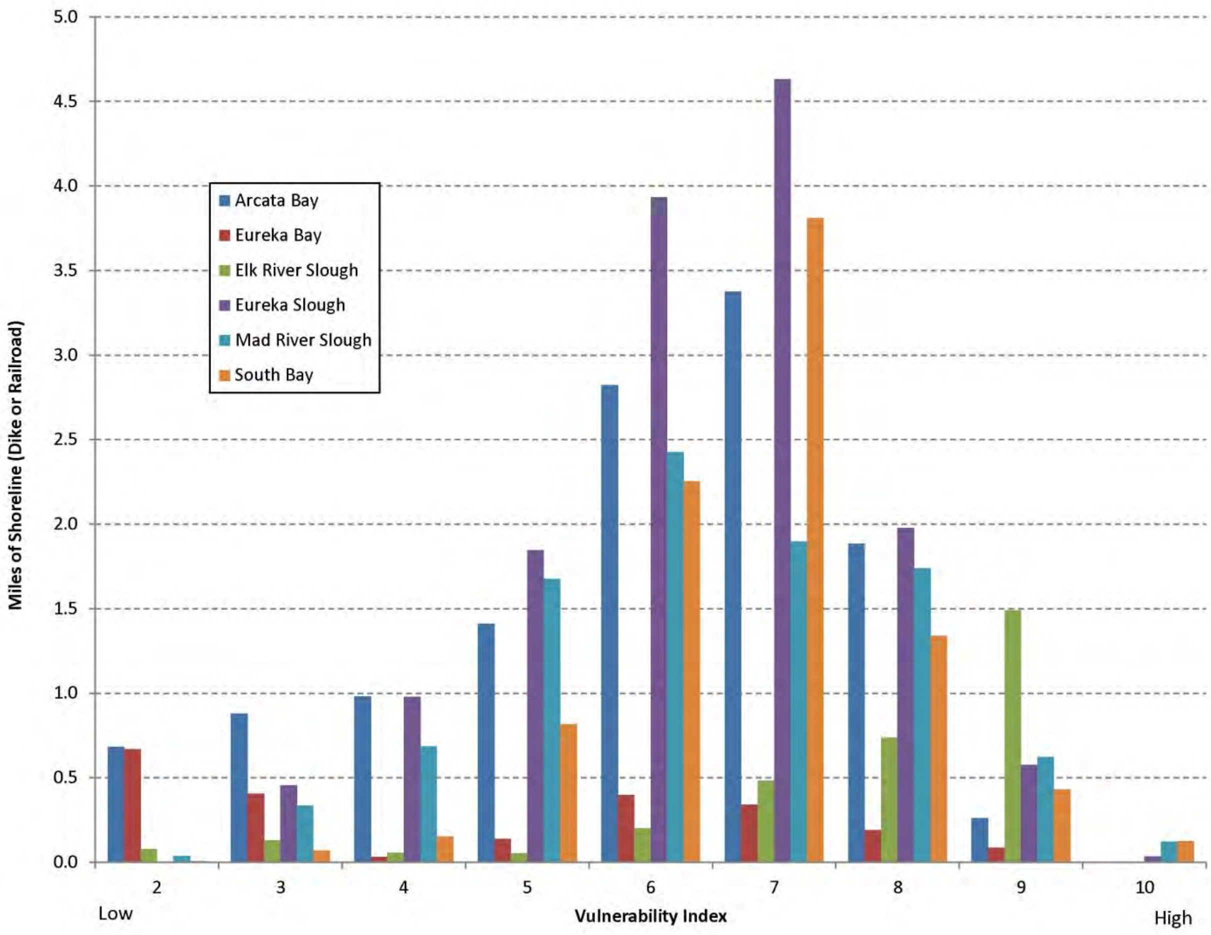


Figure 2. Diked and railroad shoreline vulnerability rating for Humboldt Bay charted by length in miles.

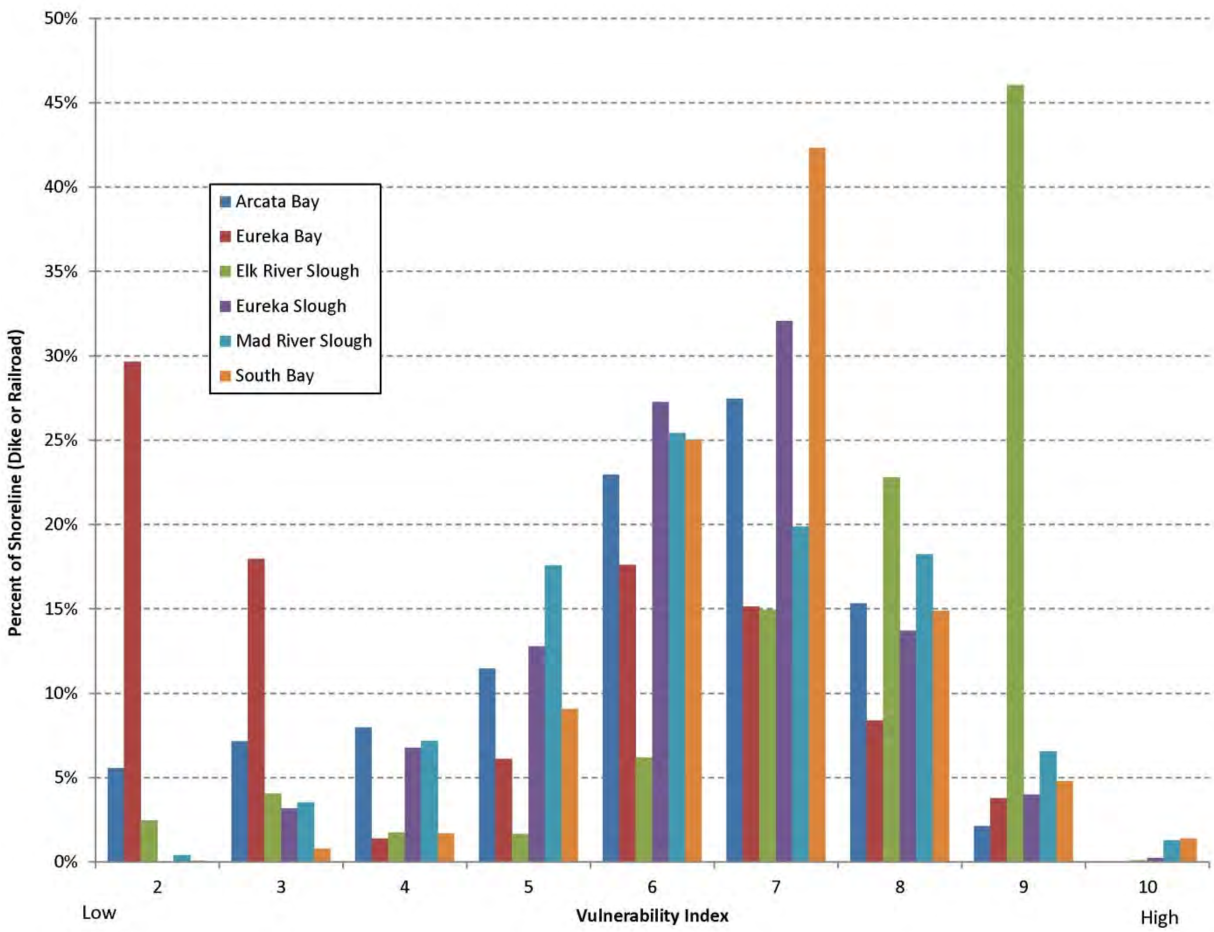


Figure 3. Diked and railroad shoreline vulnerability rating for Humboldt Bay charted as percent of total.

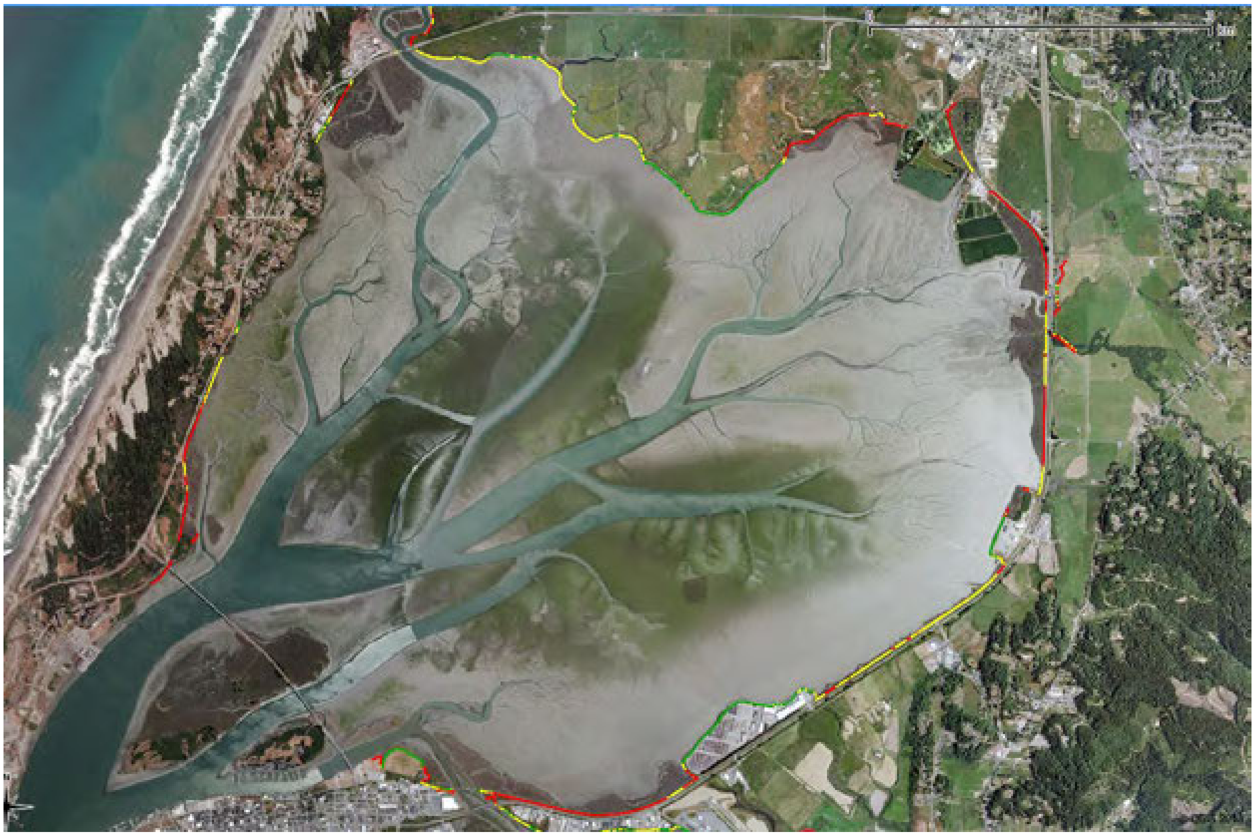


Figure 4. Diked and railroad shoreline vulnerability rating for Arcata Bay; red high, yellow moderate, and green low.

Figure 5. Diked and railroad shoreline vulnerability rating for Eureka Bay; red high, yellow moderate, and green low.

Figure 6. Diked and railroad shoreline vulnerability rating for South Bay; red high, yellow moderate, and green low.

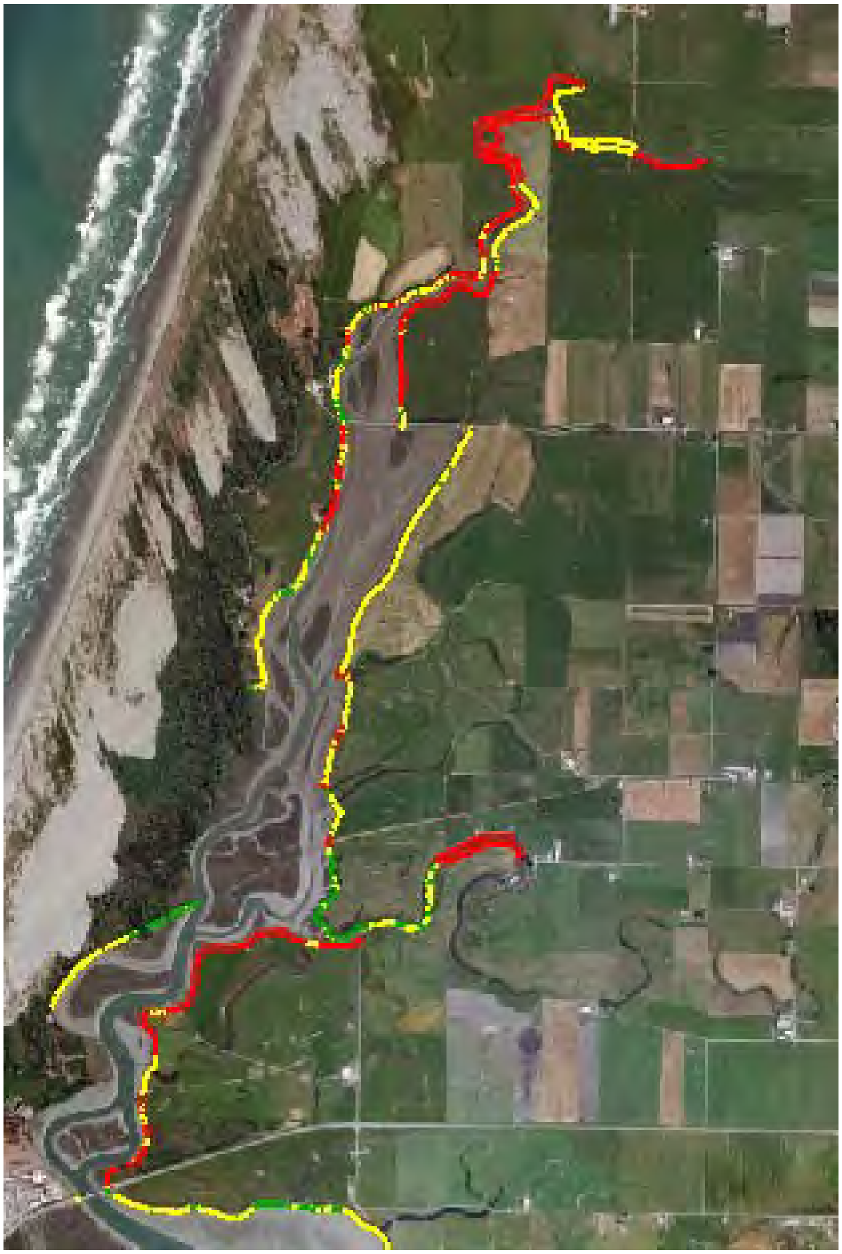


Figure 7. Diked and railroad shoreline vulnerability rating for Mad River Slough; red high, yellow moderate, and green low.

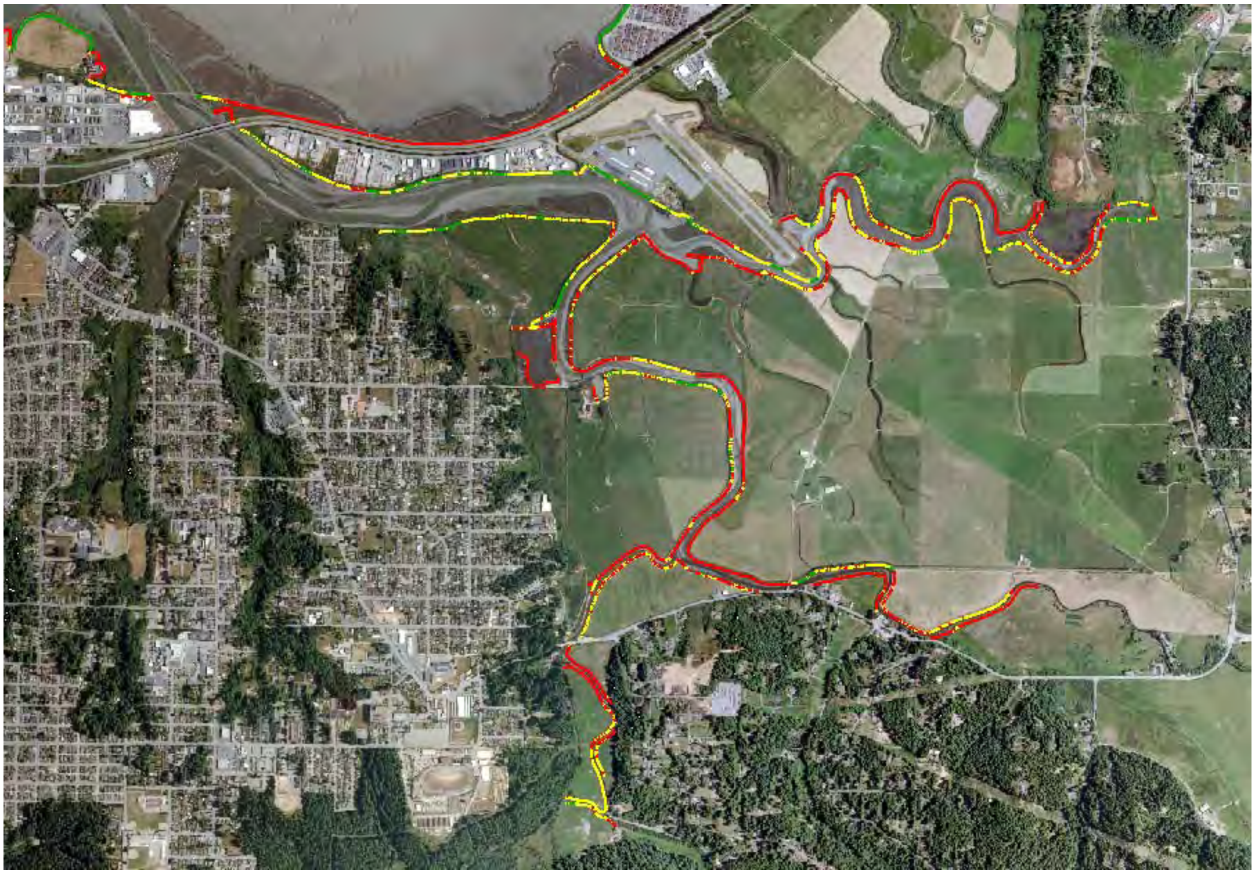


Figure 8. Diked and railroad shoreline vulnerability rating for Eureka Slough; red high, yellow moderate, and green low.

Figure 9. Diked and railroad shoreline vulnerability rating for Elk River Slough; red high, yellow moderate, and green low.

Humboldt Bay Shoreline Vulnerability Ratings

Shoreline vulnerability rating results for the entire shoreline of Humboldt Bay is shown in Tables 7 through 10 below.

The total length of shoreline that is rated highly vulnerable is 59.5 miles. South Bay has the greatest length of shoreline ranked highly vulnerable 15.2 miles; Eureka Slough 12.5 miles, Arcata Bay 10.0 miles, Elk River Slough 8.4 miles, Mad River Slough 7.7 miles, and Eureka Bay 5.2 miles.

Sum of Length (miles)	Vulnerability Rating								
	Low								High
Area	2	3	4	5	6	7	8	9	10
Arcata Bay	0.8	1.4	1.6	2.3	3.9	4.5	2.8	2.6	0.1
Eureka Bay	2.1	1.7	1.4	1.9	3.0	2.1	1.8	1.3	0.5
South Bay	0.0	0.6	0.5	1.7	3.7	5.5	3.7	5.0	1.0
Mad River Slough	0.1	0.4	0.8	1.8	2.7	2.6	2.6	2.4	0.1
Eureka Slough	0.0	0.7	1.1	2.1	4.4	5.7	3.4	3.4	0.0
Elk River Slough	0.1	0.3	0.2	0.2	0.5	1.2	1.8	5.2	0.2
Total	3.2	5.2	5.7	10.0	18.2	21.5	16.1	19.9	2.0

Table 7. Humboldt Bay shoreline vulnerability ratings summarized as length in miles by hydrologic unit.

The total length of shoreline that is rated highly vulnerable is 58.5 %. Elk River Slough has the greatest percentage, 86.3%, of shoreline ranked highly vulnerable; South Bay 69.5%, Eureka Slough 60.2%, Mad River Slough 56.5%, Arcata Bay 50.1%, and Eureka Bay at 36.2%.

Percent of Length	Vulnerability Rating								
	Low								High
Area	2	3	4	5	6	7	8	9	10
Arcata Bay	3.9%	7.0%	7.9%	11.7%	19.4%	22.7%	13.9%	13.2%	0.4%
Eureka Bay	13.4%	11.0%	8.9%	11.8%	18.7%	13.4%	11.4%	8.3%	3.1%
South Bay	0.2%	2.9%	2.4%	7.8%	17.1%	25.0%	16.7%	23.1%	4.8%
Mad River Slough	1.0%	3.2%	6.2%	13.5%	19.6%	18.7%	19.4%	17.3%	1.1%
Eureka Slough	0.1%	3.3%	5.3%	10.0%	21.2%	27.2%	16.4%	16.4%	0.2%
Elk River Slough	0.9%	3.0%	2.0%	2.3%	5.5%	12.5%	18.8%	53.3%	1.8%
Total	3.1%	5.1%	5.6%	9.9%	17.9%	21.2%	15.8%	19.6%	1.9%

Table 8. Humboldt Bay shoreline vulnerability ratings summarized as percent of length by hydrologic unit.

The total length in miles of shoreline by structure and hydrologic unit is presented in Table 9 and 10 below. Eureka Slough has the greatest length of shoreline by structure rated highly vulnerable, 7.1 miles of dike; South Bay 5.1 miles of dike, Mad River Slough 4.4 miles of dike, Arcata Bay 4.0 miles of railroad, Elk River Slough 3.0 miles of natural bank-no structure and 2.7 miles of dike, and Eureka Bay 1.3 miles of fortified shoreline and 1.3 miles of natural bank-no structure.

Sum of Length (miles)	Vulnerability Rating							
	Low							High
	2	3	4	5	6	7	8	9	10
Arcata Bay									
Bridge Abutment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulwark	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dike	0.7	0.9	0.9	1.2	0.7	0.6	0.7	0.2	0.0
Fill	0.0	0.3	0.2	0.1	0.2	0.4	0.5	0.7	0.0
Fortified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
None	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.6	0.1
Pond	0.1	0.1	0.4	0.5	0.6	0.3	0.0	0.0	0.0
Railroad	0.0	0.0	0.1	0.3	2.2	2.8	1.2	0.1	0.0
Road	0.0	0.0	0.1	0.3	0.2	0.4	0.2	0.1	0.0
Boat Ramp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eureka Bay									
Building	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulwark	0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.0	0.0
Dike	0.0	0.3	0.0	0.0	0.0	0.1	0.1	0.1	0.0
Fill	0.0	0.0	0.1	0.1	0.2	0.4	0.2	0.1	0.1
Fore Dune	0.0	0.6	0.6	0.3	0.2	0.2	0.3	0.3	0.3
Fortified	1.3	0.3	0.6	0.9	1.2	0.7	0.6	0.0	0.0
Jetty	0.1	0.0	0.0	0.2	0.2	0.0	0.1	0.0	0.0
None	0.0	0.3	0.1	0.1	0.2	0.2	0.3	0.8	0.1
Railroad	0.7	0.1	0.0	0.1	0.4	0.3	0.1	0.0	0.0
Road	0.1	0.0	0.0	0.1	0.4	0.1	0.1	0.0	0.0
Tidegate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boat Ramp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
South Bay									
Bridge Abutment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bulwark	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0
Cliff/Bluff	0.0	0.0	0.1	0.0	0.0	0.1	0.1	1.3	0.3
Dike	0.0	0.1	0.1	0.7	1.6	3.3	1.3	0.4	0.1
Fill	0.0	0.3	0.1	0.1	0.2	0.3	0.4	0.6	0.5
Fore Dune	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
Fortified	0.0	0.0	0.0	0.4	0.4	0.2	0.3	0.1	0.0
Jetty	0.0	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0
None	0.0	0.0	0.0	0.1	0.3	0.7	1.1	2.5	0.0
Railroad	0.0	0.0	0.0	0.1	0.6	0.5	0.1	0.0	0.0
Road	0.0	0.0	0.0	0.0	0.2	0.2	0.1	0.0	0.1
Tidegate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boat Ramp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9. Humboldt Bay shoreline vulnerability ratings summarized as length in miles for each type of shoreline structure and by hydrologic unit.

Sum of Length (miles)	Vulnerability Rating									
	Low								High	
	2	3	4	5	6	7	8	9	10	Total
Mad River Slough										
Bulwark	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Dike	0.0	0.3	0.5	1.5	2.3	1.9	1.7	0.6	0.1	9.0
Fill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Fortified	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
None	0.0	0.1	0.0	0.0	0.1	0.3	0.7	1.7	0.0	2.8
Railroad	0.0	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.6
Road	0.0	0.0	0.1	0.1	0.1	0.3	0.2	0.1	0.0	0.9
Boat Ramp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eureka Slough										
Bridge Abutment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Bulwark	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.3
Cliff/Bluff	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.9	0.0	1.3
Dike	0.0	0.4	1.0	1.9	3.9	4.6	1.9	0.6	0.0	14.3
Fill	0.0	0.0	0.0	0.1	0.1	0.2	0.4	0.4	0.0	1.2
Fortified	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
None	0.0	0.0	0.0	0.0	0.1	0.6	0.7	1.4	0.0	2.9
Railroad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Road	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.7
Tidegate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Boat Ramp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elk River Slough										
Bridge Abutment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Bulwark	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cliff/Bluff	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.0	0.6
Dike	0.0	0.0	0.0	0.0	0.2	0.5	0.7	1.5	0.0	2.9
Fill	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
Fore Dune	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.3	0.1	1.8
Fortified	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1
None	0.0	0.0	0.0	0.0	0.1	0.3	0.6	2.0	0.1	3.0
Railroad	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Road	0.0	0.1	0.1	0.1	0.2	0.2	0.0	0.0	0.0	0.6
Tidegate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.2	5.2	5.7	10.0	18.2	21.5	16.1	19.9	2.0	101.8

Table 10. Humboldt Bay shoreline vulnerability ratings summarized as length in miles for each type of shoreline structure and by hydrologic unit.

Reference

Laird, A., 2013
Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment. http://scc.ca.gov/webmaster/ftp/pdf/humboldt-bay-shoreline.pdf

bae urban economics

Memorandum

To: Dan Dameron and Harriet Ross, ESA

From: Matt Kowta and Aaron Nousaine, BAE

Date: April 10, 2015

Re: CDI Land Supply and Demand

This memo is intended to serve as a guide to interpreting the economic information contained in the Community Background Report as it applies to the issue of the supply and demand for CDI land in Eureka. While the Community Background Report addresses general economic and market issues for the General Plan Update process, this memo provides additional focus on whether current and projected economic conditions indicate that it is appropriate for the City of Eureka and the Coastal Commission to consider enacting land use policies that would provide more opportunity for non-CDI activities on land that is currently designated for CDI activity.

It should be noted that, based on our phone call with City staff and California Coastal Commission staff, on Thursday, April 2, 2015, we understand that it will be necessary to compile additional information and potentially conduct additional analysis, prior to determining exactly which parcels might be suitable for conversion from CDI to non-CDI uses, and before the City requests any action or determination from the Coastal Commission on such matters.

Comparison Between CDI Land Supply and Projected Demand

Exhibit 1, on the following page provides a basic comparison between the land use demand projections and vacant and underutilized sites inventory that we prepared for the Eureka General Plan Update Community Background Report (Economics Chapter) and the Annexation Policy Paper. Exhibit 1 offers a comparison between the demand projections and the sites inventory by land use type. There are a few things to keep in mind when looking at this table:

1) BAE produced both low- and high-end demand projections for each land use type.

2) The parcel counts and acreage totals provided under the vacant and underutilized sites headers are categorized based on the primary land use type permitted within a given zoning category. For example, the table shows 13 parcels, totaling only three acres, in the office category. This includes only those parcels with Office and Multi-Family Residential (OR) zoning. It is important to keep in mind that most of the commercial zoning districts (e.g., CP, CW, CS,

CN, CC) also permit office uses, so the comparisons of office land supply and demand should be interpreted with caution.

3) Although the table identifies 34 parcels, covering 117 acres of vacant and underutilized land, that are zoned for industrial activities, only 16 parcels, covering 23 acres, are in the Limited (ML) and General Industrial (MG) zoning districts, which would permit non-coastal dependent industrial activities.

4) Many of the parcels identified in the vacant and underutilized sites inventory are relatively small and often dispersed (i.e., not adjacent to each other such that consolidation would not be practical if a user needs a larger site), which may pose certain challenges for development. For example, of the 16 total ML and MG parcels, the average parcel size is only 1.4 acres, with many parcels averaging less than one acre in size.

Initial Conclusions Regarding the Supply of CDI Land

- The analysis contained in the Community Background Report estimated total demand through 2040 for up to 17 acres of industrial land, to accommodate Eureka's projected employment growth. This total demand figure is for both Coastal Dependent as well as non-Coastal Dependent Industrial Uses.
- Analysis of economic trends and conditions contained in the Community Background Report indicates that Eureka's legacy Coastal Dependent industrial uses, including fishing and Port of Humboldt Bay port activities (primarily the shipment of timber and wood products) are stable at best (fishing) or have declined drastically (Port cargo handling). Due to environmental constraints, which limit the potential for increasing fish landings and timber harvests, and landside transportation constraints, which limit the potential for attraction of other industrial activities which might also use the Port for importing raw materials or shipping finished goods, there is limited potential for increased Coastal Dependent industrial activity within the City of Eureka and the greater Humboldt Bay area.
- Limited exceptions to the above conclusion include possible growth in demand for facilities related to growth in the Port of Humboldt Bay aquaculture industry and the potential need for a new cold storage facility, which would potentially serve the local fishing fleet and aquaculture producers, as well as other non-Coastal Dependent businesses that need to store perishable goods. The City of Eureka is engaged in a feasibility study for the latter at this time.
- Overall, it is likely that a relatively small proportion of the high-end 17-acre industrial land demand figure would be associated with Coastal Dependent industrial uses, and the majority of the demand would be associated with non-Coastal Dependent industrial uses. In the most conservative scenario, if 100% of the high end projected industrial demand through 2040 comes from Coastal Dependent Industrial users, the City has over five times the amount of vacant or underutilized Coastal Dependent industrial land than would be needed. In addition, the average parcel size among Coastal

Dependent industrial sites is 5.2 acres, which is substantially larger than the average size of parcels available for non-Coastal Dependent industrial uses.

- Although the supply of vacant or underutilized land available for non-Coastal Dependent industrial uses (23 acres) exceeds a worst-case scenario in which all 17 acres of projected industrial demand would be associated with non-Coastal Dependent industrial uses, the small average parcel size (1.4 acres) in the ML and MG zoning districts poses a serious constraint to finding appropriate sites that can accommodate prospective non-Coastal Dependent industrial users.
- From a regional perspective, the analysis in the Community Background Report estimated that throughout Humboldt County, projected employment growth in all industrial activities (CDI and non-CDI) would require approximately 50 to 62 acres of industrial land. Meanwhile, the analysis found that there are 1,390 acres of land available for Coastal Dependent Industrial uses in locations around Humboldt Bay, much of which is vacant or substantially underutilized. About 975 of the 1,390 acres of CDI land are located on the Samoa Peninsula, and 850 of those acres are on parcels that are adjacent to the 38-foot shipping channel.
- Based on the above findings, it is unlikely that re-designation of a portion of Eureka's CDI land to create more opportunities for non-CDI uses would have a material effect on adequacy of the regional supply of CDI land.

Vacant and Underutilized Site Detail

Exhibit 2 provides additional detail regarding the vacant and underutilized sites inventory, as described in the Annexation Policy Paper. BAE developed this inventory using GIS data provided by the City and BAE then combined the GIS data with information provided in the 2015 Housing Element. Following an initial draft, BAE then reviewed the inventory in detail with Lisa Shikany, Principal Planner, with the City of Eureka. There were a number of sites that had significant constraints, such as the presence of wetlands, which warranted removal from the inventory. As a result, the parcels identified in Exhibit 2 should represent a complete list of those properties that could reasonably be developed.

Exhibit 1: Land Use Demand and Vacant/Underutilized Sites Comparison

Land Use Type	Projected Demand (Acres) Low-Growth	High-Growth	Vacant/Underutilized Sites Inventory (Acres) Parcels	Acres	Average Parcel Size
Residential (a)	87	188	123	72	0.6
Single-Family	*68*	*148*	*87*	*64*	*0.7*
Multifamily	*19*	*40*	*36*	*8*	*0.2*
Commercial (b)(c)	19	27	74	56	0.8
Office (d)(e)	24	48	13	3	0.2
Industrial (f)(g)	14	17	34	117	3.4
General or Limited	*n.a.*	*n.a.*	*16*	*23*	*1.4*
Coastal Dependent	*n.a.*	*n.a.*	*18*	*94*	*5.2*

Notes:

(a) Residential demand projections assume that Eureka will maintain its existing share of countywide household growth, as projected by Caltrans and the DoF. The breakdown between single-family and multifamily housing demand is based on projected household characteristics. Development densities are assumed to equal six dwelling units per acre for single-family housing and 20 dwelling units per acre for multifamily units.

(b) Commercial demand projections are based on projected household growth and account for the capture of existing retail leakage, resulting in demand for between 200,000 and 290,000 square feet of additional commercial development. The conversion to acreage assumes a floor area ratio (FAR) of 25 percent.

(c) Note that commercial zones, such as Central, Neighborhood and Service Commercial, also allow office and residential uses.

(d) Office demand projections are based on projected employment growth in office using industries with an estimated 250 square feet per employee and a FAR of between 25 and 50 percent.

(e) Includes only those vacant and underutilized parcels zoned for office and mixed-use (OR). Additional office development can be accomodated on land with commercial zoning, as mentioned in footnote (c). The OR districts also permit assorted single-family and multifamily development, including attached and detached units.

(f) Industrial demand projections are based on projected employment growth in industries typically associated with industrial land uses, with an estimated 1,000 to 1,250 square feet per employee and an FAR of 35 percent.

(g) Includes vacant and underutilized sites with both Coadtal Dependent Industrial (MC) zoning, as well as Limited (ML) and General Industrial (MG).

Sources: City of Eureka, 2014-2019 Housing Element, 2015; BAE 2015

Exhibit 2: Eureka, CA Vacant & Underutilized Parcels, by Zoning Category

Zoning Category	Vacant		Underutilized	
	Parcels	Acres	Parcels	Acres
Residential				
Multi-Family (RM-1000)	10	2.7	-	-
Multi-Family (RM-2500)	26	5.2	-	-
Single Family (RS-6000)	87	64.1	-	-
Subtotal (Residential)	**123**	**72.1**	**-**	**-**
Commercial				
Planned Shopping Center (CP)	-	-	2	5.1
Waterfront Commercial (CW)	14	19.2	1	0.1
Service Commercial (CS)	17	2.9	34	27.6
Service Commercial-Coastal (CS-C)	1	0.4	-	-
Neighborhood Commercial (CN)	1	0.4	-	-
Central Commercial (CC)	3	0.5	1	0.3
Subtotal (Commercial)	**36**	**23.3**	**38**	**33.1**
Mixed-Use				
Office and Multi-Family Residential (OR)	12	2.9	1	0.1
Subtotal (Mixed-Use)	**12**	**2.9**	**1**	**0.1**
Industrial (a)				
Limited Industrial (ML)	4	1.8	1	2.4
General Industrial (MG)	10	14.4	1	4.6
Coastal Dependent Industrial (MC)	18	93.6	-	-
Sub Total (Industrial)	**32**	**109.8**	**2**	**6.9**
Total (All Zoning Categories)	**203**	**208.1**	**41**	**40.2**

Note:
(a) All vacant or underutilized parcels zoned for industrial use are within the Coastal Zone.

Sources: City of Eureka, 2014-2019 Housing Element, 2015; BAE 2015

3 POPULATION, HOUSING AND ECONOMY

This chapter describes existing characteristics of the population, housing, employment, and local economy within the City of Eureka, General Plan Planning Area, and Humboldt County. It also identifies future growth trends and market opportunities, presenting a set of projections for population, households, and housing units for the period from 2015 to 2040. Key planning issues are discussed at the end of the chapter.

3.1 POPULATION CHARACTERISTICS

The City of Eureka is a mid-sized community with a population of around 27,000. The City lost a sizable number of residents (approximately 900) during the 1990s, but has regained much of the lost population since 2000. The population living in the City is notably younger, with a higher percentage of single person households, compared to Humboldt County as a whole. The City also has smaller proportions of family households and households with children, compared to the County. The distribution of residents by age, in both Eureka and Humboldt County, shows an increase in the number and percentage of older adults. This corresponds to a decrease in the number, and proportionate share, of preschool and school age children. Households in Eureka had a lower median income in 2010, compared to the County as a whole. However, once adjusted for inflation, it appears that income growth occurred fairly rapidly, as local households began to close the income gap with their counterparts throughout Humboldt County. One likely explanation for the comparative rise in the median household income is rapid growth in the share of residents with more advanced educational attainment (i.e., a bachelor’s degree or higher).

Population and Household Traits

According to the U.S. Census Bureau, the City of Eureka had 27,025 residents in 1990. The resident population declined to 26,128 residents by the year 2000. This represents a loss of nearly 900 residents, or 3.3 percent. **Table 3-1** indicates that over the next decade (2000 to 2010), the City of Eureka regained much of population lost during the prior period. During this time, the City grew at a rate of 0.4 percent per year, and added more than 1,000 new residents. This growth resulted in a total population of 27,191 in 2010. Although the City gained population, it did so at a rate that was slower than in the remainder of the Planning Area and Humboldt County as a whole. For example, the remainder of the General Plan Planning Area located outside of the City of Eureka added nearly 1,100 residents between 2000 and 2010, at a rate of 0.6 percent per year. Humboldt County added approximately 8,100 new residents, also at a rate of 0.6 percent per year.

TABLE 3-1: POPULATION AND HOUSEHOLD TRENDS, 2000 AND 2010

	2000	2010	Percent Change	Annual Average Percent Change
City of Eureka				
Population	26,128	27,191	4.1%	0.4%
Households	10,957	11,150	1.8%	0.2%
Average Household Size	2.3	2.3		
Household Type				
Family[1]	*54%*	*51%*		
Non-Family	*46%*	*49%*		
Tenure				
Owner	*46%*	*43%*		
Renter	*54%*	*57%*		
Planning Area[2]				
Population	19,115	20,201	5.7%	0.6%
Households	7,559	8,368	10.7%	1.0%
Average Household Size	2.5	2.4		
Household Type				
Family[1]	*66%*	*60%*		
Non-Family	*34%*	*40%*		
Tenure				
Owner	*65%*	*62%*		
Renter	*35%*	*38%*		
Humboldt County				
Population	126,518	134,623	6.4%	0.6%
Households	51,238	56,031	9.4%	0.9%
Average Household Size	2.4	2.3		
Household Type				
Family[1]	*60%*	*55%*		
Non-Family	*40%*	*45%*		
Tenure				
Owner	*58%*	*55%*		
Renter	*42%*	*45%*		

Sources: U.S. Census Bureau, Census 2000 and 2010, 2014; BAE, 2014.

Notes:

1 Family households include those with at least one member who is related to the householder by birth, marriage, or adoption.

2 Figures include those areas located outside the City of Eureka only.

According to the California Department of Finance (DoF), the City of Eureka lost approximately 107 residents between 2010 and 2013. This equals a loss of 0.6 percent, or 0.2 percent per year. Meanwhile, Humboldt County gained roughly 586 new residents, which equals an increase of 0.4 percent, or around 0.1 percent per year during this same period. The majority of the population growth that occurred in Humboldt County between 2010 and 2013 was concentrated in the City of Arcata, which gained an estimated 605 new residents for an increase of 3.5 percent over 2010. During this period, the unincorporated County gained only 197 new residents, which equals an increase of 0.6 percent.

Growth in the number of households in the City did not keep pace with population growth between 2000 and 2010. Over the decade, the City added only 193 new households, for an annual average growth rate of 0.2 percent. While population growth outpaced household growth, the effect on the average size of households was negligible. By comparison, household growth in the remainder of the Planning Area averaged 1.0 percent per year, outpacing population growth by 0.4 percentage points per year. This resulted in a slight decrease in the average household size in the remainder of the Planning Area. Household growth in Humboldt County also outpaced population growth, averaging 0.9 percent per year, which resulted in a slight decline in the average household size.

Household Composition

Household composition in the City of Eureka reflects a smaller percentage of family households, and a higher percentage of renter households, compared to the remainder of the Planning Area and the County as a whole. According to the Census Bureau, the proportion of family households in the City of Eureka decreased from 53.7 percent in 2000, to 51.2 percent in 2010. However, the data suggest that the proportion of family households declined in the Planning Area and County as well. This indicates that while the proportion of family households in the City is lower, it followed the same general trend as the surrounding area.

Table 3-2 provides additional details on the types of households residing within the City of Eureka and Humboldt County. As shown in the table, the City also has a significantly higher percentage of single person households, compared to the County, which increased marginally over the past decade. Concurrent with the declining share of family households, both the City and the County experienced a decline in the proportion of households with children under the age of 18. In the year 2000, 28.6 percent of households in Eureka contained children, compared to 25.9 percent in 2010. Despite these trends, the average household size in both areas remained relatively stable over the period.

The percentage of households by tenure, as reported in Table 3-1, indicates that the City had a lower rate of home ownership, compared to the Planning Area and the County, but that all the areas showed similar declines in the rate of home ownership between 2000 and 2010 of around three percentage points. For example, in the City of Eureka, approximately 46 percent of households owned their own home in 2000. This decreased to 43 percent in 2010. In the remainder of the Planning Area, closer to 65 percent of households were homeowners in 2000, although that percentage declined to 62 percent by 2010. Humboldt County fell in the middle, with 58 percent of households owning homes in 2000, declining to 55 percent in 2010.

TABLE 3-2: HOUSEHOLD COMPOSITION, 2000 AND 2010

	City of Eureka		Humboldt County	
Household Type	2000	2010	2000	2010
Non-Family Households	46.3%	48.8%	40.2%	44.5%
Single Person	*35.3%*	*35.6%*	*28.9%*	*31.8%*
2+ Persons	*11.0%*	*13.1%*	*11.3%*	*12.7%*
Family Households[1]	53.7%	51.2%	59.8%	55.5%
Households with Children	28.6%	25.9%	31.4%	26.5%

Under 18				
Average Household Size	2.3	2.3	2.4	2.3

Sources: U.S. Census Bureau, Census 2000 and 2010, 2014; BAE, 2014.

Note:
1 Family households include those with at least one member that is related to the householder by birth, marriage, or adoption.

Resident Age Distribution

Overall, the City of Eureka and Humboldt County have very similar age characteristics. **Table 3-3** illustrates that the population is generally concentrated among working age adults (ages 20-54), which in 2010 constituted roughly 52.3 percent of the population in the City, and 48.8 percent of the population in the County. School age children (ages 5-19) also make up a relatively large share of the population in both areas. Overall, the greatest population growth between 2000 and 2010 occurred among the group of residents age 55 to 64, which increased by 67 percent, although this was marginally offset by a 9.9 percent decrease in the number of senior citizens aged 65 and over, as shown in **Figure 3.1-1**. In Humboldt County, the number of residents in the 55 to 64 age group grew by 74 percent, while the number of senior citizens age 65 and over grew by 12.4 percent. Although both the City and County also experienced notable growth in the number of young adults (ages 20-29), this growth was somewhat offset by a decline in the number of residents of prime working age (ages 30-54). For example, the number of young adults residing in the City of Eureka increased by 19 percent over the decade. The City simultaneously lost 3.1 percent of its prime working age adults, resulting in a net gain of 491 working age adults. This difference was even more pronounced in Humboldt County, which gained 2,720 young adults (ages 20-29), but lost 2,795 residents of prime working age (ages 30-54), resulting in a small net loss of working age adults.

Household Income Distribution

Similar to most other communities in California, both Eureka and Humboldt County saw an increase in household incomes between 2000 and 2010. As shown in **Table 3-4**, the City saw a decrease in the number of households with incomes of less than $35,000 per year and a corresponding increase in the number of households with incomes greater than $35,000. The largest amount of growth occurred among households with incomes between $75,000 and $149,999. In total, this category added nearly 1,340 households. According to the Census Bureau, the median income (nominal dollars) in the City increased from $25,849 in 2000, to $36,525 in 2010. This represents an increase of roughly $10,680 over the decade, or a 41.3 percent increase over the 2000 figure. Once adjusted for inflation, using the Consumer Price Index (CPI), it appears that the inflation-adjusted median income within the City increased by closer to $2,439, or 7.2 percent, over the decade.

TABLE 3-3: RESIDENT AGE DISTRIBUTION, 2000 AND 2010

	2000		2010	
Age Group	Number	Percent	Number	Percent
City of Eureka				
Preschool (0-4 years)	1,500	5.7%	1,648	6.1%
School (5-19 years)	5,187	19.9%	4,515	16.6%
Young Adult (20-29 years)	4,126	15.8%	4,913	18.1%
Prime Working (30-54 years)	9,589	36.7%	9,293	34.2%
Retirement (55-64 years)	2,159	8.3%	3,607	13.3%
Senior Citizen (65+ years)	3,567	13.7%	3,215	11.8%

TOTAL, ALL AGES	**26,128**	**100%**	**27,191**	**100%**
MEDIAN AGE	**36.6**		**36.2**	
Humboldt County				
Preschool (0-4 years)	7,125	5.6%	7,738	5.7%
School (5-19 years)	26,741	21.1%	24,097	17.9%
Young Adult (20-29 years)	19,901	15.7%	22,621	16.8%
Prime Working (30-54 years)	45,864	36.3%	43,069	32.0%
Retirement (55-64 years)	11,111	8.8%	19,373	14.4%
Senior Citizen (65+ years)	15,776	12.5%	17,725	13.2%
TOTAL, ALL AGES	**126,518**	**100%**	**134,623**	**100%**
MEDIAN AGE	**36.3**		**37.1**	

Sources: U.S. Census Bureau, Census 2000 and 2010, 2014; BAE, 2014.

FIGURE 3.1-1: Resident Age Distribution, City of Eureka, 2000 and 2010

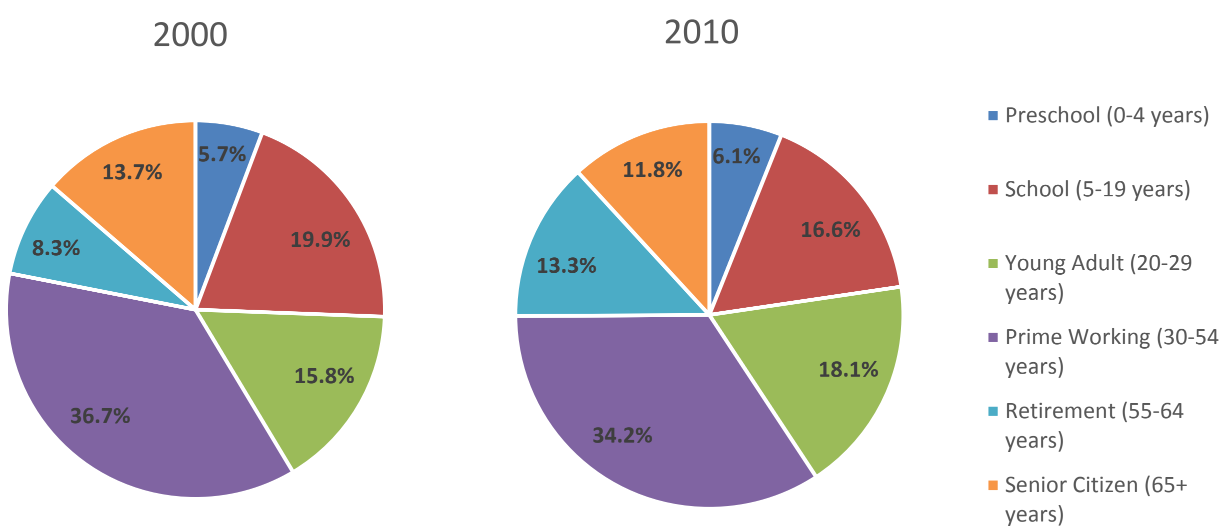


TABLE 3-4: INCOME DISTRIBUTION, 1999 AND 2010

Age Group	1999[1] Number	1999[1] Percent	2010[2] Number	2010[2] Percent
City of Eureka				
Less than $15,000	3,017	27.5%	2,139	19.2%
$15,000 to $24,999	2,315	21.1%	1,916	17.2%
$25,000 to $34,999	1,556	14.2%	1,370	12.3%
$35,000 to $49,999	1,568	14.3%	1,637	14.7%
$50,000 to $74,999	1,596	14.6%	1,749	15.7%
$75,000 to $99,999	428	3.9%	1,192	10.7%
$100,000 to $149,999	307	2.8%	880	7.9%
$150,000 to $199,999	23	0.2%	123	1.1%
$200,000 or more	147	1.3%	145	1.3%
TOTAL, ALL INCOMES	**10,957**	**100%**	**11,150**	**100%**
MEDIAN INCOME	**$25,849**		**$36,525**	
Inflation Adjusted[3]	*$34,086*		*$36,525*	
Humboldt County				
Less than $15,000	12,117	23.6%	9,516	17.0%
$15,000 to $24,999	8,804	17.2%	7,837	14.0%
$25,000 to $34,999	7,300	14.2%	6,829	12.2%
$35,000 to $49,999	8,411	16.4%	8,452	15.1%
$50,000 to $74,999	8,138	15.9%	10,076	18.0%
$75,000 to $99,999	3,485	6.8%	5,989	10.7%
$100,000 to $149,999	1,911	3.7%	4,814	8.6%
$150,000 to $199,999	471	0.9%	1,343	2.4%
$200,000 or more	600	1.2%	1,175	2.1%
TOTAL, ALL INCOMES	**51,238**	**100%**	**56,031**	**100%**
MEDIAN INCOME	**$31,226**		**$40,830**	
Inflation Adjusted[3]	*$41,177*		*$40,830*	

Sources: U.S. Census Bureau, Census 2000 and 2010, 2014; U.S. Census Bureau, 2008-2012 American Community Survey, 2014; BAE, 2014.

Notes:
1 Figures were derived using Census 2000 Summary File 1 totals and the Summary File 3 distribution.
2 Figures were derived using 2010 Census totals and the 2008-2012 ACS distribution.
3 Figures are inflation adjusted to constant 2010 dollars using an inflation factor of 1.32, based on the Consumer Price Index (CPI) for all urban consumers in the San Francisco-Oakland San Jose area.

In Humboldt County, the overall household income trends were similar, although the adjusted median income was different. The County saw a decrease in the number of households with incomes less than $35,000, but an increase in the number of households with incomes at or above that level. The greatest absolute gains occurred among households with incomes between $50,000 and $150,000. In total, the number of households within this income range increased by more than 7,340. According to the Census Bureau, the median income (nominal dollars) in the County increased from $31,266 in 2000, to $40,830 in 2010, which represents an increase of more than $9,600, or 30.8 percent. Once the CPI is applied to the 2000 Census figure, to adjust it to constant 2010 dollars, the comparison shows a decrease in the County in the real (inflation adjusted) median income of around $350, which represents a decline in the median income of 0.8 percent.

Resident Educational Attainment

Compared to the State of California, the residents of both the City of Eureka and Humboldt County exhibit below average educational attainment. For example, an estimated 30.5 percent of California residents possess a bachelor’s degree or higher. In Humboldt County, roughly 26.4 percent of the population has achieved a similar level of education. In the City of Eureka, around 22.5 percent have reached the level of a bachelor’s degree or higher.

Table 3-5 reports the number, and percentage, of residents by their level of educational attainment, in both 2000 and 2010. Overall, the number of residents with less than a high school diploma decreased in both study areas, while the number of residents with some college education or more increased substantially. More specifically, the number of residents in the City with some college education or more increased by more than 2,000 over the decade. The majority of those residents, around 64 percent, had a bachelor’s degree or higher. Humboldt County saw similar trends, with the number of residents with less than a high school diploma dropping by 28 percent. The County simultaneously saw robust growth in the number of residents with some college education or more, with nearly 10,400 new residents. It is notable, however, that growth among college-educated residents occurred more slowly in the County than in the City of Eureka. This is a critical factor in the attractiveness of the City to employers that require a skilled and highly educated workforce. Although the City exhibits strong growth among the college educated, competition may still exist from communities like Arcata, which offer closer proximity to Humboldt State University. That is not to say that proximity to Arcata would preclude Eureka from being attractive to employers for a wide variety of other reasons, especially since Arcata, and Humboldt State, are located relatively close by and College of the Redwoods is located south of Eureka.

TABLE 3-5: EDUCATIONAL ATTAINMENT, POPULATION AGE 25 AND OVER, 2000

	2000[1]		2012[2]	
Age Group	Number	Percent	Age Group	Number
City of Eureka				
Nursery to 8th grade	931	5.4%	541	2.9%
Some high school, no diploma	2,220	12.9%	1,827	9.8%
High school graduate (inc. GED)	4,621	26.8%	4,790	25.7%
Some college, no degree	5,076	29.4%	5,666	30.4%
Associate's degree	1,494	8.7%	1,622	8.7%
Bachelor's degree	1,962	11.4%	2,833	15.2%
Graduate or professional degree	947	5.5%	1,379	7.4%
TOTAL, AGE 25 AND OVER	**17,249**	**100%**	**18,658**	**100%**
Humboldt County				
Nursery to 8th grade	3,285	4.0%	2,366	2.6%
Some high school, no diploma	9,005	11.1%	6,461	7.1%
High school graduate (inc. GED)	20,945	25.7%	23,478	25.8%
Some college, no degree	22,832	28.0%	26,572	29.2%
Associate's degree	6,635	8.1%	8,099	8.9%
Bachelor's degree	12,711	15.6%	15,925	17.5%
Graduate or professional degree	6,031	7.4%	8,008	8.8%
TOTAL, AGE 25 AND OVER	**81,443**	**100%**	**90,910**	**100%**

Sources: U.S. Census Bureau, Census 2000, 2014; U.S. Census Bureau, 2008-2012 American Community Survey, 2014; BAE, 2014.

Notes:
1 Figures were derived using the Census 2000 Summary File 1 totals and the Summary File 3 distribution.
2 Figures were derived using 2010 Census totals and the 2008-2012 ACS distribution.

3.2 HOUSING CHARACTERISTCS

Between 2000 and 2010, new home construction outpaced household growth in both the City of Eureka and Humboldt County. During this time period, the City added 254 new housing units, which represents a 2.2 percent increase over 2000. The County as a whole experienced much more robust growth, adding 5,647 new units, which is equal to an increase of 10.1 percent over 2000. According to Census estimates, the majority of the new housing in the County came in the form of duplex properties, with two attached housing units.

Housing Stock Characteristics

Available data on housing stock characteristics, reported in **Table 3-6**, indicate that the majority of the housing units in Eureka and Humboldt County are single-family detached units. For example, as of 2010, roughly 60.9 percent of housing units in Eureka were single-family detached, while only 3.1 percent were single-family attached, and 22.0 percent were multifamily complexes with two to four units. This suggests that the multifamily housing stock within the City is highly concentrated in smaller apartment complexes. In Eureka, larger apartment complexes with more than 10 units represented only 8.1 percent of the total housing stock. Complexes with more than 50 units represented only 1.9 percent of the housing stock, reflecting a total of only 228 units within the category.

Humboldt County reflects similar characteristics with 67.8 percent of the housing stock characterized as single-family detached. Apartments located in smaller complexes, with two to four units, represented another 11.2 percent of the countywide housing stock. Mobile homes represent a notable component of the countywide housing stock that is largely absent from the City. For example, Humboldt County had more than 5,653 mobile home units in 2010, representing 9.2 percent of the housing stock. The City of Eureka, by comparison, had only 63 mobile home units, representing only 0.5 percent of the citywide housing stock.

TABLE 3-6: HOUSING STOCK CHARACTERISTICS, 2010[1]

	City of Eureka		Humboldt County	
Units in Structure	Number	Percent	Number	Percent
1-Unit Detached	7,240	60.9%	41,706	67.8%
1-Unit Attached	372	3.1%	1,900	3.1%
2-4 Units	2,618	22.0%	6,882	11.2%
5-9 Units	583	4.9%	2,216	3.6%
10-19 Units	456	3.8%	1,296	2.1%
20-49 Units	286	2.4%	834	1.4%
50 or More Units	228	1.9%	912	1.5%
Mobile Home	63	0.5%	5,653	9.2%
Boat, RV, Van, Etc.	45	0.4%	159	0.3%
TOTAL, ALL HOUSING UNITS	**11,891**	**100%**	**61,559**	**100%**

Sources: U.S. Census Bureau, 2008-2012 American Community Survey, 2014; U.S. Census Bureau, Census 2010, 2014; BAE, 2014.

Note:
1 Figures were derived using 2010 Census totals and the 2008-2012 ACS distribution.

Housing Occupancy Status

According to the available Census estimates reported in **Table 3-7**, housing vacancy in the City of Eureka was around 6.2 percent in 2010. This was notably lower than the 9.0 percent vacancy rate reported for the County as a whole. Housing units that were held for rent, but not yet occupied, accounted for the largest share of vacant units, with a similar proportion represented by housing units that were vacant for reasons that did not fall into the other year-round vacancy categories. A significantly smaller share were listed for seasonal use, or were for sale, but were not yet occupied. Overall, Eureka's housing vacancy rate is indicative of fairly strong demand, relative to the available supply of units.

TABLE 3-7: HOUSING OCCUPANCY STATUS, 2010

	City of Eureka		Humboldt County	
Occupancy/Vacancy	Number	Percent	Age Group	Number
Occupied Housing Units	11,150	93.8%	56,031	91.0%
Vacant Housing Units	741	6.2%	5,528	9.0%
For rent	*246*	*2.1%*	*936*	*1.5%*
Rented, not occupied	*34*	*0.3%*	*124*	*0.2%*
For sale only	*97*	*0.8%*	*467*	*0.8%*
Sold, not occupied	*29*	*0.2%*	*139*	*0.2%*
For seasonal use	*102*	*0.9%*	*2,247*	*3.7%*
For migrant workers	*1*	*0.0%*	*15*	*0.0%*
Other vacant	*232*	*2.0%*	*1,600*	*2.6%*
TOTAL, ALL HOUSING UNITS	**11,891**	**100%**	**61,559**	**100%**

Sources: 2014; U.S. Census Bureau, Census 2010, 2014; BAE, 2014.

Housing Prices and Rents

According to data presented in the public review draft Housing Element for the 2014-2019 planning period, the estimated median home value in Eureka increased by roughly 142 percent, between the 2000 Census and the 2008-2012 American Community Survey. Census estimates indicate that the median home value was $113,600 in 2000, which increased to an estimated $274,000 between 2008 and 2012. Despite this increase, the median value in the City of Eureka remained lower than the Humboldt County median home value of $309,400. The majority of the housing stock in the City, around 71.2 percent, is valued between $200,000 and $300,000. Only a little over 20 percent is valued at less than $200,000.

Additional information collected from Dataquick Information Systems, reported in Table 4-20 of the public review draft Housing Element, indicates that the median sale prices for homes sold within the City increased by 17.3 percent between September 2012 and September 2013. According to Dataquick, 41 homes sold during this period. As of September 2012, the median sales price was $194,000. This increased to $227,500 by September 2013. This rate of appreciation remains somewhat below the County average. It is, nonetheless, higher than most of the other incorporated areas, such as Arcata, Fortuna, and Rio Dell. Only McKinleyville showed a higher rate of increase in the median price, equal to 17.93 percent. In terms of absolute value, however, housing within the City of Eureka remains relatively affordable compared to other communities throughout Humboldt County. For example, the median sales price in Eureka was below the County average, and was less than the median home price reported for the communities of Arcata and McKinleyville.

Data from the California Association of Realtors also indicates that the percentage of single-family home sales that were distressed has declined from 29 percent in December of 2012 to 14 percent in December of 2013. As the housing market continues to recover, and home values once again begin to appreciate, Eureka will be in a relatively strong position to promote modest new home construction that is commensurate with projected household growth.

As reported in Table 4-23 of the Housing Element, the median gross rent in Eureka was $802 per month between 2008 and 2012. This was lower than the $869 median rental rate reported for Humboldt County, as well as the median rate for nearby Arcata, which had a median rate of $912. Additional rental listings collected from Craigslist and Padmapper.com in October of 2013 indicate that the asking rental rate for a two-bedroom single-family home was $1,300 per month, while the rate for a two-bedroom apartment was $850 per month. Information on gross rents as a percentage of household income indicate that roughly 63.7 percent of renter households paid greater than 30 percent of their household income for housing. This suggests that there may be some additional unmet demand for lower-cost rental housing that would allow residents to avoid spending more than the recommended portion of their incomes for housing.

Anticipated Housing Need

In order to sufficiently accommodate population and household growth, as well as to ensure the availability of decent and affordable housing for households of all incomes, the State of California enacted Government Code Section 65584, which requires each Council of Governments (COG) to periodically estimate the projected need for housing within each respective region of the state. The State Department of Housing and Community Development (HCD) is then responsible for working with the regional COGs to identify the distribution of the regional housing need amongst the jurisdictions located within each region. For the 2014-2019 Housing Element planning period, the Humboldt County Association of Governments (HCAOG) provided the City of Eureka with a Regional Housing Needs Allocation (RHNA) of 609 units, including 145 units for very low-income households, 96 units for low-income households, 104 units for moderate-income households, and 264 units for above moderate-income households. A 2006 amendment to the state housing element law requires that each jurisdiction also identify the relative housing needs of extremely low-income households. For the purposes of the 2014-2019 RHNA, the City of Eureka’s projected housing need for extremely low-income households is assumed to be half of the very low-income allocation, or approximately 72 housing units. Although the RHNA covers only a portion of the General Plan time horizon, it provides an indicator of the general distribution of housing affordability that would help to meet the needs of all economic segments of the community.

Residential Building Permits

According to the available data on the number of building permits issued by the City, there were 46 permits issued for the construction of single-family dwelling units between 2005 and 2013. Roughly 20 of these permits were issued between 2006 and 2007, prior to the onset of the national housing crisis. Beginning in 2008, the volume of new permits dropped substantially, with only four new permits issued in 2008, five issued in 2009, and three issued in 2010. The volume of new single-family residential construction has remained relatively low through 2012 and 2013, with only five new units permitted each year. The volume of new multifamily housing permits is considerably smaller than for single-family units. Between 2005 and 2010, the City issued only 18 new multifamily permits. Although unit totals are not provided in the data, limited descriptive information indicates that many of these new permits were issued for smaller tri-plex and quad-plex units, with between three and four housing units each. However, there were at least two projects that received building permits for greater than ten units. One of these was permitted in 2003, while the second was permitted in 2010.

3.3 EMPLOYMENT AND THE LOCAL ECONOMY

The City of Eureka is a community that has experienced above average unemployment in recent years. Its residents are most highly concentrated in service-related occupations such as food preparation, sales, and administrative support. The portfolio of jobs that are available in Eureka has changed significantly over the past decade. For example, since the year 2000, the manufacturing industry has contracted by more than 60 percent, shedding roughly 3,100 jobs. Although the City also lost a significant number of jobs in other industries, those contractions occurred more slowly, resulting in a gradual shift away from manufacturing and industrial, toward a more service-based economy.

Resident Employment Status

As in many other parts of the state, Eureka has struggled in recent years with elevated levels of unemployment. As illustrated in **Table 3-8**, in 2008 the labor force was comprised of roughly 11,700 Eureka residents. Of those, 10,800 were employed, leaving 7.7 percent without work. During the same period, an average of 7.2 percent of the labor force was unemployed in both Humboldt County and California. With the onset of the housing crisis and the global economic downturn, the unemployment rates increased throughout the state, reaching the peak in 2010 and 2011. During that two-year period, the unemployment rate averaged 11.4 percent in Humboldt County and 12.4 percent statewide. Unemployment in Eureka peaked in 2010, with a rate of 12.2 percent, representing 1,500 unemployed workers. By 2012, the unemployment rate began to subside, dropping to an annual average of 10.4 percent across California, 10.5 percent in Humboldt County, and 11.1 percent in Eureka.

TABLE 3-8: LABOR FORCE TRENDS, 2008 AND 2012

	2008			2012		
Location	Labor Force	Employed Residents	Unemployment Rate	Labor Force	Employed Residents	Unemployment Rate
City of Arcata	8,700	8,100	6.8%	8,700	7,800	9.8%
City of Blue Lake	600	600	7.2%	600	600	10.5%
City of Eureka	11,700	10,800	7.7%	11,700	10,400	11.1%
City of Ferndale	700	700	1.3%	700	700	2.0%
City of Fortuna	4,600	4,300	6.4%	4,600	4,200	9.3%
Hydesville	600	500	6.4%	600	500	9.2%
McKinleyville	6,500	5,900	8.4%	6,500	5,700	12.1%
Redway	600	600	2.8%	600	600	4.3%
City of Rio Dell	1,400	1,200	12.0%	1,400	1,200	16.9%
City of Trinidad	200	200	4.9%	200	200	7.2%
Willow Creek	700	700	5.1%	700	700	7.3%
Humboldt County	**60,100**	**55,700**	**7.2%**	**60,100**	**53,900**	**10.5%**

Sources: California Employment Development Department, Monthly Labor Force Data for Cities and Census Designated Places (CDP), 2014; BAE, 2014.

Occupations of Residents

Table 3-9 reports the number of employed residents by occupation. The data reflect the employed civilian population 16 years of age or older. The largest concentrations of employment are in the Office and Administrative Support Occupations, and the Sales and Related Occupations. In Eureka, an estimated

12.9 percent of employed residents were employed in Office and Administrative Support Occupations between 2008 and 2012. This was down from 2000, when 15.7 percent of employed residents worked in this same field. Another 12.6 percent of employed residents were employed in the Sales and Related Occupations between 2008 and 2012. This was up slightly from 2000, when 12.3 percent of employed residents worked in this field. Humboldt County shows similar concentrations in these two occupational categories, with 13.8 percent employed in Office and Administrative Support Occupations, and 10.4 percent in Sales and Related Occupations. In addition to these two sectors, the City showed a high concentration of employed residents working in Food Preparation and Serving Related Occupations. Between 2008 and 2012, an estimated 10.7 percent of employed City residents worked in this field, which was up from only 6.7 percent in 2000.

TABLE 3-9: EMPLOYED RESIDENTS BY OCCUPATION, AGE 16 AND OVER, 2000 AND

	City of Eureka		Humboldt County	
	2000[1]	2008-2012[2]	2000[1]	2008-2012[2]
Architecture and Engineering Occupations	101	141	141	749
Arts, Design, Entertainment, Sports and Media Occupations	134	267	267	1,345
Building and Grounds Cleaning and Maintenance Occupations	542	613	613	3,141
Business and Financial Operations	344	418	418	1,948
Community and Social Services Occupations	204	296	296	1,122
Computer and Mathematical Occupations	76	132	132	525
Construction and Extraction Occupations	666	826	826	3,850
Education, Training and Library Occupations	409	690	690	4,166
Farming, Fishing and Forestry Occupations	183	116	116	1,253
Food Preparation and Serving Related Occupations	721	1,304	1,304	4,038
Healthcare Practitioners and Technical Occupations	395	523	523	2,872
Healthcare Support Occupations	505	317	317	1,235
Installation, Maintenance and Repair Occupations	321	296	296	1,849
Legal Occupations	102	108	108	365
Life, Physical and Social Science Occupations	152	93	93	960
Management Occupations	679	807	807	5,504
Office and Administrative Support Occupations	1,684	1,565	1,565	8,216
Production Occupations	655	368	368	1,890
Protective Service Occupations	238	287	287	1,563
Sales and Related Occupations	1,314	1,539	1,539	6,203
Personal Care and Service Occupations	571	813	813	3,421
Transportation and Material Moving Occupations	698	650	650	3,168
TOTAL, ALL OCCUPATIONS	**10,694**	**12,169**	**12,169**	**59,383**

Sources: U.S. Census Bureau, Census 2000, 2014; U.S. Census Bureau, 2008-2012 American Community Survey, 2014; BAE, 2014.

Notes:
1 Figures were derived using Census 2000 Summary File 1 totals and the Summary File 3 distribution.
2 Figures were derived using 2010 Census totals and the 2008-2012 ACS distribution.

Within the City there were four occupational categories that grew by more than 200 employed residents between 2000 and 2008-2012. These include Education, Training, and Library Occupations; Food Preparation and Serving Related Occupations; Sales and Related Occupations; and Personal Care and Service Occupations.

The category with the greatest increase in the number of employed residents included the Food Preparation and Serving Related Occupations. This particular occupational category employed roughly 580 more residents between 2008 and 2012, than in the year 2000. The occupational categories that saw the largest decreases include Production Occupations, Healthcare Support Occupations, and Office and Administrative Support Occupations. In the County, the occupational categories with the greatest decreases in employment include the Production Occupations, which contracted by more than 1,580 employed residents over the period.

Major Employers

According to data provided by the Employment Development Department (EDD), six of the ten largest employers in the City of Eureka are government agencies. As reported in **Table 3-10**, these include the City and five County agencies. The County agencies include the Office of Education, the Department of Health, the Sheriff's Department, the Social Services Department, and the Public Health Administration. Other major employers include the Pacific Gas and Electric Company, the St. Joseph Health System and Hospital, and Umpqua Bank.

TABLE 3-10: TOP EMPLOYERS IN HUMBOLDT COUNTY, 2014

Employer Name	Location	Industry
City of Eureka	Eureka	City Government-Executive Offices
Humboldt County Office-Education	Eureka	Schools
Humboldt County Dept. of Health	Eureka	Clinics
Humboldt County Sheriff Dept.	Eureka	Sheriff
Humboldt County Social Services	Eureka	County Government-Social/Human Resources
Pacific Gas & Electric Co.	Eureka	Electric Companies
Public Health Admin	Eureka	County Government-Public Health Programs
St. Joseph Health	Eureka	Hospitals
St. Joseph Hospital	Eureka	Hospitals
Umpqua Bank	Eureka	Banks

Sources: California Employment Development Department, 2014; BAE, 2014.

Jobs by Industry

The EDD reports jobs by industry at the county level only. The data suggest that the number of jobs provided within the County fluctuates substantially from year to year. For example, between 2000 and 2005, the County lost around 800 jobs. By 2006, roughly three fourths of those jobs were recovered. Unfortunately, since that time, the County has lost additional jobs. **Table 3-11** reports the number of jobs, by industry, in Humboldt County in 2008 and 2012. During this period, the County lost approximately 3,200 jobs, which is equal to seven percent of the 2008 jobs total. As of 2012, jobs in the County were most heavily concentrated in Retail Trade, Education and Health Services, Leisure and Hospitality, and Government. Between 2008 and 2012, the Retail Trade sector contracted by approximately five percent, representing the loss of around 400 jobs. The Government sector also contracted by around four percent, which represented about 500 jobs. The Leisure and Hospitality sector remained unchanged, while the Educational and Health Services sector expanded by around eight percent, adding roughly 500 jobs.

TABLE 3-11: EMPLOYMENT TRENDS BY MAJOR INDUSTRY, HUMBOLDT COUNTY,

	2008		2012		Percent
Industry Sector	Number	Percent	Number	Percent	Change
Agriculture	1,200	2.4%	900	2.0%	-25.0%
Mining & Logging	500	1.0%	400	0.9%	-20.0%
Construction	2,300	4.7%	1,700	3.7%	-26.1%
Manufacturing	2,800	5.7%	2,000	4.4%	-28.6%
Wholesale Trade	1,000	2.0%	1,000	2.2%	0.0%
Retail Trade	7,300	14.9%	6,900	15.1%	-5.5%
Transportation, Warehousing, & Utilities	1,300	2.7%	1,300	2.8%	0.0%
Information	700	1.4%	500	1.1%	-28.6%
Financial Activities	1,800	3.7%	1,600	3.5%	-11.1%
Professional and Business Services	3,200	6.5%	2,700	5.9%	-15.6%
Educational & Health Services	5,900	12.0%	6,400	14.0%	8.5%
Leisure & Hospitality	5,200	10.6%	5,200	11.4%	0.0%
Other Services	1,900	3.9%	1,800	3.9%	-5.3%
Government	14,000	28.6%	13,500	29.5%	-3.6%
TOTAL, ALL INDUSTRIES[1]	**49,000**	**100%**	**45,800**	**100%**	**-6.5%**

Sources: California Employment Development Department, 2014; BAE, 2014.

Note:
1 Figures may not sum to totals due to rounding.

Of the industry sectors that represent smaller proportions of countywide employment base, only two remained relatively unchanged between 2008 and 2012. These include Wholesale Trade and Transportation, Warehousing, and Utilities. The remaining smaller industry sectors experienced substantial contractions, shedding a combined total of around 2,800 jobs between 2008 and 2012. The two industry sectors that lost the greatest percentage of their 2008 employment levels were Manufacturing and Information. These two sectors contracted by roughly 29 percent over the five year period. The Manufacturing sector shed approximately 800 jobs, while the information sector shed around 200 jobs. The Agriculture, Mining and Logging, and Construction sectors also contracted by upwards of 20 percent from their 2008 employment levels.

Industry Economic Trends

The remainder of this section focuses on a number of subsectors of the Eureka economy that will play an important role in defining future economic activity and land use demand within the City. These include an assortment of industrial uses, which have historically served as the City's primary economic base, and which have factored prominently in the City's land use patterns. This section also discusses recent trends in the tourism and the retail trade sectors, which are helping to offset declines in the more traditional base industries, like timber and fishing. Lastly, the section discusses a grouping of industry categories that characterize the primary users of office real estate, recognizing that the City acts as a hub for government offices, healthcare, and professional services, serving both Humboldt County and the larger North Coast region.

Industrial Development

In Eureka, industrial land use takes the form of a range of development types; however, given the North Coast location, industrial uses most closely associated with the community include those related to the timber industry, and to fishing and other maritime activities. Indeed, these export-oriented uses have historically served as the region's economic base and, although diminished, remain important today. These "basic industries", along with manufacturing and agriculture, generate regional income through export of the goods they produce. The income these industries generate flows to local business owners, property owners, and employees, whose spending in the local economy helps support other businesses, employees, and so forth. As a result of these types of multiplier effects, industrial development can be an important component of the local economy, in addition to playing a large role in the community's identity. For these reasons, it is important for the Eureka General Plan Update process to acknowledge the historic role of industrial activities as part of the local economy as well as the outlook for industrial activity moving forward.

INDUSTRIAL EMPLOYMENT TRENDS

On a countywide basis, the general trend since 1990 has been a decline in industrial employment. As shown on **Table 3-12**, and **Figure 3.3-1**, according to the EDD, in 1990, employment in industrial sectors represented 24 percent of countywide employment, declining through the 1990s and 2000s, to approximately 14 percent of the total by 2010. From 1990 to 2012, this represents a decline of 4,400 industrial jobs, or a 41 percent reduction from 1990 job levels. Most of this shift occurred as a result of declines in durable goods manufacturing and, to a lesser extent, non-durable goods manufacturing. For example, durable goods manufacturing includes forest product processing and non-durable goods manufacturing includes seafood processing, among other products. Although the available data are not sufficiently detailed to determine the exact role changes in the forest products and seafood processing sectors played in the shift, additional data presented below will suggest that it is likely that changes in these sectors had an impact. With the exception of construction, which showed significant fluctuations in line with the general state and national economic trends, employment in the other industrial sectors did not vary by more than a few hundred jobs over the 22-year period. The loss of 300 jobs in the Mining and Logging sector is nevertheless a significant portion of that sector's total.

TIMBER INDUSTRY

The surrounding landscape, logging trucks on the roadways, log decks and lumber mills, and shipping activity in the port all reinforce the prominence of the timber industry within Humboldt County. Humboldt County timber makes a significant contribution to statewide timber harvests, according to data compiled by the State Board of Equalization, shown in **Table 3-13**. In 1994, Humboldt County produced almost 490,000 million board feet (MBF) of timber, but this has steadily declined and, by 2012, Humboldt County timber production was 221,617 MBF. However, even this 18-year period does not fully represent the dramatic change in the County's timber industry. According to a 1979 publication from the California Department of Forestry, timber production in Humboldt County was 903,527 MBF in 1977.[1] Humboldt County's declining timber harvests are not primarily a result of reduced competitiveness on a statewide basis. As shown in **Figure 3.3-2**, the timber production trend in Humboldt County has mirrored statewide trends. However, even at its present timber harvest levels, Humboldt is still California's leading timber harvesting county, although the County's share of the state total has declined from about 21 percent in 1994 to about 16 percent in 2012.

[1] California Department of Forestry, *State Forest Notes, No. 74*. 1979.

TABLE 3-12: INDUSTRIAL EMPLOYMENT TRENDS, HUMBOLDT COUNTY, 1990 TO

Industry Sector	1990	1995	2000	2005	2010	2011	2012
Total Farm	900	900	1,100	1,200	800	900	900
Mining and Logging	700	600	500	400	400	400	400
Construction	2,100	1,700	1,700	2,400	1,700	1,800	1,700
Durable Goods Mfg.	4,100	4,100	3,700	2,600	1,300	1,200	1,100
Nondurable Goods Mfg.	1,500	1,500	1,400	1,100	900	900	900
Wholesale Trade	1,200	1,000	1,000	1,100	1,000	1,000	1,000
Transport., Whse., & Util.	1,200	1,100	1,100	1,400	1,200	1,200	1,300
SUB-TOTAL INDUSTRIAL SECTORS	**10,800**	**10,000**	**9,400**	**9,000**	**6,500**	**6,500**	**6,400**
Industrial as Percent of Total	*24%*	*21%*	*19%*	*18%*	*14%*	*14%*	*14%*
SUB-TOTAL ALL OTHER INDUSTRIES	**33,200**	**36,300**	**39,800**	**39,300**	**39,200**	**38,300**	**38,500**
TOTAL, ALL INDUSTRIES[1]	**44,900**	**47,200**	**50,300**	**49,500**	**46,500**	**45,700**	**45,800**

Sources: California Employment Development Department, 2014; BAE, 2014.

Note:
1 Figures may not sum to totals due to rounding.

FIGURE 3.3-1: Industrial Employment Trends, Humboldt County, 1990 to 2012

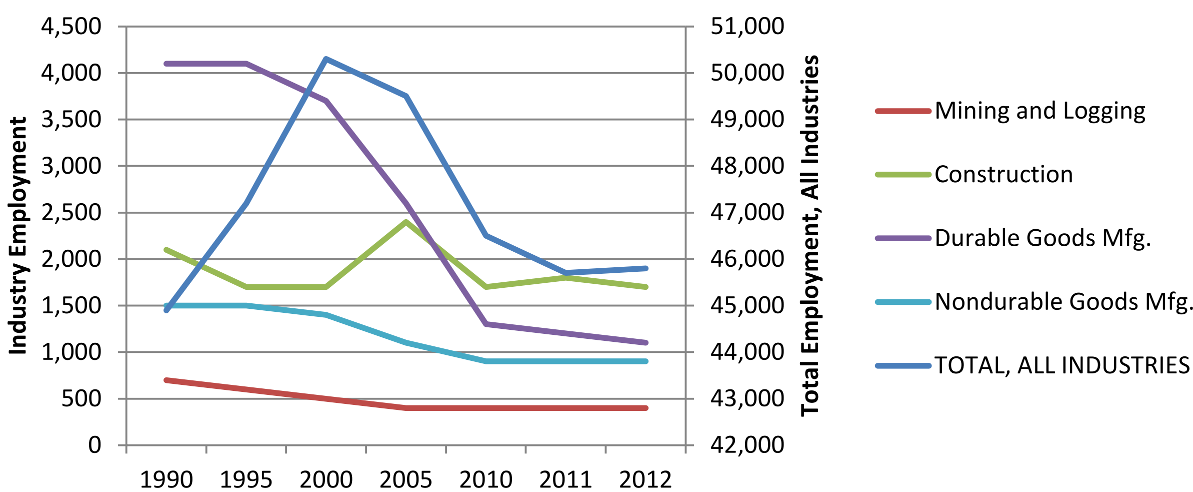
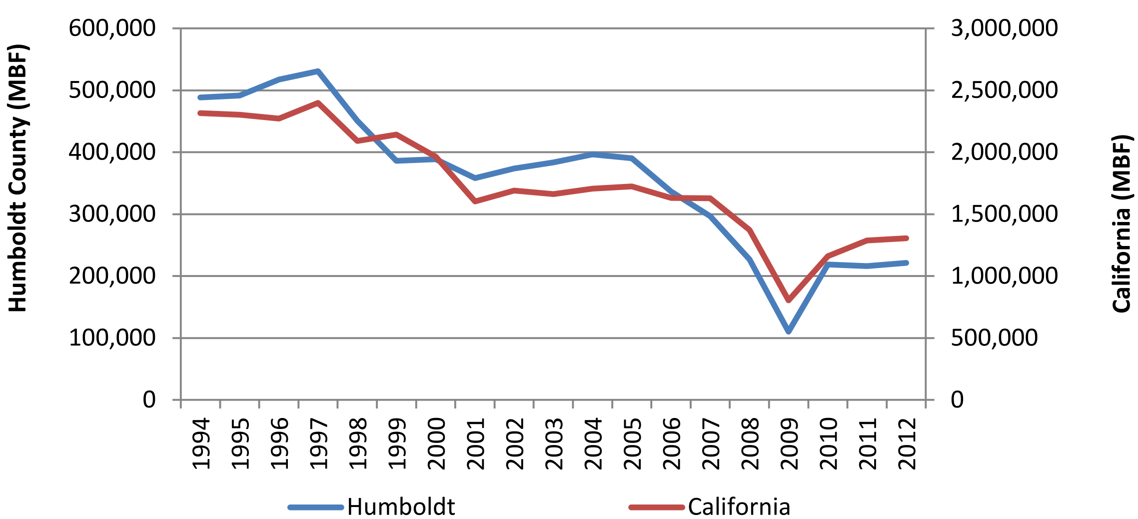


TABLE 3-13: HUMBOLDT COUNTY AND CALIFORNIA TIMBER HARVESTS,

Year	Humboldt (Million Board Feet)	California (Million Board Feet)
1994	488,742	2,316,328
1995	491,765	2,304,253
1996	517,524	2,272,928
1997	531,151	2,399,672
1998	450,629	2,090,715
1999	386,496	2,144,151
2000	388,886	1,965,657
2001	358,225	1,603,378
2002	374,041	1,690,199
2003	383,675	1,663,014
2004	396,500	1,705,900
2005	390,333	1,725,024
2006	336,743	1,631,200
2007	296,840	1,628,118
2008	227,339	1,372,024
2009	110,197	804,940
2010	218,651	1,160,588
2011	216,272	1,288,325
2012	221,617	1,307,337

Sources: CA State Board of Equalization, 2014; BAE, 2014.

FIGURE 3.3-2: Humboldt County and California Timber Harvests, 1994 to 2012



COASTAL DEPENDENT INDUSTRIAL ACTIVITY

Humboldt Bay is a natural hub for coastal dependent industrial activity. In addition to serving as a shipping port for timber products, the Port of Humboldt Bay is also a natural location to serve as a center for commercial fishing activity, including serving as a home port for fishing vessels and a location for seafood processing and distribution facilities. Parts of Humboldt Bay itself host aquaculture operations for oyster production, and the Port of Humboldt Bay also handles petroleum products and general cargo shipments as well as the occasional cruise ship. Given this range of activity, Eureka hosts an array of on-shore facilities related to this trade activity, including boat launches, marinas, and docks; boat and equipment storage yards; repair facilities; and processing and storage facilities. Additional facilities are spread throughout Humboldt Bay, including locations outside the City, such as the Samoa Peninsula and Fields Landing.

In recognition of the important relationship between the viability of maritime industries and the provision of appropriate facilities on land to support these industries, the California Coastal Act requires that local jurisdictions like Eureka, which include land within the Coastal Zone, prepare a Local Coastal Program, which prioritizes the use of land within the Coastal Zone for coastal dependent industrial and agricultural uses, with secondary consideration given to other coastal dependent uses, such as recreation and visitor-serving uses. In preparing its General Plan Update, it will be important for the City of Eureka to understand the long-term demand for coastal dependent industrial uses, so that the Land Use Element can provide sufficient land in suitable locations to accommodate demand for these uses.

For the City of Eureka, there are several primary indicators of demand for coastal dependent industrial land. First, activity in the two local sectors that are most closely tied to port usage - fishing and timber - will be an important indicator. Overall maritime shipping activity, which serves as an indicator of the use of port facilities as cargo handling hubs, can provide an indicator of potential demand for port facilities. In addition, growth in regional population can serve as an indicator of demand for goods that could be shipped into the area via the port facilities or for goods that could be produced by local industry and shipped out of the region via the port. This in turn could provide an indicator of potential increases in demand for port facilities over the long term. A long-term pattern of decline in the timber industry, which leaves Humboldt County at about one fourth of its production from 1977, has already been discussed. Following are discussions of trends in indicators for commercial fishing activity and for general port cargo activity over time.

EUREKA AREA COMMERCIAL FISHING ACTIVITY

Commercial fishing activity in the Eureka area (primarily based out of Eureka and Fields Landing) has a history of fluctuation. According to the Eureka Fishing Community profile (Caroline Pomeroy, 2011), which summarized historic data for the 1947 to 2007 period, total pounds of fish landed was close to 20 million in 1947, peaked between 35 and 40 million at the end of the 1950s, declined to between 15 and 20 million pounds by the mid-1960s, peaked in the early 1980s at near 40 million pounds, and then exhibited a mostly declining trend through the mid-2000s. Table 3-14 summarizes commercial fishing activity from 2000 to 2012, based on data from the California Department of Fish and Game, indicating a slightly declining trend, dropping from 30 million pounds landed in 2000, to about 27 million pounds in 2012. This was punctuated by peak years of over 38 million pounds in 2004 and 2006, while the lowest year during that time period was 2011, with about 17.5 million pounds landed.

The lower part of **Table 3-14** and **Figure 3.3-3** provide detail on the type of fish landed and indicates that in addition to fluctuations in the volume of fish landed from year to year, there has also been significant change in the type of fish landed, within the relatively short 2000 to 2012 time period. The data show that Dungeness crab and shrimp have become much more important parts of the local catch, while Pacific Whiting has almost completely disappeared during this period. These fluctuations can be due to environmental factors, regulatory factors, and/or competitive/market factors.

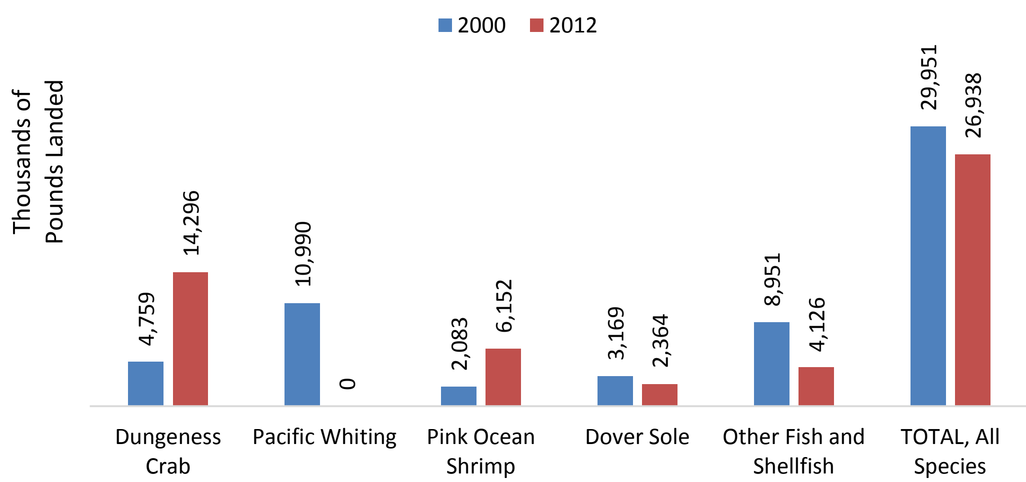
TABLE 3-14: EUREKA AREA COMMERCIAL FISH LANDINGS, 2000 TO 2012

Year	Pounds Landed (All Species)
2000	29,951,195
2001	20,973,936
2002	23,070,019
2003	30,594,947
2004	38,155,691
2005	20,712,110
2006	38,411,169
2007	25,730,940
2008	28,376,608
2009	29,430,330
2010	24,395,401
2011	17,530,089
2012	26,938,169

Species	2000	2012
Dungeness Crab	4,758,757	14,295,619
Pacific Whiting	10,989,758	216
Pink Ocean Shrimp	2,083,385	6,152,197
Dover Sole	3,168,694	2,364,261
Other Fish and Shellfish	8,950,601	4,125,876
TOTAL, ALL SPECIES	**29,951,195**	**26,938,169**

Sources: CA Department of Fish and game, 2014; BAE, 2014.

FIGURE 3.3-3: Eureka Area Commercial Fish Landings, 2000 to 2012



PORT OF HUMBOLDT BAY CARGO ACTIVITY

In addition to handling timber and commercial fishing activities, the Port of Humboldt Bay handles a range of general cargos that move into and out of the north coast region via ship. **Table 3-15** summarizes Port of Humboldt Bay cargo activity (assessable cargo loaded and unloaded) from 1995 through 2013. The table also tracks cargo activity for all Northern California ports combined, for the same time period.

TABLE 3-15: TONS OF ASSESSABLE CARGO LOADED AND UNLOADED, EUREKA AND NORTHERN CALIFORNIA 1995 TO 2013

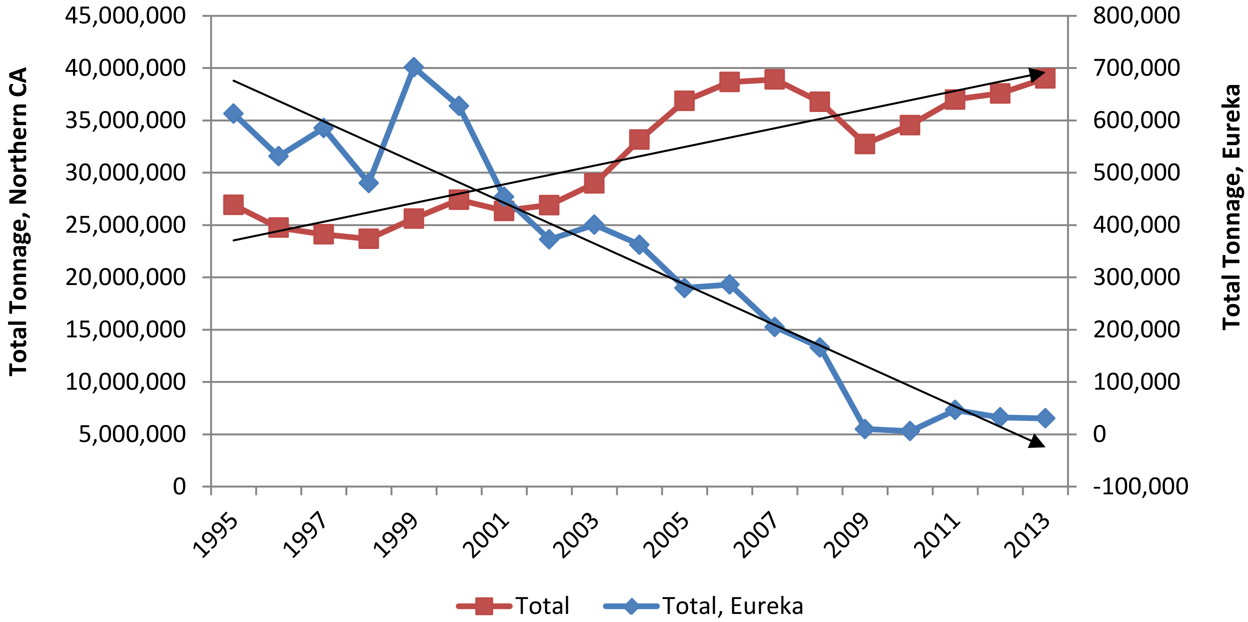
		Tonnage - Eureka				
Year	Containers	General	Lumber/Logs	Bulk	Total, Eureka	Total, No. CA[1]
1995		194,246	69,291	349,413	612,950	26,927,542
1996		214,351	33,752	283,228	531,331	24,744,949
1997		203,063	21,589	360,466	585,118	24,106,034
1998		156,031	35,882	288,481	480,394	23,683,193
1999	3,927	223,588	114,747	358,994	701,256	25,616,222
2000		173,541	175,046	278,850	627,437	27,410,647
2001		174,869	128,553	150,347	453,769	26,349,912
2002		184,777	124,913	62,596	372,286	26,903,111
2003		217,789	174,298	8,446	400,533	28,963,471
2004		204,037	158,229		362,266	33,158,796
2005		103,837	134,849	41,109	279,795	36,862,655
2006		156,137	88,877	41,096	286,110	38,665,635
2007		145,641	52,184	7,400	205,225	38,913,487
2008		143,746	22,122		165,868	36,772,921
2009	17	5,146	4,923		10,086	32,746,197
2010		340	5,783		6,123	34,556,584
2011			46,535		46,535	37,002,997
2012			32,502		32,502	37,573,535
2013			30,597		30,597	39,009,938

Sources: Pacific Maritime Association, BAE, 2014.

Note:
1 Northern California Area ports include: Benicia, Crockett, Eureka, Oakland, Port Chicago, Redwood City, Richmond, San Francisco, Stockton, and West Sacramento.

The data show a significant decline in overall Eureka area cargo activity, such that by 2013, total cargo volume was about five percent of the 1995 volume, with lumber/logs as the only remaining cargo type since 2011. 2010 was the last year in which the port handled general cargo, 2009 was the last year that the port handled containers, and 2007 was the last year that the port handled bulk cargo. Meanwhile, ship cargo activity has increased substantially at Northern California ports as a group, increasing about 50 percent in assessable tonnage since 1995. **Figure 3.3-4** shows the countervailing trends in Eureka versus Northern California ports as a group.

FIGURE 3.3-4: Tons of Assessable Cargo Loaded and Unloaded, Eureka and Northern California 1995 to 2013



It is likely that a primary reason for the disparity between the performance of the Port of Humboldt Bay and the Northern California ports as a group is that much of the growth in West Coast maritime shipping activity is due to increased trade with Pacific Rim countries, particularly imports of goods to the U.S. Meanwhile, the Port of Humboldt Bay has primarily been an export-oriented port, with a focus on forest products. Due to environmental regulations and other factors, exports of forest products from Humboldt Bay have declined. Due to the relatively small size of the local market area, combined with limited transportation access from Eureka to other markets elsewhere on the West Coast and beyond, it is difficult for Humboldt Bay to compete with other locations as a port of entry for imports. As a result, Humboldt Bay has not participated in the general increase in trade and port activity that has increased port activity elsewhere on the West Coast. As discussed later in this chapter, long-term population growth within Eureka and elsewhere in Humboldt County is expected to be modest, meaning that there will be limited increases in local demand for products shipped via the port.

Agriculture

The City of Eureka itself does not contain significant agricultural production; however, in addition to timber production, Humboldt County has substantial production of other agricultural commodities. Agriculture is often considered a basic industry, because a large portion agricultural production is typically exported out of the immediate area. As a regional hub, Eureka has the opportunity to capture economic activity related to processing, marketing, and distribution of agricultural and food products.

Increasing consumer interest and awareness of benefits of consumption of locally produced food products creates opportunities for local economic development, as do agricultural products produced for export. To the extent that businesses operating in Eureka participate in this food system “value chain”, it creates the opportunity for the local economy to leverage the economic activity associated with agricultural projection, capturing more income generated from the process of adding value to the raw commodities within the local economy. A number of well-known local businesses provide examples of this type of activity, including the

Lost Coast Brewery, and Bien Padre snack foods. As mentioned previously, processing and shipping of seafood produced by local aquaculture operations is another form of local value-added activity.

Table 3-16 summarizes data from the Humboldt County Department of Agriculture's annual crop reports, from 1993 to 2012. The data indicate that the value of the County's reported crops has increased 144 percent since the beginning of the time period. As in 1993, the most valuable non-timber crops reported in the Agriculture Department's reports are Nursery Stock, Livestock/Poultry, and Livestock/Poultry Products. Combined, these product types represent 94 percent of the reported crop values. The crop growing in value most rapidly over the period was fruit and nut crops, and the crop with the biggest dollar gain over the period was livestock and poultry. **Figure 3.3-5** shows the trend in the value of non-timber crop production over time.

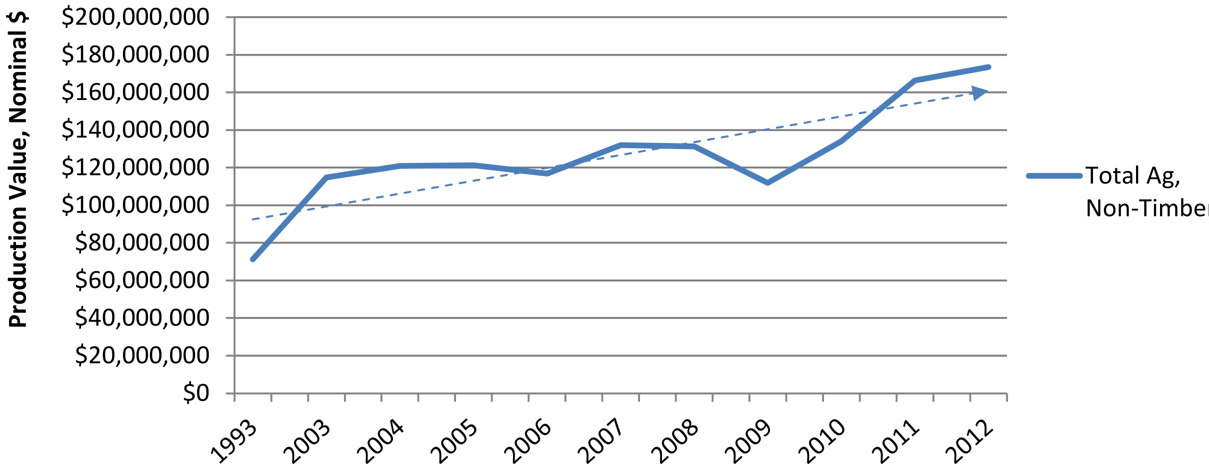
TABLE 3-16: HUMBOLDT COUNTY AGRICULTURAL PRODUCTION, INCLUDING

Crop Type	1993	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Field Crops/Hay & Pasture	$7.4	$9.3	$9.3	$9.5	$10.8	$10.0	$10.5	$13.4	$3.7	$6.8	$7.0
Vegetable Crops	$1.1	$0.9	$0.9	$0.9	$0.9	$1.2	$1.2	$1.2	$3.7	$1.4	$1.2
Fruit/Nut Crops	$0.1	$0.7	$0.7	$0.8	$0.8	$1.6	$1.5	$1.6	$1.2	$1.8	$1.8
Nursery Stock	$20.3	$35.9	$40.8	$43.5	$49.1	$47.3	$49.4	$40.2	$44.9	$43.4	$46.4
Livestock/Poultry	$15.3	$24.9	$23.5	$24.0	$24.2	$24.8	$23.9	$18.5	$45.0	$54.7	$58.4
Livestock/Poultry Products[1]	$27.1	$43.2	$45.7	$42.5	$31.0	$47.0	$44.7	$36.9	$35.6	$58.2	$58.7
TOTAL AG, NON-TIMBER	$71.2	$114.8	$120.8	$121.2	$116.8	$132.0	$131.2	$111.8	$134.1	$166.3	$173.5
TIMBER	$268.0	$148.0	$174.5	$199.0	$178.0	$151.5	$107.9	$28.7	$68.0	$65.8	$62.6
TOTAL AG AND TIMBER	$339.3	$262.8	$295.3	$320.2	$294.8	$283.6	$239.2	$140.6	$202.1	$232.1	$236.1

Sources: Humboldt County Department of Agriculture, 2014; BAE, 2014.

Note:
1 Starting in 2011, this category also includes aquaculture.

FIGURE 3.3-5: Humboldt County Agricultural Production, 1993 to 2012



A discussion of Humboldt County agriculture requires acknowledgement that the marijuana industry is a significant economic driver. At the same time, because of the illicit nature of much of the economic activity surrounding marijuana, it is difficult to precisely quantify the economic impact of the crop within the local economy.

One attempt to quantify the impact of the marijuana industry in Humboldt County was a thesis prepared by Jennifer Budwig, a local banker, for her graduate program at the Pacific Coast Banking School, of the University of Washington. As reported in a 2011 article by Thadeus Greenson in the Times-Standard (Greenson, 2011), Budwig estimated that the total value of marijuana cultivated in the County was worth a minimum of $1 billion in 2010. At this level, the value of marijuana production would be over five times the value of all non-timber crops reported by the County Agriculture Department. Of the billion dollar figure, the article reported that Budwig estimated that the income from growers supports about $415 million of the County's taxable retail sales. The article noted that this was equal to about one-fourth the size of the County's whole economy. It is worth noting that in addition to retail sales, many other local industries, such as business and personal services, utilities, and real estate also benefit from the money circulated in the local economy by the marijuana industry.

Given the magnitude of the marijuana industry in Humboldt County, relative to the total size of the County's economy, the trend towards relaxed laws pertaining to production and use of marijuana in the U.S. is an important issue for local economic development. Impacts of legalization could include increased competition from other areas that are closer to major population concentrations that create demand for the product, and reductions in wholesale prices. On the other hand, with legalization, the overall market for marijuana might grow, which may give Humboldt County the opportunity to more fully capitalize on its historic image as a high quality producer, within an expanding market. Relaxed regulation could also result in increased revenue to government agencies, since marijuana products are not currently subject to taxation.

The Retail Trade Sector

The City of Eureka is a hub for retail commerce in Humboldt County, and on the North Coast. As such, the City captures a large portion of the countywide retail sales, especially in certain retail sales categories. Data published by the State Board of Equalization (SBoE), and illustrated in **Figure 3.3-6**, indicate that the City captured more than 45 percent of the countywide taxable sales in 2011. Broken down by the type of retail, the City shows a clear competitive advantage in the more destination oriented retail categories. For example, the City captured nearly 89 percent of all countywide taxable sales in the General Merchandise Stores category, 73 percent in the Clothing and Clothing Accessories Stores category, 69 percent in the Motor Vehicle and

Parts Dealers category, and 59 percent in the Home Furnishings and Appliance Stores category. The City captured a significantly lower share of the more convenience oriented retail sales categories. For example, the City captured around 30 percent of countywide sales in the Gasoline Stations category, and 30 percent in the Food and Beverage Stores category.

Table 3-17 illustrates the results of a retail leakage analysis conducted for Humboldt County. Estimates for 2014 are derived based on estimates of existing consumer demand and retail sales published by Claritas, Inc., a private data vendor. The results indicate that the County currently loses out on approximately $294.8 million per year in local consumer spending, in individual retail categories where sales in local establishments are less than the anticipated expenditures of local residents. These dollars are essentially spent by Humboldt County households on goods and services purchased outside of the County. Despite this evidence of substantial economic leakage in specific categories, the County shows a net overall retail sales “injection” of nearly $801.5 million, due to the fact that in some other categories, local retail establishments capture sales that are greater than the anticipated expenditures of local residents. This suggests that the County also captures a substantial volume of retail expenditures from households that live outside of Humboldt County, but which purchase goods and services within the County. However, the Claritas retail demand model may not be fully compensating for unreported household income from the marijuana trade, which may cause the analysis to underestimating local retail purchasing power.

TABLE 3-17: TAXABLE SALES, CITY OF EUREKA AND HUMBOLDT COUNTY, 2011

	City of Eureka			Humboldt County			Share of County Total
	Thousands	%	Per Capita	Thousands	%	Per Capita	
Motor Vehicles	$117,779	15%	$4,357	$170,895	10%	$1,270	69%
Furnishings and Appliance Stores	$26,183	3%	$969	$44,617	3%	$332	59%
Building Material and Garden Equipment	$54,939	7%	$2,032	$177,004	10%	$1,315	31%
Food Stores	$36,688	5%	$1,357	$120,568	7%	$896	30%
Gasoline Stations	$52,388	7%	$1,938	$176,188	10%	$1,309	30%
Clothing Stores	$33,832	4%	$1,251	$46,445	3%	$345	73%
General Merchandise	$167,073	22%	$6,180	$188,516	11%	$1,401	89%
Food Service and Drinking Places	$62,369	8%	$2,307	$141,211	8%	$1,049	44%
Other Retail Group	$76,929	10%	$2,846	$159,082	9%	$1,182	48%
ALL RETAIL AND FOOD	**$628,178**	**82%**	**$23,237**	**$1,224,525**	**72%**	**$9,099**	**51%**
ALL OTHER OUTLETS	**$140,700**	**18%**	**$5,205**	**$473,653**	**28%**	**$3,519**	**30%**
TOTAL, ALL OUTLETS	**$768,878**	**100%**	**$28,441**	**$1,698,178**	**100%**	**$12,618**	**45%**

Sources: California Board of Equalization, 2014; California Department of Finance, 2014; BAE, 2014.

FIGURE 3.3-6: Taxable Sales, City of Eureka and Humboldt County, 2011

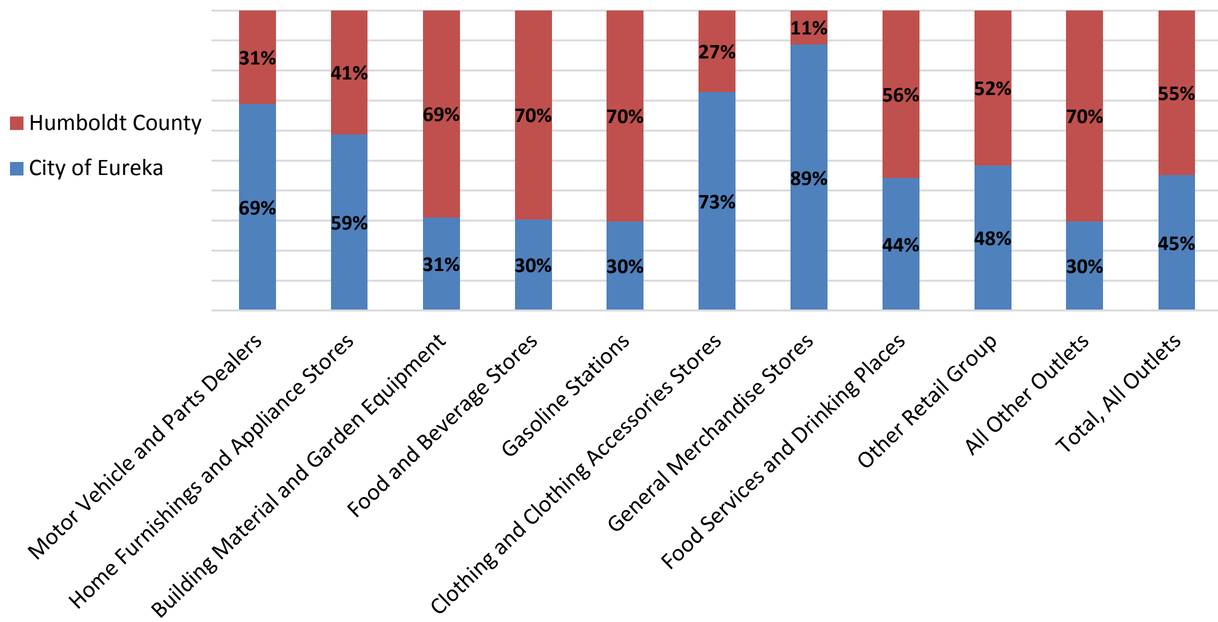


Table 3-18 illustrates how the retail leakage estimates can be converted into estimates of the additional retail development that could theoretically be supported through the capture of existing leakage. The estimates reported in the table represent a 'best case' scenario, in which the County is able to capture all of the existing leakage. The estimates represent the maximum amount of development that could be supported based solely on local consumer demand. This level of retail capture is unlikely to be achieved due to a variety of factors. These include factors such as the portion of expenditures that "leaks" out of the local area to online retailers, and the fact that the local trade population may simply not be large enough to support retailers dealing in certain specialty items, such as luxury goods. However, even under this maximum capture scenario, existing retail leakage may only translate to approximately 367,000 square feet of additional retail space, if fully captured. To put this into perspective, the average floor area of a community shopping center in the western United States is approximately 233,000 square feet. Based on the share of countywide taxable sales, the maximum amount of additional retail sales that could be captured within the City of Eureka would equal an estimated $50.5 million. If realized, this would translate into a maximum of about 175,000 square feet of additional supportable retail space.

TABLE 3-18: ADDITIONAL SUPPORTABLE SQUARE FEET, HUMBOLDT COUNTY,

Retail Category	Retail Sales (Leakage)/Injection	Estimated Sales Per Square Foot[1]	Additional Supportable Square Feet	Total Supportable Square Feet[2]
Motor Vehicle and Parts Dealers	($74,792,705)	n.a.	n.a.	n.a.
Furniture and Home Furnishings Stores	$687,339	$230	n.a.	n.a.
Electronics and Appliance Stores	($6,107,496)	$332	18,374	20,212
Building Material, Garden Equip Stores	$481,837,593	$427	n.a.	n.a.
Food and Beverage Stores	$492,407,819	$453	n.a.	n.a.
Health and Personal Care Stores	$42,688,502	$472	n.a.	n.a.

Gasoline Stations	$22,293,854	n.a.	n.a.	n.a.
Clothing and Clothing Accessories Stores	($5,297,359)	$256	20,699	22,769
Sporting Goods, Hobby, Book, Music Stores	($9,203,929)	$242	38,062	41,868
General Merchandise Stores	$56,408,726	$164	n.a.	n.a.
Miscellaneous Store Retailers	($6,996,281)	$272	25,697	28,267
Non-Store Retailers	($112,712,253)	n.a.	n.a.	n.a.
Foodservice and Drinking Places	($79,715,614)	$346	230,723	253,796
Total for all Categories with Leakage	**($294,825,637)**		**333,556**	**366,911**
Estimated Surplus[3]	**$801,498,196**			

Sources: Claritas, Inc., 2014; Urban Land Institute, Dollars and Cents of Shopping Centers/The SCORE 2008, 2014; BAE, 2014.

Note:
1 Sales per square foot estimates are based on the Urban Land Institute's Dollars and Cents of Shopping Centers. The estimates were adjusted using the Consumer Price Index for All Urban Consumers and are based on Gross Leasable Area.
2 Total supportable square feet estimates include a ten percent vacancy allowance.
3 An estimated surplus of taxable sales exists when actual sales are greater than expected, based on estimated household incomes and spending patterns.

An additional consideration is the role of the illicit economy, as it pertains to retail spending. As mentioned previously, according to research conducted by Jennifer Budwig, the illegal cultivation and sale of marijuana results in the injection of approximately $415 million (2010 dollars) into the Humboldt County economy on an annual basis. This additional unreported income naturally filters down to local retailers and food service establishments in the form of cash sales. While per capita taxable sales in Humboldt County are roughly on par with the statewide average, per capita sales in Eureka are more than double the statewide average. While a portion of this difference is attributable to the City's role as a regional commercial hub, the impact of the marijuana economy is undoubtedly substantial.

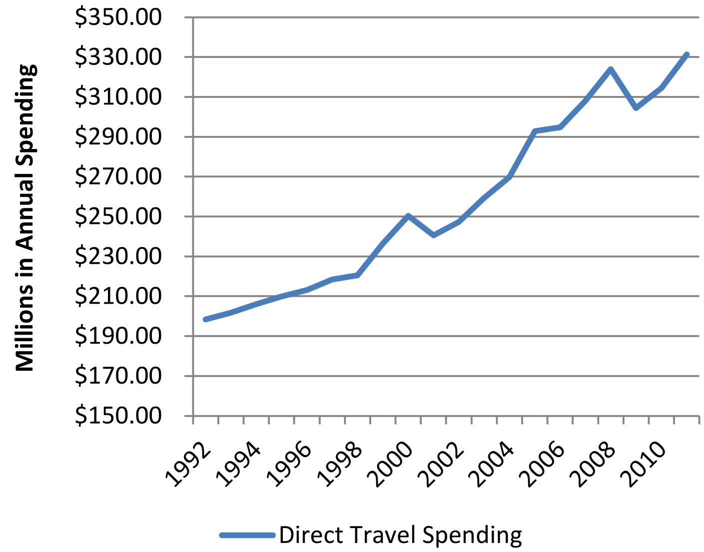
Tourism and Visitor Spending

In addition to "export" industries such as timber and fishing, tourism is an industry by which communities bring income into their local economies, by attracting visitors who spend money on lodging, food, transportation, shopping, and services. According to the publication, California Travel Impacts by County, 1992-2011 (Dean Runyon Associates, May, 2013), tourism generated $331.3 million in total visitor spending in Humboldt County in 2011, generating 4,510 jobs and $6 million in local tax revenues. According to this publication, employment supported by tourism within Humboldt County was equal to about 6.6 percent of total wide jobs. Detailed information about the portion of all Humboldt County tourism activity within the City of Eureka itself is not available; however, information in the Dean Runyon Associates report regarding transient occupancy taxes (i.e. hotel taxes, or TOT) indicate that Eureka hotels collected about 40% of the countywide total. Given that lodging expenditures represent one of the largest components of daily visitor spending, this provides one indicator of the amount of countywide visitor expenditures.

Figure 3.3-7 shows that on a nominal basis, un-adjusted for inflation, countywide travel spending in Humboldt County has increased over the years by 67 percent. If spending kept pace with inflation, it would have increased about 60 percent over the period; thus, the County may have achieved a modest "real" increase in travel spending.

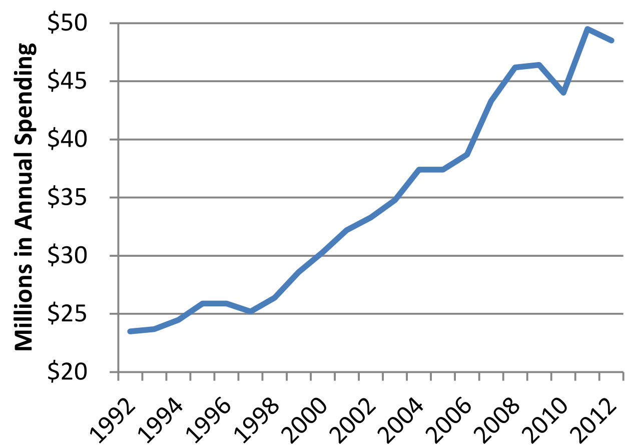
According to the Dean Runyon Associates report, the number of jobs within the County supported by travel has declined slightly, from 4,750 in 1992 to 4,510 in 2011. This suggests that the countywide travel industry may have contracted slightly from the early 1990s, at least in terms of the ability to support local jobs.

FIGURE 3.3-7: Humboldt County Travel Spending by Year, 1992 to 2011



Within the City of Eureka, the non-inflation adjusted value of taxable room sales increased over the 1992 to 2012 time period; however, at a slower rate than travel expenditures countywide. According to the data in the Dean Runyon Associates report, summarized in **Figure 3.3-8**, Eureka taxable room sales increased about 49 percent between 1992 and 2012. This suggests that after accounting for inflation over the 1992-2011 period, the value of Eureka's taxable room sales have contracted slightly. Meanwhile, Humboldt countywide taxable room sales grew by 106 percent over the same time period, indicating that Eureka's share of countywide tourism has likely decreased to some degree.

FIGURE 3.3-8: Taxable Room Sales in Eureka, 1992 to 2012



Forecasts for Eureka and Humboldt County tourism activity are not available; however, a statewide travel forecast prepared for the California Travel and Tourism Commission (Travel Economics, 2013) indicates that California visits by domestic travelers will increase between two and three percent each year, between 2011 and 2016, and California visits by international travelers will typically increase at rates between 3.3 and 5.4 percent over the same time period. The analysis further indicates that the strongest growth markets will be visitors from Asia and Latin America (i.e., China, Japan, South Korea, Brazil), while visitation from Europeans will be flat for the period. Primary domestic markets are Arizona, Nevada, Oregon, Washington, Utah, and Colorado, with Texas, Illinois, and New York identified as "opportunity markets" for future expansion. This information suggests that there will be opportunities for Eureka to capture a share of increasing tourist visits to California; however, the local tourism industry will likely need to work to overcome challenges to visitor attraction that arise due to the area's remote location and limited access.

Government and Healthcare

The City of Eureka functions as a hub for office-based industry on the North Coast, including government, healthcare, finance and real estate, and professional services. As the county seat of Humboldt County, the City functions as a dominant government center, hosting the County administrative office, the Superior Court, the County Office of Education, the Department of Health and Human Services, and the Sheriff's department. Even independently, some of the County departments listed above represent some of the largest employers in the County. Although the Federal Bureau of Investigations recently relocated its offices from downtown Eureka to Fortuna, the City still hosts a variety of other state and local government agencies, such as the Department of Motor Vehicles, Caltrans, and the California Department of Fish and Wildlife.

According to the EDD, the government sector in Humboldt County employed an estimated 13,500 people in 2012. Additional data from the Quarterly Census of Employment and Wages (QCEW) suggest that this employment was fairly evenly split between educational services and public administration. For example, in 2012, an average of 42 percent of all government workers in the County were engaged in education. An additional 39 percent participated in public administration for city or county government agencies. As the County's single largest employment sector, government is projected to add a significant number of jobs over the planning period. As will be discussed in more detail in the following section, the County is projected to gain roughly 1,880 new government sector jobs by 2040, with around 710 of those going to Eureka.

In addition to being a major government center for the County, the City of Eureka also functions as a central point of access for health care services on the North Coast. For example, the City is served by St. Joseph Hospital, which is the largest acute medical care facility located on the California coast, north of San Francisco Bay. The hospital system employs roughly 1,400 individuals between two campuses, making it one of the largest employers in Humboldt County. As such, the hospital has attracted a cluster of clinics and medical specialists, who provide services to residents of Humboldt County and beyond.

Data from the QCEW indicate that roughly 92 percent of countywide healthcare employment was in the private sector in 2012. Approximately a third of the County's employment in the sector was associated with private hospital facilities, while another third was associated with private sector ambulatory care services. Roughly 19 percent was associated with social assistance, while 16 percent was associated with nursing and resident care facilities. Moving forward, employment in the health services sector, combined with education, is expected to grow by approximately 23 percent, or some 1,500 jobs through 2040. Around 750 of those jobs, including both healthcare and education, are likely to locate within the City of Eureka.

While the City functions as a clear focus of activity for the government and healthcare sectors, it also plays an important role as a center for private financial and business activity in Humboldt County. For example, with the office of the Humboldt County Recorder located in Eureka, the City is a natural location for real estate firms and related financial services, such as title companies, that benefit from close proximity to certain government offices. Although based out of Portland, Oregon, the Umpqua Bank has a strong presence in Eureka, with an estimated 250 to 499 individuals based out of the bank's 5th Street location. According to the EDD the Information, Financial Activities, and Professional and Business Services industries provide approximately 4,800 jobs throughout the county. The largest employment sector is Professional and Business Services, with some 2,700 jobs, while the Financial Activities sector employs around 1,600 individuals.

3.4 ANTICIPATED GROWTH AND MARKET OPPORTUNITIES

To identify future growth trends for the City of Eureka, the Planning Area, and Humboldt County, this chapter presents a set of projections for population, households, and housing units, for the period from 2015 to 2040. The projections are based on countywide growth projections published by the California Department of Transportation (Caltrans) and the DoF (Schniepp, 2013). The population growth rates indicated by these two sources define the basis for the high-growth and low-growth scenarios reported in Table 3-12. Both sets of countywide projections were benchmarked to the 2010 Census, and trended forward, based on the compound annual average growth rate reported for each five-year period. Because the countywide DoF projections do not provide household and housing unit estimates, the forecast utilizes the implicit household formation and vacancy rates reported by Caltrans. To generate projections for the City and the Planning Area, the forecast assumes that the City of Eureka, and the portion of the Planning Area located outside of the City limits, will maintain a constant share of countywide population, households, and housing units.

Employment projections for the period from 2015 to 2040 are based on industry employment projections published by Caltrans. The countywide projections were initially benchmarked to the 2012 EDD industry employment estimates, then trended forward based on the average annual growth rate reported for each five-year period by Caltrans. The projections incorporated data from Claritas, Inc., a private data vendor, to identify the share of employment within each industry that is located within the City of Eureka. These estimates were then applied to the countywide industry level employment estimates to derive projections for the City of Eureka through 2040.

Population and Employment Growth

Population Growth Trends

As reported in **Table 3-19**, under the high growth scenario, Humboldt County could add more than 13,200 new residents between 2010 and 2040. This would equal an increase of 9.8 percent over 2010, and an average growth rate of 0.3 percent per year. Under the low-growth scenario, the County would add 3,370 new residents. This would represent an increase of 2.5 percent over 2010, and an average growth rate of only 0.1 percent per year. If the City were to maintain its existing share of the countywide population, these projections suggest Eureka could add between 680 and 2,670 new residents through 2040. The population located outside of the City, but within the Planning Area, would grow by an estimated 510 to 1,980 new residents. Combined, this suggests that the population of the Planning Area, including both the City of Eureka and those areas located outside the City limits, could see between 1,190 and 4,650 new residents by 2040.

Note that the above projections assume that the City and the Planning Area will maintain their current shares of the countywide population, as the County grows in future years. Based on U.S. Census Bureau population estimates, Eureka’s share of the countywide population declined from 22.7 percent in 1990, to 20.7 percent in 2000. From 2000 to 2010, the City’s share dropped by only one half of a percentage point, to 20.2 percent. While the population residing in the remainder of the Planning Area also declined in its share of the countywide population, the share dropped by only 0.1 percentage points, from 15.1 percent in 2000 to 15.0 percent in 2010. These projections assume that land use policies and other growth-related policies will support long-term outcomes whereby the City and the Planning Area maintain a relatively constant share of the countywide population moving forward.

TABLE 3-19: HISTORIC AND PROJECTED POPULATION GROWTH

	Historic Growth		Projected Growth					
	2000	2010	2015	2020	2025	2030	2035	2040
Low-Growth[1]								
City of Eureka								
Population	26,128	27,191	27,340	27,700	27,810	27,720	27,720	27,870
Households	10,957	11,150	11,310	11,490	11,630	11,730	11,790	11,870
Housing Units	11,637	11,891	12,080	12,270	12,420	12,500	12,570	12,670
Planning Area								
Population	19,115	20,201	20,310	20,580	20,660	20,590	20,600	20,710
Households	7,559	8,368	8,490	8,620	8,730	8,800	8,850	8,910
Housing Units	7,953	8,886	9,030	9,170	9,280	9,340	9,390	9,470
Humboldt County[2]								
Population	126,518	134,623	135,350	137,120	137,710	137,240	137,270	137,990
Households	51,238	56,031	56,830	57,730	58,430	58,930	59,230	59,630
Housing Units	55,912	61,559	62,530	63,510	64,290	64,710	65,050	65,570
High-Growth[1]								
City of Eureka								
Population	26,128	27,191	27,400	28,090	28,900	29,420	29,710	29,860
Households	10,957	11,150	11,330	11,650	12,080	12,450	12,630	12,710
Housing Units	11,637	11,891	12,100	12,440	12,900	13,260	13,460	13,570
Planning Area								
Population	19,115	20,201	20,350	20,870	21,470	21,850	22,070	22,180
Households	7,559	8,368	8,510	8,750	9,070	9,340	9,480	9,540
Housing Units	7,953	8,886	9,040	9,300	9,640	9,910	10,060	10,140
Humboldt County[2]								
Population	126,518	134,623	135,640	139,090	143,060	145,640	147,070	147,830
Households	51,238	56,031	56,950	58,560	60,710	62,540	63,470	63,890
Housing Units	55,912	61,559	62,660	64,420	66,790	68,670	69,700	70,250

Sources: U.S. Census Bureau, Census 2000, 2014; U.S. Census Bureau, Census 2010, 2014; California Department of Transportation, 2014; California Department of Finance, 2014; BAE, 2014.

Notes:

1 Assumes that the population growth will at the countywide projected rate (i.e., maintaining a constant share of the total population, compared to 2010), as projected by Caltrans and the DoF.

2 Projections are benchmarked to the 2010 Census using the annual average growth rates projected by the California Department of Finance (DoF) and Caltrans for each five year period between 2010 and 2040.

POPULATION AGE PROFILE

The age profile for growing segments of the population may have important implications for planning for new residential development in Eureka. As noted previously, the population of the City of Eureka and Humboldt County grew older over the past decade. The segment of the population that grew most rapidly were adults age 55 and over, which constituted more than 25 percent of the population in 2010. The available data for Humboldt County indicate similar trends, with a marginal increase in the median age, but a substantial increase in the number of retirement age adults and senior citizens. Population projections for Humboldt County published by the DoF suggest that the population will continue to grow older throughout the planning period, such that senior citizens (ages 65 and up) will constitute upwards of 24 percent of the population by 2040 and retirement age adults (ages 55 to 64) will constitute an additional 14 percent. Growth among the older population will coincide with a decline in the number, and percentage share, of children and younger adults. For example, the population under age 20 is projected to contract by nearly 13 percent, while the population between age 20 and 39 will contract by around eight percent. While a more in-depth evaluation would be necessary to project the future profile of the Eureka population, it appears likely that older adults, especially those over the age of 65, will be the fastest-growing segment of the population during the planning period and will represent 86 percent of the projected population growth between 2010 and 2040. As will be discussed further below, households whose residents are younger adults or retirement age or older may have less interest in traditional single-family detached homes, and more interest in smaller attached or multifamily housing that is more suitable for small households without children living at home.

Employment Growth

The EDD reports industry employment projections for the North Coast Region only, which includes the counties of Del Norte, Humboldt, Lake, and Mendocino. The EDD does not provide detailed industry projections at the county or city levels. However, as part of their annual projections series, Caltrans does provide a highly limited set of industry employment projections at the county level. **Table 3-20** reports the Caltrans projections, based on the 2013 data series, which are benchmarked to the 2012 EDD estimates. Caltrans projects that the Humboldt County will add approximately 9,540 jobs between 2012 and 2040, which represents a growth rate of 0.7 percent per year. The largest amount of growth is projected to occur in the Leisure and Hospitality sector, which is projected to add 2,280 jobs by 2040, at a rate of 1.3 percent per year. The two other sectors projected to produce the greatest number of new jobs include Government, and Wholesale and Retail Trade. Caltrans expects the Government sector to add roughly 1,880 new jobs by 2040, at an annual rate of 0.5 percent per year. The Wholesale and Retail Trade sector is anticipated to add approximately 1,190 new jobs by 2040, also at a rate of 0.5 percent per year.

Employment projections for the City of Eureka were derived based on the Caltrans countywide industry employment projections, which are benchmarked to the 2012 EDD estimates, and estimates of the local share of countywide employment, by industry, provided by Claritas, Inc. Please note that these estimates are intended to indicate the rough order of magnitude of employment growth within the City of Eureka over the planning period, and are not intended to represent precise estimates of the changes in employment that may be expected within each industry sector. As such, the data indicate the City of Eureka may be likely to add around 3,800 new jobs through 2040. Similar to countywide trends, the greatest amount of employment growth may be expected in Education and Health Services, Leisure and Hospitality, and Government sectors. Each of these sectors is projected to add upwards of 700 jobs during the planning period. Other sectors that may experience significant job growth include Professional and Business Services, and Wholesale and Retail Trade. The Professional and Business Services industry is projected to add about 440 new jobs over the planning period, for an average annual growth rate of around one percent. By comparison, the projections suggest that the Wholesale and Retail Trade sector will add around 190 positions through 2040, for an average annual growth rate of 0.7 percent.

TABLE 3-20: PROJECTED JOBS BY INDUSTRY, 2012 TO 2040

	(Est.)[1]	Projected Growth[2]						
Industry Sector	2012	2015	2020	2025	2030	2035	2040	Projected Change
City of Eureka								
Agriculture	110	120	120	120	120	130	130	20
Construction	570	600	600	580	570	570	590	20
Manufacturing	460	480	500	510	510	520	520	60
Wholesale Trade	440	450	470	480	490	500	510	70
Retail Trade	3,050	3,120	3,210	3,300	3,380	3,450	3,520	470
Transportation, Warehousing, & Utilities	250	270	290	290	300	310	310	60
Information	220	210	210	210	210	220	220	0
Financial Activities	840	860	900	940	970	1,000	1,030	190
Professional and Business Services	1,380	1,490	1,570	1,650	1,720	1,770	1,820	440
Educational & Health Services	3,190	3,360	3,500	3,590	3,650	3,790	3,940	750
Leisure & Hospitality	1,650	1,740	1,870	1,980	2,100	2,230	2,380	730
Other Services	850	890	930	980	1,030	1,080	1,120	270
Government	5,140	5,300	5,370	5,450	5,580	5,710	5,850	710
TOTAL, ALL INDUSTRIES[3]	**18,270**	**19,000**	**19,660**	**20,200**	**20,760**	**21,400**	**22,070**	**3,800**
	(Est.)[3]	Projected Growth[5]						
Industry Sector	2012	2015	2020	2025	2030	2035	2040	Projected Change
Humboldt County								
Agriculture	900	920	940	960	1,000	1,030	1,060	160
Construction	1,700	1,780	1,780	1,730	1,680	1,700	1,740	40
Manufacturing	2,000	2,070	2,170	2,190	2,210	2,240	2,260	260
Wholesale Trade	1,000	1,020	1,050	1,080	1,110	1,130	1,150	150
Retail Trade	6,900	7,050	7,250	7,460	7,630	7,790	7,940	1,040
Transportation, Warehousing, & Utilities	1,300	1,390	1,490	1,520	1,550	1,580	1,610	310
Information	500	480	490	490	490	500	500	0
Financial Activities	1,600	1,650	1,730	1,800	1,850	1,910	1,970	370
Professional and Business Services	2,700	2,900	3,070	3,220	3,360	3,460	3,550	850
Educational & Health Services	6,400	6,750	7,030	7,200	7,330	7,600	7,900	1,500
Leisure & Hospitality	5,200	5,480	5,870	6,240	6,620	7,030	7,480	2,280
Other Services	2,200	2,320	2,430	2,560	2,690	2,800	2,920	720
Government	13,500	13,920	14,100	14,310	14,660	15,010	15,380	1,880
TOTAL, ALL INDUSTRIES[6]	**45,800**	**47,630**	**49,300**	**50,650**	**52,050**	**53,660**	**55,340**	**9,540**

Sources: California Employment Development Department, 2014; California Department of Transportation, 2014; Claritas, Inc., 2014; BAE, 2014.

Notes:
1 2012 estimates for the City of Eureka are based on countywide industry employment estimates from the EDD and the City's share of countywide employment in each industry sector as reported by Claritas, Inc.
2 Employment projections for the City of Eureka are based on employment growth rates by industry, as published

TABLE 3-20: PROJECTED JOBS BY INDUSTRY, 2012 TO 2040

Industry Sector	(Est.)[1] 2012	Projected Growth[2] 2015	2020	2025	2030	2035	2040	Projected Change

by Caltrans.
3 Figures may not sum to totals due to rounding
4 2012 estimates for the Humboldt County are as published by the EDD.
5 Employment projections for the Humboldt County are based on employment growth rates by industry, as published by Caltrans.
6 Figures may not sum to totals due to rounding

Anticipated Market Opportunities

This section provides discussion of the potential land use demand during the next 20 to 25 years that could be expected within the City of Eureka, by land use category. These estimates are based on synthesis of existing demographic and economic conditions, real estate market conditions, and projected countywide population and employment growth.

Residential Development

EXISTING MARKET CONDITIONS

According to data from the California Association of Realtors and the Humboldt Association of Realtors, the residential housing markets in Humboldt County and the City of Eureka began to decline well before the onset of the national housing crisis. Between January of 2006 and January of 2007, the median sales price for a single-family detached housing unit in Humboldt County declined by 4.2 percent. The median price for homes in Eureka declined by more than 20 percent during the same period. While the County saw continued price decreases through 2008 and 2009, the City saw a minor reprieve, with the median home price increasing year-over-year. However, by 2010, prices were once again on the decline, with the median sales price in the City reaching a low of $160,000 in January of 2012. As discussed in Section 3.2, Dataquick reported a median sales price of $225,500, as of September 2013, suggesting continued rapid price appreciation. Data for Humboldt County also show significant signs of recovery, with modest price appreciation through 2012 and 2013, bringing the January 2014 median sales price for all of Humboldt County to $270,590. Combined with the relatively normal vacancy rates (i.e., averaging six percent for the period from 2008 to 2012) and a declining percentage of distressed sales, the outlook for residential housing development in Eureka is cautiously optimistic.

ANTICIPATED DEVELOPMENT POTENTIAL

As summarized in Table 3-19 above, the City of Eureka could add between 720 and 1,560 new households between 2010 and 2040. The remainder of the Planning Area could see an additional 540 to 1,170 new households. Humboldt County as a whole could add between 3,600 and 7,860 new households over the projection period. Note that under the low-growth scenario, Caltrans projects a larger number of new households than new residents. This implies that there will be a decline in the average household size, and a possible fragmentation of some existing households to form new households (e.g., adult children moving out of their parents' homes to form their own households). Assuming that both the City and the Planning Area maintain their existing share of the county's housing stock, this could translate into demand for between 780 and 1,680 new housing units in the City of Eureka, as well as 540 to 1,170 new housing units in the remainder of the Planning Area. Throughout all of Humboldt County, these additional households could generate sufficient demand to support the construction of between 4,010 and 8,690 new housing units.

Given the projected age profile of the local population moving forward, with an increasing share of older, retirement age households, and younger single-person households, the area is likely to experience slackening demand for single-family housing. This will likely correspond to an increase in demand for smaller multifamily housing units. Based on this understanding, **Table 3-21** reports estimates of the projected distribution of housing demand by unit type. According to this data, roughly 53 percent of households, primarily those whose householder is between the ages of 35 and 64, are likely to demand more traditional single-family housing units. The remaining 47 percent are more likely to demand smaller, more efficient, multifamily housing units. These households are most likely to include those where the householder is below 35 years of age, or 65 years of age or older. The projected household growth reported in Table 3-19 of 720 new households at the low end, to 1,560 new households at the high end, could generate sufficient demand for 780 to 1,680 new housing units in Eureka. Based on the distribution of households by age of householder described above, this could translate into demand to accommodate 410 to 890 new single-family housing units, as well as 370 to 790 new multifamily housing units.

TABLE 3-21: PROJECTED HOUSING GROWTH, 2015 TO 2040

	Projected Growth						Projected Change
	2015	2020	2025	2030	2035	2040	
Low-Growth[1]							
City of Eureka							
Housing Units	190	190	150	80	70	100	**780**
Single-Family	*100*	*100*	*80*	*40*	*40*	*50*	***410***
Multifamily	*90*	*90*	*70*	*40*	*30*	*50*	***370***
Humboldt County							
Housing Units	970	980	780	420	340	520	**4,010**
Single-Family	*510*	*520*	*410*	*220*	*180*	*270*	***2,110***
Multifamily	*460*	*460*	*370*	*200*	*160*	*250*	***1,900***
High-Growth[2]							
City of Eureka							
Housing Units	210	340	460	360	200	110	**1,680**
Single-Family	*110*	*180*	*240*	*190*	*110*	*60*	***890***
Multifamily	*100*	*160*	*220*	*170*	*90*	*50*	***790***
Humboldt County							
Housing Units	1,100	1,760	2,370	1,880	1,030	550	**8,690**
Single-Family	*580*	*930*	*1,250*	*990*	*540*	*290*	***4,580***
Multifamily	*520*	*830*	*1,120*	*890*	*490*	*260*	***4,110***

Sources: U.S. Census Bureau, Census 2000, 2014; California Department of Transportation, 2014; California Department of Finance, 2014; BAE, 2014.

Notes:

1 Assumes that Eureka will grow at the same rate as the county as a whole (i.e., maintaining a constant share of the total population, compared to 2010), as projected by Caltrans.

2 assumes that Eureka will grow at the same rate as the county as a whole (i.e., maintaining a constant share of the total population, compared to 2010), as projected by the DoF.

Retail Development

EXISTING MARKET CONDITIONS

According to local real estate brokers, the market for retail real estate in Eureka is generally divided between top-tier national retailers, who occupy larger big-box type spaces (e.g., the Bayshore Mall), and smaller second-tier local retailers that occupy smaller, less expensive spaces (e.g., Henderson Center). Generally, the national retailers exhibiting demand for retail space in Eureka are looking for between 20,000 and 40,000 square feet. The majority of the available spaces are located in existing mall developments. There are also a number of vacant grocery store sites that are available for occupancy, which would fit the demands of some national chain retailers. These include the former Safeway site at the southeast corner of Harris and Harrison Streets, across the street from its replacement store, which has been vacant for the past two years, and the Ray's Food Place supermarket at the Bayshore Mall, which closed in 2013 and is listed for lease. Most brokers feel that the national chains are beginning to gain market share in Humboldt County, and that Eureka is the dominant hub for that activity, with Sears, Michaels, Staples, Petco, and Walmart already located in the City.

Local real estate brokers have a sense that the locally based retail establishments in Eureka are struggling, which translates into weak demand for small retail spaces within the City. The Old Town district is considered the strongest submarket, followed by Henderson Center. Both of these districts exhibit sufficient foot traffic to ensure that they remain desirable locations for retail establishments. Retail market conditions in surrounding areas, such as Cutten and Myrtletown, remain relatively stable, with demand for additional retail space remaining relatively static. Reflecting the slack demand for existing commercial real estate, very little new retail space is being produced in Eureka and its surroundings.

The existing market conditions for retail real estate in Eureka indicate that there is more than sufficient supply to meet existing demand. Brokers reported vacancy rates within the City ranging from 15 to 20 percent, although there is no centralized tracking for vacancy or lease rates for commercial real estate in the City. Brokers reported that the national chain retailers that are occupying existing mall spaces are paying between $0.80 per square foot and $1.50 per square foot, depending on the location and condition of the existing leased space. Smaller retail spaces in Henderson Center and Old Town are leasing for between $0.60 and $1.00 per square foot.

ANTICIPATED DEVELOPMENT POTENTIAL

Table 3-22 projects potential future retail demand in terms of total retail sales, and additional supportable retail real estate demand. Driven by population growth,[2] retail spending in Eureka is projected to grow by between $58.9 million and $84.6 million from 2011 through 2040. The previously mentioned potential to capture a portion of existing countywide leakage also contributes to the City's long-term retail absorption potential. Based on estimates of average revenue per square foot of retail, the combination of capturing existing leakage and capturing a share of projected countywide retail demand due to population growth could translate into demand sufficient to support approximately 200,000 to 290,000 square feet of additional retail space. Note that these projections assume that the City is able to capture the maximum possible share of existing retail leakage, which would then be absorbed gradually through 2020.

[2] The retail demand projections rely on the population projections reported in Table 3-19.

TABLE 3-22: PROJECTED TAXABLE SALES AND SUPPORTABLE RETAIL SQUARE FEET, 2015 TO 2040

	Projected Growth						
	2015[1]	2020[1]	2025	2030	2035	2040	Total Change
Low-Growth[2]							
City of Eureka							
Retail Sales (Millions)	$796	$826	$827	$826	$826	$828	***$58.9***
Retail Demand (Sq. Ft.)	92,600	103,400	4,900	(4,000)	0	6,700	***203,600***
Humboldt County							
Retail Sales (Millions)	$1,731	$1,779	$1,787	$1,781	$1,781	$1,791	***$92.3***
Retail Demand (Sq. Ft.)	112,100	164,900	26,200	(20,900)	1,300	32,000	***315,600***
High-Growth[2]							
City of Eureka							
Retail Sales (Millions)	$796	$831	$841	$848	$852	$854	***$84.6***
Retail Demand (Sq. Ft.)	94,700	118,200	36,400	23,300	13,000	6,700	***292,300***
Humboldt County							
Retail Sales (Millions)	$1,734	$1,804	$1,856	$1,889	$1,908	$1,918	***$219.5***
Retail Demand (Sq. Ft.)	122,500	239,600	176,400	114,600	63,500	33,800	***750,400***

Sources: California Employment Development Department, 2014; California Department of Transportation, 2014; Claritas, Inc., 2014; BAE, 2014.

Notes:
1 Assumes that half of the City's share of the existing countywide retail leakage will be absorbed through 2015, while the remainder will be absorbed through 2020.
2 Assumes that the population growth will at the countywide projected rate (i.e., maintaining a constant share of the total population, compared to 2010), as projected by Caltrans and the DoF.

Office Development

EXISTING MARKET CONDITIONS

The City of Eureka is a hub for office activity in Humboldt County, with multiple city, county, and state government agencies and private businesses. Despite this, the existing demand for office space is relatively weak. According to interviews with local real estate brokers, the greatest demand from users in the current office market is for smaller office spaces, of approximately 1,200 square feet or less. Although these spaces see the most demand, the vacancy rate remains higher for smaller office spaces, compared to their larger counterparts. The stated reason for this is the prevalence of government agencies that occupy a significant and increasing amount of space.

The overall condition of the office market in Eureka indicates a vacancy rate ranging from a low of 12 percent, to a potential high of 30 percent, demonstrating relatively weak demand. One broker provided anecdotal evidence of this, in the form of a high quality, reasonably priced office space that was listed for a long period with not even a single showing. Generally speaking, downtown Eureka is the strongest performing district within the office real estate market. This is primarily due to the proximity of downtown to various services and amenities, such as an assortment of government offices, as well as restaurants, shops, and other consumer services. According to brokers, the average lease rate for downtown office space is approximately $1.00 per square foot. The typical range for asking lease rates is between $0.50 per square foot, to $1.25 per square foot.

Brokers described that over the past five or so years, the market for office space in Eureka has softened, which was reflected in increased vacancies. They also noted that the Eureka office market has a tendency to fluctuate significantly, especially in comparison to other local communities. The only real competition, they described, is from office space located in Arcata. However, office spaces in Arcata are typically leased for between $1.10 per square foot, to $1.15 per square foot. This provides the owners of Eureka office spaces with a clear price advantage. Moving into the next fifteen to twenty years, the brokers interviewed expect to see modest growth in office demand that will build slowly over time. This outlook, of course, depends greatly on the overarching economic conditions facing the City, growth in the local population base, which helps to create demand for government and private office-based businesses, as well as the relative consumer confidence of area businesses and ability of government agencies to support multiple offices. While brokers indicated that City policies do not represent the most significant barrier to growth in the office market, they suggested that the City could be more flexible in their approvals process and that a reduction in City fees would help to improve the economics of establishing office uses in downtown Eureka.

ANTICIPATED DEVELOPMENT POTENTIAL

The future demand for office development is estimated based on projected employment growth in industries that typically exhibit the greatest demand for office space. For the purposes of this analysis, this includes the following industry sectors: Information, Financial Activities, Professional and Business Services, Educational and Health Services, and Government. As of 2012, these industries employed approximately 24,700 workers in Humboldt County. Based on an average of 250 square feet per office employee, this translates into demand sufficient to support approximately 6.2 million square feet of office space at present. Based on the projected employment growth reported in Table 3-20, Humboldt County may expect to add approximately 4,600 new jobs in these industry sectors through 2040. Using the same conversion factor, this would translate into sufficient demand to support an additional 1.15 million square feet of office space. The City of Eureka is projected to add approximately 2,090 new jobs in these industry sectors, which could translate into sufficient demand to support approximately 522,500 square feet of additional office space within the City, although it is important to note that some portion of this demand will be absorbed within existing vacant office buildings. Therefore, the total development potential is likely somewhat less than the projected demand.

Industrial Development

EXISTING MARKET CONDITIONS

The market for industrial space is currently the strongest real estate submarket in Eureka. Despite the fact that Eureka and Humboldt County were hard hit by the decline of the fishing and logging industries, brokers report that smaller industrial operations are expanding and generating demand for light industrial and warehouse spaces under 2,000 square feet in size. The most desirable spaces are approximately 1,500 square feet in size or smaller. They must be in relatively good condition, with power, and generally need to have been built in the 1970's or later. Demand for these smaller warehouse spaces is driven primarily by local construction contractors (e.g., painters, plumbers, etc.) and industrial distributors, as well as start-up businesses. Some tenants desire storage spaces with power, where vehicles and other large items can be kept. Augmenting this local demand is an influx of entrepreneurs from outside of Eureka, some of whom were drawn by proximity to Humboldt State and the College of the Redwoods. Some examples of these entrepreneurs include winemakers, distilleries, jewelers, musical instrument makers, glass blowers, and car wrap manufacturers, among others.

Overall, the supply of industrial space includes a combination of smaller warehouse spaces in the 1,000 to 2,000 square foot range, and larger industrial sites that include some existing built space, and large amounts of undeveloped acreage. While the estimated vacancy rate for industrial properties is around 10 percent, the majority of the vacant inventory is characterized by larger undeveloped industrial properties, such as the abandoned lumber mill sites. Those smaller developed warehouse spaces between 1,000 and 2,000 square feet are in strongest demand, with a vacancy rate near zero.

COASTAL DEPENDENT INDUSTRIAL LAND SUPPLY

There are approximately 205 acres of land zoned for Coastal-Dependent Industrial (CDI) use within the City of Eureka.[3] A significant portion of this land is vacant or under-utilized, prompting the question of whether it is in the City of Eureka's long-term interest to maintain the current zoning, or to explore the potential to rezone the property to allow for more flexible use of the sites, including non-coastal dependent industrial uses. This could be a challenge given the priority placed on CDI uses by the California Coastal Act. A key question that must be addressed is whether there is sufficient land available within the region to accommodate potential demand for land by coastal dependent industrial users, and an important consideration in this regard is the quantity of Coastal Dependent Industrial land available elsewhere in the Humboldt Bay region.

In 2003, PB Ports & Marine completed a Harbor Revitalization Plan for the Humboldt Bay Harbor Recreation and Conservation District (HBHRCD) (PB Ports & Marine, 2003). This study involved extensive analysis of the various development sites within the District, potential market opportunities for various types of economic activities, and the specific sites' and the larger region's compatibility and competitiveness to capture demand. One of the key findings from the 2003 study was that there are three large sites on the Samoa Peninsula, each of which include over 200 acres of land, and which collectively cover about 850 acres of land. At least one site, previously known as the location of the Freshwater Tissue pulp mill, was recently acquired by the HBHRCD and is in the early stages of being redeveloped for a number of uses, including aquaculture/aquaponics production activities. Each of the three main sites on the peninsula are located on the 38-foot shipping channel. In addition to these sites, there are other smaller properties on the Samoa Peninsula that bring the total inventory of land zoned CDI to an estimated 975 acres, as reported by Humboldt County. Elsewhere around the Bay, there is additional land that is set aside for coastal dependent uses. For example, there is an estimated 210 acres of land zoned CDI located in Fields Landing, south of Eureka, and another 205 acres located along the waterfront within the City of Eureka itself. Together, this brings the total countywide inventory to upwards of 1,390 acres of Coastal Dependent Industrial Land.

ANTICIPATED DEVELOPMENT POTENTIAL

Projected demand for industrial development is estimated based on projected employment growth in industries that typically exhibit the greatest demand for industrial space. For the purposes of this analysis, this includes the following industry sectors: Construction; Manufacturing; Wholesale Trade; and Transportation, Warehousing, and Utilities. As of 2012, these industries employed approximately 6,000 workers in Humboldt County. Based on a range of 1,000 to 1,250 square feet per industrial job, this translates into demand sufficient to support between six million and 7.5 million square feet of industrial space.

Based on the projected employment growth reported in Table 3-20, Humboldt County may expect to add approximately 760 new industrial or warehouse oriented jobs through 2040. Using the same conversion factors described above, this would translate into sufficient demand to support an additional 760,000 to 950,000 square feet of industrial or warehouse space to support both CDI and non-CDI activity. At a relatively low floor area ratio of 35 percent, this would generate demand for between 50 and 62 acres of industrial land within the County. Even allowing for the possibility that new industrial uses might need substantial acreage for materials storage, the likely need for industrial land is far less than the supply of 975 acres of CDI land surrounding Humboldt Bay, discussed previously.

[3] Note that the 15-acre site known as "Parcel 4" is subject to an open space easement and is no longer available for CDI use.

The City of Eureka is projected to draw around 210 new industrial or warehouse oriented jobs through 2040. If realized, this would translate into an estimated 210,000 to 262,500 square feet of additional space. This would translate to roughly 14 to 17 acres of land at a floor area ratio of 35 percent. Given the structural changes in the region's industrial economy, there is likely far more land zoned for CDI development within the City, and the larger Humboldt Bay area, than is necessary to meet long-term demand.

3.5 REGULATORY CONTEXT

There is no regulatory context for the Population, Housing and Economy Chapter.

3.6 PLANNING ISSUES

Planning Issues

Changing Demographics and Housing Needs

There is a need to identify appropriate policies and land uses for new housing development, in light of changing demographics. Given the projected age profile of the local population moving forward, with an increasing share of older, retirement age households and households with single people living alone and couples without children, the City is likely to experience slackening demand for single-family housing. This is anticipated to correspond to an increase in demand for smaller higher density housing units. Locations near dining and shopping, recreation, transit, and other services are generally most desirable for higher density housing. The vacant and underutilized upper floors in the Old Town and Downtown areas may be able to accommodate some of this demand. The City will want to balance providing new higher density housing opportunities, with protecting the character and stability of its existing neighborhoods.

Affordable Housing Demand

The City of Eureka has been assigned a 2014-2019 Regional Housing Needs Allocation (RHNA) of 609 units, including 72 units for extremely low-income households, 73 units for very low-income households, 96 units for low-income households, 104 units for moderate-income households, and 264 units for above moderate-income households. Although the RHNA covers only a portion of the General Plan time horizon, it provides an indicator of the general distribution of housing affordability that would help to meet the needs of all economic segments of the community. In general, lower income affordability needs can most practically and economically be met through the availability of higher density housing units.

Below Average Educational Attainment

Compared to the State of California, the residents of both the City of Eureka and Humboldt County exhibit below average educational attainment. For example, an estimated 30.5 percent of California residents possess a bachelor’s degree or higher, in the City of Eureka that number is 22.5 percent. This is a critical factor in the attractiveness of the City to employers that require a skilled and highly educated workforce. In addition to the recent gains in educational attainment within the community, the proximity of Humboldt State University and College of the Redwoods may partially offset this concern, and help to enhance the City’s attractiveness to potential employers.

Unemployment and a Shifting Economy

The City of Eureka has experienced above average unemployment in recent years. The types of jobs that are available in Eureka have changed significantly over the past decades. In general, jobs in Eureka have been shifting away from manufacturing and industrial, toward a more service-based economy. Constraints such as restrictions on the fishing and timber industries, limited transportation access, and various coastal and other regulations have made it difficult for the City to fully take advantage of its economic development opportunities. While efforts need to be focused on addressing this shift and defining a long term sustainable economic base for the City, it is important for the General Plan Update process to acknowledge the influence that Eureka’s traditional base industries have had on the local economy, community identity, and land use pattern, and will have on the outlook for industrial activity moving forward.

Declining Port Activity

In addition to handling timber and commercial fishing activities, the Port of Humboldt Bay historically handled a range of general cargos that moved into and out of the north coast region via ship. There has been a significant decline in overall Eureka area cargo activity, with lumber/logs as the only remaining cargo type since 2011. Meanwhile, ship cargo activity has increased substantially at Northern California ports as a group. It is likely that a primary reason for the latter is that much of the growth in West Coast maritime shipping activity is due to increased trade with Pacific Rim countries, particularly imports of goods to the U.S. The Port of Humboldt Bay has primarily been an export-oriented port, with a focus on forest products. Due to the relatively small size of the local market area, combined with limited transportation access from Eureka to other markets elsewhere on the West Coast and beyond, it is difficult for Humboldt Bay to compete with other locations as a port of entry for imports. Improving transportation efficiency between the Eureka area and other parts of Northern California and the national rail and highway transportation systems would not only enhance the competitiveness of the port, but also provide benefits for local businesses that are dependent upon truck and rail for goods movement.

Agriculture

The City of Eureka itself does not contain significant agricultural production; however, in addition to timber production, Humboldt County has substantial production of other agricultural commodities. As a regional hub, Eureka has the opportunity to capture economic activity related to processing, marketing, and distribution of agricultural and food products. A discussion of Humboldt County agriculture requires acknowledgement that the marijuana industry is a significant economic driver. At the same time, because of the illicit nature of much of the economic activity surrounding marijuana, it is difficult to precisely quantify the economic impact of the crop within the local economy. Given the magnitude of the marijuana industry in Humboldt County relative to the total size of the County's economy, the trend towards relaxed laws pertaining to production and use of marijuana in the U.S. is an important concern for local economic development.

Opportunities for Retail and Lodging Uses

The City of Eureka is a hub for retail commerce in Humboldt County, and on the North Coast. As such, the City captures a large portion of the countywide retail sales, in particular in the more destination oriented retail categories. The City also captures a significant portion of the region's tourism and visitor economy, such as lodging. According to local real estate brokers, locally based retail establishments in Eureka are struggling, which translates into weak demand for small retail spaces within the City. Most brokers also feel that the national chains are beginning to gain market share in Eureka. Given the somewhat slack demand for existing commercial real estate, very little new retail space is being produced in Eureka, and market conditions for retail real estate project that there will be relatively modest demand for additional retail space. Opportunities for new retail and lodging development could potentially be focused as follows:

- Retail development will be most successful and beneficial if it is located where it can establish critical mass with other retailers, so that the area(s) are strengthened as shopping destinations. Participants in the General Plan Update Economic Development Focus Group have indicated that the City of Eureka should strive to maintain its position as a retail hub for the North Coast.
- Lodging facilities should be placed near shopping and dining facilities, and visitor attractions. Economic Development Focus Group participants identified problems with transients, homeless, and persons suffering from mental illness and/or drug addiction problems congregating in visitor-serving and commercial areas as a significant barrier to tourism activities. Focus Group participants also identified a need for general clean-up and beautification in areas meant to attract tourists, such as the Broadway Corridor.

Opportunities for Office Uses

The City of Eureka functions as a hub for office-based industry on the North Coast, including government, healthcare, finance and real estate, and professional services. Despite this, the existing demand for office space is relatively weak and vacancy rates relatively high. Generally speaking, the greatest demand from users in the current office market is for smaller office spaces, with Downtown Eureka the strongest performing district within the office real estate market. According to local real estate brokers, moving into the next fifteen to twenty years, it is anticipated that there will be modest growth in office demand that will build slowly over time. Opportunities for office development should be focused near other complementary office uses as well as daytime dining and business services establishments. Medical offices will tend to gravitate towards the locations of other medical facilities, such as the hospital.

Opportunities for Industrial Uses

Industrial uses most closely associated with Eureka include those related to the timber industry, and to fishing and other maritime activities. These export-oriented uses have historically served as the region's economic base and, although diminished, remain important today. According to the EDD, employment in industrial sectors declined significantly since the 1990s, with most of this shift a result of declines in durable goods manufacturing and, to a lesser extent, non-durable goods manufacturing. According to local real estate brokers, smaller industrial operations are expanding and generating demand for light industrial and warehouse spaces. The City has little to no industrial land available that is not regulated as CDI or located in the Coastal Zone.

Industrial facilities have the potential to create impacts on adjacent land uses; thus, it will be important to consider neighboring sensitive land uses when locating new industrial facilities. If the uses would generate heavy truck traffic, they should be sited on parcels where direct truck route access is possible and potential for conflicts with other types of traffic is minimized.

Excess of Coastal Dependent Industrial Land Use

Humboldt Bay is a natural hub for CDI activity. In addition to serving as a shipping port for timber products, the Port of Humboldt Bay is also a natural location to serve as a center for commercial fishing activity, including serving as a home port for fishing vessels and a location for seafood processing and distribution facilities. Parts of Humboldt Bay itself host aquaculture operations for oyster production, and the Port of Humboldt Bay also handles petroleum products and general cargo shipments as well as the occasional cruise ship. Given this range of activity, Eureka hosts an array of on-shore facilities related to this trade activity, with additional facilities spread throughout the Bay, such as the Samoa Peninsula and Fields Landing.

There is most likely a substantial excess of CDI land surrounding Humboldt Bay; however, the City of Eureka only has land use jurisdiction over a portion of the region's CDI land. It will be valuable for the City to coordinate planning efforts with Humboldt County and other major private and public entities e.g., the HBHRCD) in order to demonstrate to the Coastal Commission that the land needs for CDI uses will be adequately met on appropriate sites available within the region. If successful, this would then open up the possibility to re-designate CDI sites within the City of Eureka that may be identified as excess for more flexible use by non-CDI activities.

- Given the location considerations for different uses presented above, it may be most appropriate to focus certain CDI activities on the Samoa Peninsula, and certain CDI activities on Eureka's waterfront. For example, fishing-related activities and infrastructure traditionally associated with Eureka's waterfront, such as docks and associated on-shore facilities for fishing boats, are part of the charm of the Eureka waterfront and constitute part of its attractiveness as a tourism destination. On the other hand, certain heavy industrial activities, such as bulk cargo storage and handling, may be more appropriate on the peninsula.
- Short of redesignating CDI land for other uses, the City may also consider seeking Coastal Commission approval to allow "interim" or "temporary" uses on CDI land.

Summary of Key Findings

- Given the increasing share of older, retirement age households, households with single people living alone, and couples without children, the City is likely to experience slackening demand for single-family housing, and a corresponding increase in demand for smaller higher density housing units.
- The City's RHNA provides an indicator of the general distribution of housing affordability that would help to meet the needs of all economic segments of the community. In general, identified lower income affordability needs can most practically and economically be met through the availability of higher density housing units.
- The below average educational attainment in the County and City is a critical factor in the attractiveness of the area to employers that require a skilled and highly educated workforce.
- The City of Eureka has experienced above average unemployment in recent years, with the types of jobs that are available shifting away from manufacturing and industrial, toward a more service-based economy. Efforts are needed to address this shift and define a long term sustainable economic base for the City, while acknowledging the continued importance of Eureka's traditional base industries.
- There has been a significant decline in overall cargo activity at the port. Improving transportation efficiency between Eureka and other parts of Northern California and the national rail and highway transportation system would enhance the competitiveness of the port.
- In addition to timber production, Humboldt County has substantial production of other agricultural commodities. As a regional hub, Eureka has the opportunity to capture economic activity related to processing, marketing, and distribution of agricultural and food products.
- The marijuana industry is a significant local economic driver. Given the magnitude of the industry in Humboldt County, the trend towards relaxed laws pertaining to production and use of marijuana in the U.S. is an important concern for local economic development.
- The City of Eureka is a hub for retail commerce in Humboldt County, capturing a large portion of the countywide retail sales and tourism economy. Despite its position, locally based retail establishments in Eureka are struggling, very little new retail space is being produced, and market projections anticipate a relatively modest demand for additional retail space.
- There is a recognized need for general clean-up and beautification in areas meant to attract tourists, such as the Broadway Corridor.
- The City of Eureka functions as a hub for office-based industry on the North Coast. Despite this, the existing demand for office space is relatively weak, vacancy rates high, and it is anticipated that there will be modest growth in office demand that will build slowly over the next fifteen to twenty years.
- Employment in industrial sectors declined significantly since the 1990s, with most of this shift a result of declines in durable goods manufacturing. Despite this, smaller industrial operations are expanding and generating demand for light industrial and warehouse spaces; however, the City has little to no industrial land available that is not located in the Coastal Zone, or further restricted as coastal-dependent.
- There is most likely a substantial excess of CDI land surrounding Humboldt Bay; however, the City of Eureka only has land use jurisdiction over a portion of the region's CDI land. It will be important for the City to coordinate with the County and other entities to demonstrate to the Coastal Commission that the land needs for CDI uses will be adequately met on appropriate sites available within the region.
- It may be most appropriate to focus certain CDI activities such as bulk cargo storage and handling on the Samoa Peninsula, and focus others such as fishing-related activities more traditionally associated with the City and its character on Eureka's waterfront.

References

Articles and Reports

Caroline Pomeroy, C. J. (2011). *California's North Coast Fishing Communities, Historical Perspective and Recent Trends, Eureka Fishing Community Profile.* La Jolla, CA: California Sea Grant College Program.
Dean Runyon Associates. (May, 2013). *California Travel Impacts by County, 1992-2011.* Sacramento: California Tourism and Travel Commission.
Greenson, T. (2011, December 4). Humboldt's $400 million question: bankers thesis quantifies impact of pot on local economy. *The Times Standard* , pp. http://www.times-standard.com/ci_19468081.
PB Ports & Marine. (2003). *Harbor District Revitalization Plan.* Eureka, CA: Humboldt Bay Harbor Recreation and Conservation District.
Schniepp, M. (2013). *California County-Level Economic Forecast 2013-2040.* Sacramento, CA: California Department ofTransportation.
Travel Economics. (2013). *California Travel and Tourism Outlook, October 2013.* Sacramento: California Travel and Tourism Commission.

Other Data Sources

California Association of Realtors, distressed home sales data

California Department of Finance, Population and Housing Estimates

California Department of Fish and Game, commercial fish landings, 2000-2012

California Department of Forestry, State Forest Notes, No. 74, 1979

California Department of Transportation, California County-Level Economic Forecast 2013-2040

California Employment Development Department, Employment by Industry, 2014

California Employment Development Department, Employment Forecasts, 2015-2040

California Employment Development Department, Labor Market Information, 2014

California Employment Development Department, Monthly Labor Force Data for Cities and Counties, 2014

California State Board of Equalization, Taxable Sales, 2014

California State Board of Equalization, Timber Yield Tax data, 2014

California State Department of Finance, Population Projections to 2040

City of Eureka, Public Review Draft Housing Element, 2013

City of Eureka, residential building permit information, 2005-2013

Claritas, Inc., retail gap analysis, 2014

Dataquick Information Systems, Humboldt County home sales data

Humboldt County Association of Governments, 2014-2019 Regional Housing Needs Allocations

Humboldt County Department of Agriculture, Annual Crop Reports, 1993-2012

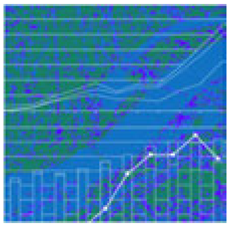
Pacific Maritime Association, assessable cargo reports, 2014

Urban Land Institute, Dollars and Cents of Shopping Centers/The SCORE, 2008

U.S. Bureau of Labor Statistics, Consumer Price Index

U.S. Bureau of the Census, 2000 and 2010 Census

U.S. Bureau of the Census, 2008-2012 American Community Survey



Humboldt Bay
Maritime Industrial Use Market Study
FINAL REPORT

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Humboldt Bay Maritime Industrial Use Market Study Final Report

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Executive Summary

BST Associates was retained by Humboldt County to prepare an assessment of the long-term demand for land zoned for Coastal-Dependent Industry (CDI) on Humboldt Bay, and to compare this demand with the existing supply.

Supply

- Humboldt Bay currently has 1,380 acres of property zoned for Coastal-Dependent Industrial use. Of this total, 1,100 acres are on land and 278 acres are in the water. More than two-thirds of the property, or 948 acres, is located on the Samoa Peninsula.
- Projected sea level rise may impact a significant portion of the CDI land. As much as 113 acres may be vulnerable by 2030, and as much as 400 acres by 2100.

Economic Background

- Demand for CDI land has been falling for decades.
- The decline in demand is due mainly to the decline of the forest products industry.
- Demand from the forest products industry is unlikely to recover.
- The number of jobs in coastal-dependent industries (primarily forest products and commercial fishing) has fallen substantially. While this decline may have stopped, employment in these industries is not projected to grow substantially.
- The population of Humboldt County is projected to grow at a low rate, i.e. 0.2% per year.
- Marine terminals on Humboldt Bay are farther from inland markets than most other ports on the West Coast. Combined with a lack of rail infrastructure, this makes it unlikely that Humboldt Bay can attract high-volume marine cargo.

Growth and new uses

- Industries most likely to show growth in demand for CDI property are local marine cargo, commercial fishing, mariculture, marine research, and recreational boating.
- A multi-use marine cargo terminal could handle most of the projected growth in local bulk and breakbulk cargo, and possibly a limited volume of local container traffic.
- A system of "marine highways" to shift freight traffic from roads to water has been discussed and studied. This traffic could likely be handled at the multi-purpose terminal.
- Humboldt Bay may see an increase in cruise ship visits, to as many as 10 per season. This traffic can likely be handled at existing facilities.
- Humboldt County quarries may be able to compete for aggregate business in the San Francisco Bay Area and Southern California.
- Humboldt Bay has a potential future in exporting shellfish seed and larvae cultivated in subtidal areas.
- A National Marine Research and Innovation Park (NMRIP) has been proposed for repurposing of the Samoa pulp mill into a multi-use facility housing both research and commercial opportunities in aquaculture, biomass conversion, and renewable energy.

Projected Demand

- Current demand for CDI land is 121 acres.
- Future demand is projected to range from 120 to 492 acres.
- The wide range in projected demand is due to uncertainty of the potential offshore energy sector.
- Without offshore wind energy development, demand is projected to range from 120 acres to 192 acres.

Comparison of Supply and Demand

- The supply of land zoned Coastal-Dependent Industrial exceeds projected long-term demand by 600 to 980 acres.
- Under the high estimate of demand for CDI land and the high estimate of loss of CDI land due to sea level rise, the surplus of CDI land exceeds 200 acres; under lower levels of demand and/or land loss, the surplus of CDI land is higher.

Infrastructure needs

- A single multi-purpose marine terminal of approximately 41 acres could support most of the projected growth in marine cargo.
- The Samoa Peninsula is the only location with CDI properties larger than 25 acres and which are located on the 38-foot deep navigation channel.

Humboldt Bay Maritime Industrial Use Market Study Final Report

1 Introduction

1.1 Purpose

BST Associates was retained by Humboldt County to prepare an assessment of the long-term demand for land zoned for Coastal-Dependent Industry (CDI) on Humboldt Bay, and to compare this demand with the existing supply.

The results of this analysis will be used by the County to determine which properties should remain zoned for CDI and which might be rezoned for other industrial uses, if it is determined that the supply exceeds projected long-term demand.

In addition, throughout the report we address the types of infrastructure that are needed in order to meet the projected demand.

1.2 Methodology

This report uses existing reports and analyses, where possible, and combines this material with original research and interviews. A list of sources is included at the end of the report.

1.3 Description of the Study Area

Humboldt Bay is the largest harbor of commercial importance between San Francisco and Coos Bay, Oregon. The Bay is 14 miles long and 4.5 miles wide at its broadest point, and is divided from the ocean by two sand spits. The Bay is generally divided into the North Bay, Middle Bay, and South Bay.

Most Coastal-Dependent Industrial uses are concentrated in the Middle Bay, with some in the South Bay. The North Bay is relatively shallow, with more than half exposed as mudflats during low tide. The North Bay is separated from the Middle Bay by a fixed-span highway bridge that prevents large vessels from entering the North Bay. No CDI lands are located in the North Bay.

The Middle Bay runs north from the Bay entrance channel to the highway bridge, with the north spit to the west and the city of Eureka to the east. A 38-foot deep navigation channel serves numerous current and former marine terminals and industrial sites on the east and west banks of the Middle Bay. Most of the CDI lands are located on the Middle Bay.

The South Bay is located south of the entrance channel and is fairly similar in character to the North Bay, with more than half exposed as mudflats at low tide. A 26-foot deep navigation channel provides access to several unused or underutilized CDI properties along east bank.

Historically, two of the largest industries in the region were forest products and commercial fishing. Both of these have seen significant long-term declines and are not projected to recover to their former levels. This significantly impacts the future demand for Coastal-Dependent Industrial lands, since a large share of the vacant CDI lands were once used for manufacturing and shipping forest products.

1.4 SUMMARY OF SUPPLY AND DEMAND

The current use and future demand for CDI land was analyzed for a number of different uses, including marine cargo, commercial fishing, recreational boating, mariculture, marine research, and offshore energy. Current estimated use of CDI lands is 121 acres, of which nearly half is related to marine cargo and half to fishing and recreational boating. A smaller share is also used for mariculture.

Projected future demand spans a wide range, due to the uncertainty of the potential offshore energy sector. Without offshore energy, future demand is estimated to range from 120 acres under the low case to 192 acres under the high case. The high case includes growth in demand from marine cargo, fishing and recreational boating, mariculture, and marine research.

Estimates of demand for CDI land from offshore energy are extremely uncertain at this time. Initial planning is underway by parties interested in the concept, but the future scale of the sector is unknown. Estimated demand for CDI ranges from 0 acres under the low forecast to 300 acres under the high forecast, but could end up anywhere in that range.

Table 1-1: Summary of Current CDI Use, Future Demand, and Supply

	Current	Future Acres		Change in Acres		
Use Category	**Acres**	**Low**	**High**	**Low**	**High**	**Comments**
Marine Cargo	54	46	95	-8	41	A single multi-use terminal may accommodate other general cargo, marine highway, and containers
Fishing & Recreational Boating	60	64	67	4	7	
Other Uses						
Mariculture	7	10	20	3	13	
Marine Research	0	0	10	0	10	
Offshore Energy	0	0	300	0	300	Large range of uncertainty
Sub-Total	7	10	330	3	323	
Total	121	120	492	-1	371	
Existing Supply	1,100	1,100	1,100			
Surplus	979	980	608			

Source: BST Associates

2 Supply Analysis

2.1 Existing Supply

Humboldt Bay currently has 1,380 acres of property zoned for Coastal-Dependent Industrial use. Of this total, 1,100 acres are on land and 281 acres are in the water.

More than two thirds of the CDI property, or 948 acres, is located on the Samoa Peninsula. Approximately half of the remainder is located in Eureka (i.e. 225 acres), and the rest is split between Fields Landing (i.e. 139 acres), and King Salmon (i.e. 69 acres).

Projected sea level rise may impact a significant portion of the CDI land. According to the high estimate of sea level rise, by the year 2030 as much as 113 acres of CDI land may be vulnerable to inundation. By 2050 this may increase to 278 acres, and by 2100 as much as 400 acres of CDI land may be vulnerable.

Table 2-1: Supply of CDI Land

Location	Land	Water	Total
Eureka	133.9	90.8	224.7
Samoa Peninsula	802.5	145.6	948.1
Fields Landing	99.6	38.9	138.5
King Salmon	63.9	5.2	69.1
Total	1,099.9	280.5	1,380.4

Source: Humboldt County Planning Department

2.2 Description of Land Use and Zoning

The Humboldt Bay Area Plan (HBAP), a component of the County's Local Coastal Program, states that the purpose of the land use designation Industrial/Coastal-Dependent (MC) is to protect and reserve parcels on or near the sea for industrial uses dependent on, or related to, the harbor.[1] Under the HBAP, principal uses allowed on MC lands include any coastal-dependent industrial use that requires access to a maintained navigable channel in order to function, including, but not limited to:

- public docks,
- waterborne carrier import and export operations,
- ship building and boat repair,
- commercial fishing facilities, including berthing and fish receiving, and fish processing when product is for human consumption,
- marine oil terminals,
- offshore oil service or supply bases,
- ocean intake, outfall or discharge pipelines, and
- pipelines serving offshore facilities, aquaculture and aquaculture support facilities.

[1] Humboldt County, *Humboldt County General Plan for the Areas Outside the Coastal Zone*, adopted October 23, 2017

Lands with a land use designation of MC are generally zoned Industrial/Coastal-Dependent (MC), as well. Principally permitted uses in the MC zone district are: Minor Utilities; Coastal-Dependent (subject to Coastal-Dependent Industrial Development Regulations); and Aquaculture (subject to Coastal-Dependent Industrial Regulations).

2.3 Description of Humboldt Bay

This following description of Humboldt Bay is taken from the Humboldt Bay Area Plan.

> Humboldt Bay is by far the largest and most important estuary on the Northern California coast. It is also the only harbor of commercial importance for major shipping between San Francisco and Coos Bay, Oregon. The Humboldt Bay Planning Area extends from the Mad River to Table Bluff/Hookton Road, excluding the cities of Eureka and Arcata. The coastal zone runs inland to include flood prone bottomlands south of the Mad River, important drainages at Freshwater Creek and Elk River, and Hookton Slough which drains into South Bay.
>
> Humboldt Bay: The Bay itself is 14 miles long and 4.5 miles wide at its broadest point. The Bay system is protected from the ocean by two sand spits, separated by the Bay entrance which is maintained by two rubblemound jetties. Dredged channels extend two miles into South Bay and four miles north from the Bay entrance. Numerous natural tidal channels are also present.
>
> Excluding its tributary sloughs, the Bay is about 16,000 acres in area. Historically the Bay was much larger, perhaps 27,000 acres, but land reclamation of salt marshes and mud flats has reduced it to its present size.
>
> The North (Arcata) Bay covers an area of approximately 8,000 acres. Most of this area, excluding a number of channels formed by tributaries and tidal erosion, is relatively shallow. At low tide 4,500 acres of mud flats are exposed. The areas immediately north and east of North Bay were once marshlands, much of which now serve as pasture.
>
> To the west the North Bay is separated from the Pacific Ocean by a vegetated expanse of forest and dunes that extends north to the Mad River. This dune forest habitat is one of the few stands of its type between Crescent City and Fort Bragg.
>
> The Middle Bay forms a channel which connects the North and South Bays. This channel is nearly six miles long and ranges between ½ and one mile in width. Woodley and Indian Islands are located at the north end of the Middle Bay.
>
> The South Bay is fairly similar in character to the North Bay with a total area of about 4,670 acres, 57% of which are exposed mudflats at low tide. The Hookton Channel, with an average depth of 26 feet, provides deepwater access to King Salmon and Fields Landing. Most of the agricultural area east and south of South Bay is comprised of diked former tidelands.
>
> The Spit separating the South Bay from the ocean is typically more narrow and sparsely vegetated than the North Spit. It is also subject to inundation from the ocean during periods of high tides and seas.[2]

[2] Humboldt County, *Humboldt Bay Area Plan of the Humboldt County Local Coastal Program*, December 2014

2.4 ACREAGE BY LOCATION

2.4.1 Samoa Peninsula

2.4.1.1 History

The Vance and Garwood Lumber Company was established in Eureka in 1856, and moved to a new mill and company town on the Samoa Peninsula in the 1890's. In 1900, the Vance Redwood Lumber Company was sold to A.B. Hammond, and became part of the Hammond Lumber Company. In 1956 the company was sold the Georgia Pacific Corporation (G-P), and in 1972 a portion of G-P was spun off into a newly created company, the Louisiana Pacific Corporation.

The Samoa Pulp Mill was built on the site of the lumber mill in 1965 by Georgia Pacific, and then became a part of Louisiana Pacific when that company was created. In subsequent years the mill operated as Samoa Pacific Cellulose and Stockton Pacific. The mill and town were sold in 1998 to a new company called Simpson-Samoa. At that time, the town of Samoa was one of only two intact lumber company towns in northwestern California.[3]

In 2000, Simpson-Samoa reopened the pulp mill, which had closed in 1993, and sold the remainder of the site to the Samoa Pacific Group LLC. By this time most of the buildings on the mill site had been demolished. The Simpson-Samoa pulp mill was later sold to Evergreen Pulp and finally to Freshwater Tissue Company, before closing for good in 2008. The Humboldt Bay Harbor, Recreation and Conservation District (Harbor District) purchased the site in 2013, and much of the facility has since been demolished.

South of the town of Samoa, Simpson purchased U.S. Plywood's Mutual Plywood Mill at Fairhaven, California for $1 million and an option to buy about 40 million bd. ft. of stumpage. Simpson modified the Mutual Plywood mill to produce redwood siding, changed its name to Fairhaven Plywood, and closed the obsolete Eureka Plywood Mill. With its Mad River and Fairhaven mills, Simpson became the largest plywood producer in California – annual production of 235 million sq. ft. (3/8" basis) of Douglas fir, redwood and overlaid panels.[4]

Crown Zellerbach and Simpson created a new company in 1966 (Crown Simpson), which built a second pulp mill on the Samoa peninsula in 1966, at Fairhaven. Simpson later purchased entire control of the plant from Zellerbach, and operated the mill until it closed in 1992.

2.4.1.2 Existing CDI Property

A large share of the MC-zoned property on the Samoa Peninsula is at the Eureka Municipal Airport. The airport is located near the south end of the peninsula, west/southwest of the old Fairhaven mill site. The airport is located on a single parcel encompassing 311.0 acres, including 272.4 acres that are zoned MC. Included in this MC acreage are 259.1 acres of land and 13.3. acres of water.

Most of the airport property is located along the Pacific Ocean shoreline, and to the west of New Navy Base Road. A small portion of the parcel is located east of the road, along Humboldt Bay. The portion

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[3] Humboldt State University Special Collections website, http://library.humboldt.edu/humco/holdings/LPHammondAid.htm#publicinfooffice (accessed 2-16-2018).

[4] Simpson Timber Company, *Five Generations of Family Management, Number 22*, September 1999.

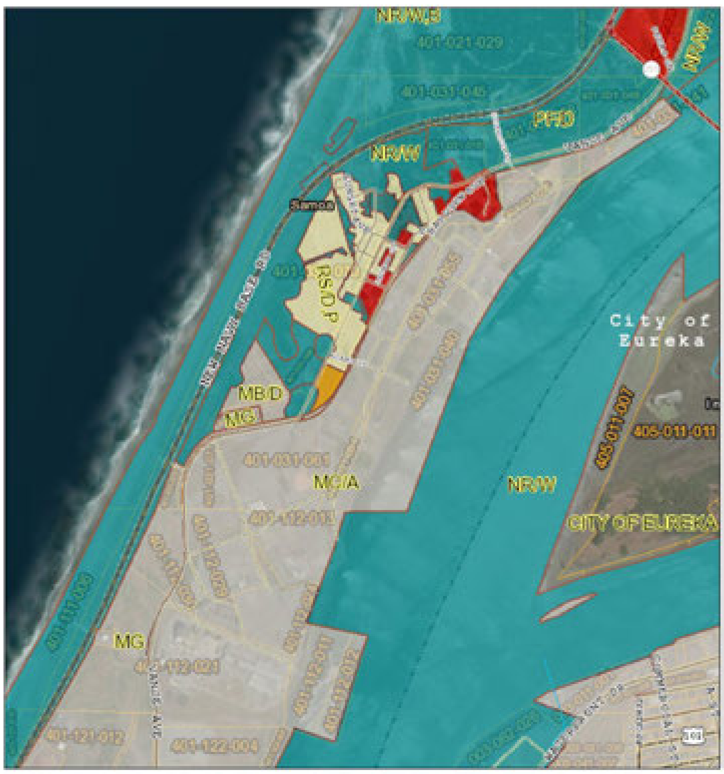
east of the road is vacant and contains no dock or other structures. The airport has not been used for coastal-dependent industries since before World War II. The U.S. Navy operated coastal patrol blimps from the property during World War II, after which it was developed into Eureka Municipal Airport. The site also contains the Samoa Drag Strip, which was built in 1952 and runs parallel to the runway.

Immediately north of the small portion of airport property on Humboldt Bay is a 27.1 acre parcel that is zoned MC, with 23.4 acres of land and 3.7 acres of water. The property is currently in residential use; it has a single residence, and no dock. It does not appear to have had coastal-dependent industrial uses in the past. It is owned by O'Connor and Cirincione.

North of the O'Connor/Cirincione property is a 31.9 acre parcel owned by the City of Eureka. This parcel is vacant. The parcel is located on Humboldt Bay, but does not have a dock, and does not appear to have had coastal-dependent industrial uses in the past.

Finntown is a small enclave of approximately nine residences and a few small industrial businesses. It is located on the bay front approximately midway along the peninsula.

Figure 2-1: Map of Samoa Peninsula



Source: Humboldt County GIS

Table 2-2: MC Property on Samoa Peninsula

Owner	Land	Water	Total
City of Eureka	330.8	13.3	344.1
Harbor District	118.2	35.6	153.8
California Redwood Co.	77.3	0.6	77.9
Sequoia Investments	96.4	13.9	110.3
Other	179.8	82.2	262.0
Total	802.5	145.6	948.1

Source: Humboldt County Planning Department

Existing facilities on the Samoa Peninsula include:

Fairhaven Terminal is located at the former site of Crown-Simpson Pulp Mill and is now owned by Sequoia Investments X LLC. The dock was used for shipping and receiving conventional general cargo, wood pulp, and lumber. The property has a variety of uses, but most of these are not coastal-dependent. The Fairhaven property also contains a number of buildings formerly associated with the mill, as well as a large amount of vacant land.

Redwood Marine Terminal 2 is the site of the majority of the former Freshwater Tissue property. Commonly known as the Samoa pulp mill site, it is now the Harbor District's Redwood Marine Terminal 2 (RMT 2). The District purchased 72-acres of the industrial site in August of 2013 for $1. An adjacent 17 acres is also being purchased, making the entire District-owned complex 89 acres. As an abandoned site, the remaining pulp liquors and other contaminants represented an enormous hazard to Bay health. The District immediately engaged EPA in cleanup. With phases 1 and 2 done, new tenants have begun to move in. One of these tenants is Taylor Mariculture, which makes use of the existing industrial infrastructure to grow clam and oyster seeds. Humboldt County, in cooperation with the Harbor District, has received a Community Development Block Grant (CDBG) to engineer the reuse of the water and wastewater facilities in order to plan for upgrades.

California Redwood Chip Export Dock. The California Redwood Chip Dock was originally constructed to serve the Samoa pulp mill. In 2010, Samoa Properties Inc. acquired the export facility when the Samoa pulp mill was sold to Evergreen Pulp. Prior to this acquisition, the dock had been idle for approximately a decade. The California Redwood Company uses the wood chip export facility to export sawmill byproducts to overseas customers.[5]

Redwood Marine Terminal 1. The Redwood Marine Terminal 1 (RMT 1) is owned by the Harbor District, and was formerly the Town of Samoa Wharf and Dock. Redwood logs were shipped to the site by rail where they were milled into lumber, and then the lumber was shipped out by water. The property now houses a variety of operations; RMT 1 functions primarily as a working dock for commercial fishermen, but also houses an aquaponics research facility and a hagfish processing/shipping operation. Adjacent to RMT 1 are the Samoa Shops and railroad roundhouse, which are being renovated into a museum. The adjacent historic Town of Samoa is also undergoing renovation.

2.4.2 Woodley Island

The Woodley Island Marina is located across Eureka Channel from downtown Eureka and is at the end of the navigation channel. The marina is owned and operated by the Humboldt Bay Harbor Recreation and Conservation District, and is used for mooring commercial fishing boats, and recreational and other small craft. The marina is located in land zoned as "Public Facilities – Marina", as opposed to "Coastal-Dependent Industry".

2.4.3 Eureka

Within the City of Eureka there 79 parcels containing a total of 225 acres of CDI zoned property, of which 134 acres are land and 91 acres are water. These properties currently host a mix of CDI and non-

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[5] Driscoll, John, "California Redwood looks to restart chip export facility; ships would move sawmill byproduct to Asian markets", *The Times-Standard*, October 15, 2010. http://www.times-standard.com/article/zz/20101015/NEWS/101019432 (accessed March 8, 2018).

CDI uses. The 79 parcels of CDI property in Eureka are combined into 25 properties; some of these properties contain only one parcel and some contain multiple parcels.

The CDI properties in Eureka are relatively small when compared to those on the Samoa Peninsula or at Fields Landing. As shown in Table 2-3, 12 of the 25 properties are less than 3 acres in size, including both land and water acreage. Three of the properties are between 3 and 10 acres, six properties are 10 to 20 acres, and four properties are larger than 20 acres. None of the properties is larger than 24 acres.

All but one of the properties are currently zoned MC. The one exception is a 2.9-acre water parcel south of the Chevron Terminal.

While these properties (with the one exception) are zoned for coastal-dependent industry (i.e. MC zoning), many were not historically used for coastal-dependent purposes, and even fewer are currently in CDI use. Of the 25 properties, 14 were historically in CDI use and 11 were not. The 14 properties encompass approximately 110 acres, including 72 acres of land and 38 acres of water. Property not historically in CDI use totals 114 acres, including 62 acres of land and 52 acres of water.

Only nine of the 25 properties are currently in CDI use. These nine properties total 86 acres, including 54 acres of land and 32 acres of water. Property not currently in CDI use totals 138 acres, including 79 acres of land and 59 acres of water.

Table 2-3: CDI Property in Eureka

			Acres (approx.)			CDI Status		
Sub Area	#	Description	Land	Water	Total	Current Use	Historical Use	Zoned MC
1	1	Fisherman's Terminal	2.3	0.2	2.5	Yes	Yes	Yes
1	2	Coast Seafood / Sanford	1.7	1.2	2.9	Yes	Yes	Yes
1	3	Old Ice House	1.4	0.0	1.4	No	Yes	Yes
1	4	COE Parking Lot East of Bar Fly	1.1	0.4	1.5	No	Yes	Yes
1	5	EDA Fish Plant (Pacific Choice)	2.0	0.1	2.1	Yes	Yes	Yes
1	6	Marina, Public Bathroom, and Parking Lot	1.7	1.1	2.8	No	No	Yes
2	7	City-owned Parcel in center of Marina Way	2.9	-	2.9	Yes	Yes	Yes
2	8	Wharfinger, Dock B, and Schneider Dock	1.3	16.3	17.6	Yes	Yes	Yes
2	9	Schneider Properties	21.4	-	21.4	Yes	Yes	Yes
2	10	Tosco (Former Renner Bulk Plant)	4.3	2.8	7.1	Yes	Yes	Yes
2	11	Eureka Forest Products	15.3	4.2	19.5	Yes	Yes	Yes
2	12	Isolated Parcel within Eureka Forest Products	1.4	-	1.4	No	No	Yes
2	13	Preston Properties	12.1	9.4	21.5	No	No	Yes
3	14	Peninsula Directly South of Del Norte St	5.7	14.6	20.3	No	No	Yes
3	15	Waterfront West of Poleshed	3.4	20.6	24.0	No	No	Yes
3	16	Mall Back Lot	6.3	-	6.3	No	No	Yes
3	17	Parcel 4 and North	14.8	3.0	17.8	No	Yes	Yes
4	18	Chevron	3.4	7.0	10.4	Yes	Yes	Yes
5	19	Waterfront South of Chevron	0.0	0.3	0.3	No	Yes	Yes
5	20	Offices South of Chevron	0.8	-	0.8	No	No	Yes
5	21	Water South of Chevron	0.0	2.9	2.9	No	Yes	No
5	22	Hikshari Trail North	3.8	3.4	7.2	No	No	Yes
5	23	Truesdale South Trailer Park Area	14.7	-	14.7	No	No	Yes
5	24	Residential N. of HBF Training Grounds	0.5	-	0.5	No	No	Yes
5	25	HBF Training Grounds	11.6	3.3	14.9	No	No	Yes
		Total	133.9	90.8	224.7			

Source: City of Eureka

The City of Eureka grouped the 25 properties into five sub-areas for their 2017 analysis of CDI property. (See Figure 2-2). These sub-areas are numbered one through five, arranged from north to south.

Sub-Area 1 includes six properties:

- Fishermen's Terminal is a 2.5-acre property that is currently in CDI use, including 2.3 acres of land and 0.2 acres of water. This processing facility is used by several fish processors, as well as a seafood restaurant.
- The Coast Seafood / Sanford property is 2.9 acres, most of which is in CDI use. The property includes approximately 2.2 acres that are occupied by the Coast Seafood processing plant and the adjacent 0.7-acre vacant property. Total land area of the property is 1.7 acres and water area is 1.2 acres.
- The Old Ice House property has been vacant since Eureka Ice and Cold Storage closed in 2008. This property is 1.4 acres, all of which is land.
- The City of Eureka owns a 1.5-acre property to the west of the old ice house that is used as a parking lot (i.e. non-CDI use). This property includes 1.1 acres of land and 0.4 acres of water.
- The EDA Fish Plant is located on a 2.1 acre property owned by the City of Eureka. This property is in CDI use, with a fish processing plant currently operated by Pacific Choice. The property includes 2.0 acres of land and 0.1 acre of water.
- The remainder of sub-area one is used by the City of Eureka marina, along with the associated parking lot and restroom facility. This property is 2.8 acres, including 1.7 acres of land and 1.1 acres of water.

Sub-Area 2 is located to the southeast of Sub-Area One. It is the largest of the five sub-areas, accounting for 91 of the 225 acres. More than a third of this sub-area is water acreage; water accounts for nearly 33 acres and land 59 acres. Most of the waterborne cargo activities in Eureka occur in this sub-area.

- The northernmost property is a city-owned parcel that is currently vacant. This parcel is 2.9 acres, all of which is land. The parcel is adjacent to Dock B.
- To the west and south of the City parcel is large water parcel that has several docks. The property is 17.6 acres, of which 16.3 acres is water and 1.3 acres is land. The property contains Humboldt Dock B, which is unused and in poor condition. The dock is approximately 200 feet long, and the navigation channel adjacent to the dock has an authorized depth of 26 feet. This property also contains the Schneider dock currently used for exporting logs.
- Adjacent to the city-owned parcel is the 21-4-acre Schneider property. This property is currently in CDI use, and is where logs are handled for export via the Schneider dock.
- South of the Schneider is the 7.1-acre former Tosco Refining property. This property was historically used for receiving and storing petroleum products, but the oil receiving equipment and tanks have been removed, and contamination has been remediated.
- Eureka Forest Products owns a 19.5-acre property that is currently used for shipping woodchips by water. The property includes 15.3 acres of land and 4.2 acres of water, and has a dock in active use.
- Surrounded by the Eureka Forest Products property is a vacant 1.4-acre property that is zoned MC but has not historically been used for CDI purposes.
- At the south end of Sub-Area 2 is Preston Properties, a 12.08 acre former plywood mill site. The property contains several large buildings, with some current non-CDI use. Most of the property (i.e. 9.37 acres) consists of tidelands that historically served as a log pond.

Sub-Area 3 is the second-largest of the sub-areas, containing a total of 68.5 acres. The majority of this property is water acreage; water accounts for 38.3 acres and land accounts for 30.2 acres. None of the property is currently in CDI use, and most is natural area.

- The first property is a 20.3-acre parcel located adjacent to and south of the Del Norte Street Fishing Pier. This property consists mainly of a natural area, but also contains a parking lot for the fishing pier. It is not in CDI use, and was not historically in CDI use. Most of the property (i.e. 14.6 acres) is water, and the remaining 5.7 acres is land.
- The next property to the south is also primarily natural area that has not historically been used for CDI purposes. Total area is 24.0 acres, of which 20.6 acres is water and 3.4 acres is land. This property and the one adjacent are located between the tide line and the new Humboldt Bay Trail. This trail is located along the right of way of the North Coast Railroad Authority.
- Located east of the Humboldt Bay Trail is a 6.3-acre parcel that contains a parking lot for the Bayshore Mall. This property is not in CDI use, and was not used historically for CDI purposes.
- West of the mall and south of the two natural area properties is a 17.8-acre property that is also now primarily natural area. The property historically had CDI uses but has been vacant for decades.

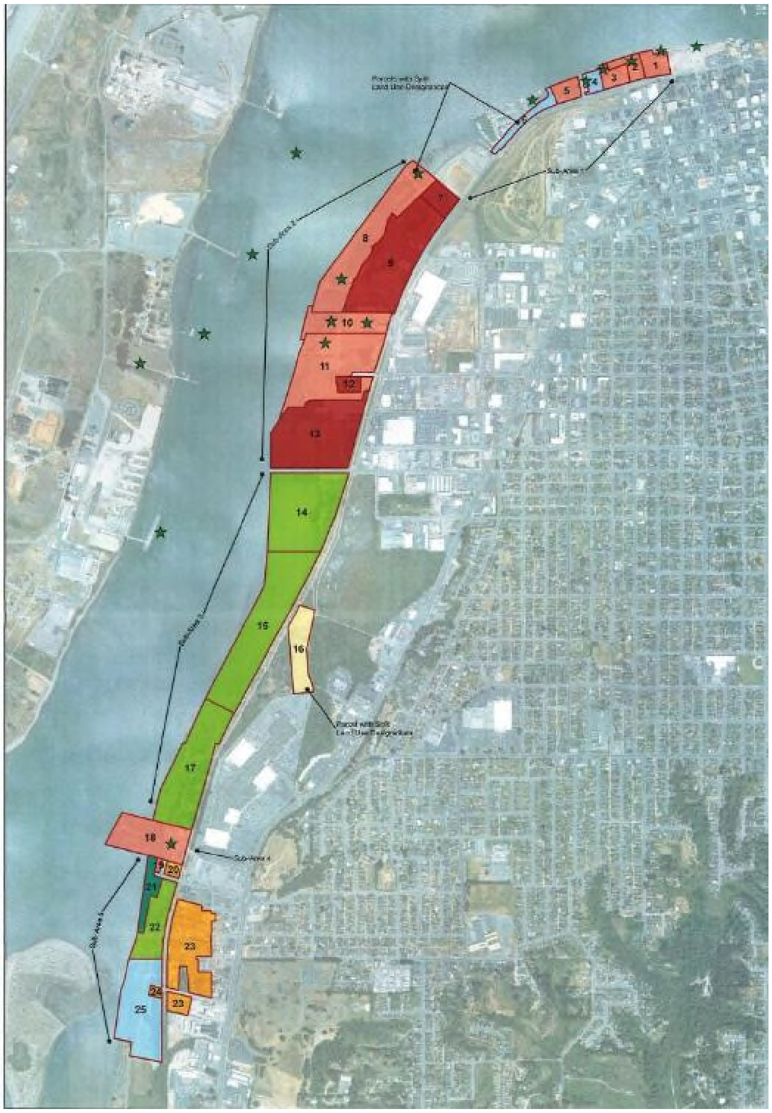
Sub-Area 4 has one property, which is the location of the Chevron Terminal.

- The Chevron Eureka Terminal is a 10.4-acre property that contains the dock and bulk fuel storage facility. Seven acres of the property are water and 3.4 acres are land. The facility receives petroleum products by barge and ships them out by truck. Approximately 80% of the fuel used by the greater Eureka area is delivered via barge to the Chevron Terminal.

Sub-Area 5 has 41.2 acres of property, including 31.4 acres of land and 9.9 acres of water. None of the properties currently has CDI uses, and only one of the seven properties historically had CDI use.

- The northernmost property consists of three parcels that are primarily water, and that contain a total of 0.3 acre. This property is not currently in CDI use, and was not historically in CDI use.
- Across Christie Street to the west is a 0.8-acre property. This property has several non-CDI office buildings on it, and the property was not historically in CDI use.
- Five water parcels form a 2.9 acre property to the south of the 0.3 acre property. This property is not currently in CDI use, and but a portion of it was used for CDI purposes.
- A number of parcels are combined into one 7.2-acre property that contains the City's Hikshari Trail, a recreational trail that runs along the waterfront. Although zoned MC, this was not historically in CDI use.
- The largest property in Sub-Area Five is the 14.7-acre Truesdale South Trailer Park Area. This property is in residential use, and was not historically in CDI use.
- The southernmost property in Sub-Area 5 is 14.9 acres used by Humboldt Bay Fire as training grounds. The property contains 11.6 acres of land and 3.3 acres of water. The current use is non-CDI, and the property was not historically in CDI use.

Figure 2-2: Map of Eureka



Source: City of Eureka

2.4.4 Fields Landing and King Salmon

The Fields Landing - King Salmon area is located on the east side of Humboldt Bay, south of the entrance channel and along the 26-foot Fields Landing Channel. The North Coast Railroad right of way runs parallel to the shoreline through this area, and the MC land is located between the shoreline and the railroad right of way.

Total MC area is 207.6 acres, including 163.5 acres of land and 44.1 acres of water.

King Salmon is located north of Fields Landing and several miles south of Eureka. Four parcels in the area are wholly or partially zoned as MC. Total MC area is 69.1 acres, of which 63.9 acres are land and 5.2 acres are water.

There are no docks associated with MC land at King Salmon.

All of the MC land in King Salmon is associated with the Humboldt Bay Generating Station, operated by Pacific Gas & Electric Company (PG&E). Originally this site contained a nuclear power plant, Humboldt Bay Power Plant, which began operations in 1963. The nuclear plant operated until 1976, when it was shut down for refueling. Due to changes in safety regulations, upgrades to the plant were uneconomical and the plant was not restarted, and the plant was subsequently used only to store spent fuel. Decommissioning of the plant was approved in 2009 and is currently in process, as is restoration of the site. This process is projected to continue for several decades. The Humboldt Bay Generating Station is a natural gas-powered facility that began operations on the site in 2010.

A key feature of the power plant site is a man-made channel that runs from Humboldt Bay to the property. The channel was previously used to provide cooling water to the nuclear power plant, but the gas-fired plant that replaced the nuclear plant does not use the same cooling process. PG&E transferred ownership of Fisherman's Channel to the Humboldt Bay Harbor, Recreation and Conservation District, and the Harbor District assumed to the responsibility for dredging the channel. This channel is crossed by several fixed low-level bridges which prevent navigation in the channel to the MC property.

Figure 2-3: Map of King Salmon

Source: Humboldt County GIS

Table 2-4: MC Property at Fields Landing and King Salmon

Location	Land	Water	Total
King Salmon			
Humboldt Bay Generating Station	63.9	5.2	69.1
Sub-total	63.9	5.2	69.1
Fields Landing			
Humboldt Bay Forest Products	52.5	23.5	76.0
Fields Landing Terminal	30.6	13.3	43.9
Small parcel marine related uses	3.9	1.1	5.0
Other	12.6	1.0	13.6
Sub-total	99.6	38.9	138.5
Total	163.5	44.1	207.6

Source: Humboldt County Planning Department

Fields Landing at one time had three cargo docks, but now there are just two. These facilities historically handled logs, woodchips, and other forest products, as well as fuel and fish. Fields Landing was also home to one of the last remaining whaling stations in the United States, which operated until 1951.

The Humboldt Bay Forest Products dock is located at the north end of Fields Landing. Humboldt Bay Forest Products controls most of the MC property at Fields Landing, including 52.5 acres of land and 13.3 acres of water, or a total of 76.0 acres. The site includes adjacent parcels from several ownerships, and contains potential wetlands, flood areas, mud flats and old pilings.[6]

The other dock is located at the mid-point of the Fields Landing shoreline, between the Humboldt Bay Forest Products dock and Fields Landing Terminal. This site consists of several small parcels owned by several different parties. MC property includes 4.1 acres of land, 1.3 acres of water, and 5.2 acres in total. Uses on the site have included fish processing and fishing related operations, as well as others.[7]

The former Kramer Dock at the south end of Fields Landing was purchased by the Harbor District and renamed Fields Landing Terminal. The terminal formerly had a dock approximately 900 feet long, but it was not in usable condition and was removed in 2010[8]. The primary use of the site is now the Fields Landing Boat Yard, operated by the Harbor District. This is self-serve facility, with the haul-out services provided by the Harbor District.[9] There is also one commercial boat repair operation at the site. The terminal encompasses a total of 43.9 acres of MC property, of which 30.6 acres is land and 13.3 acres is water.

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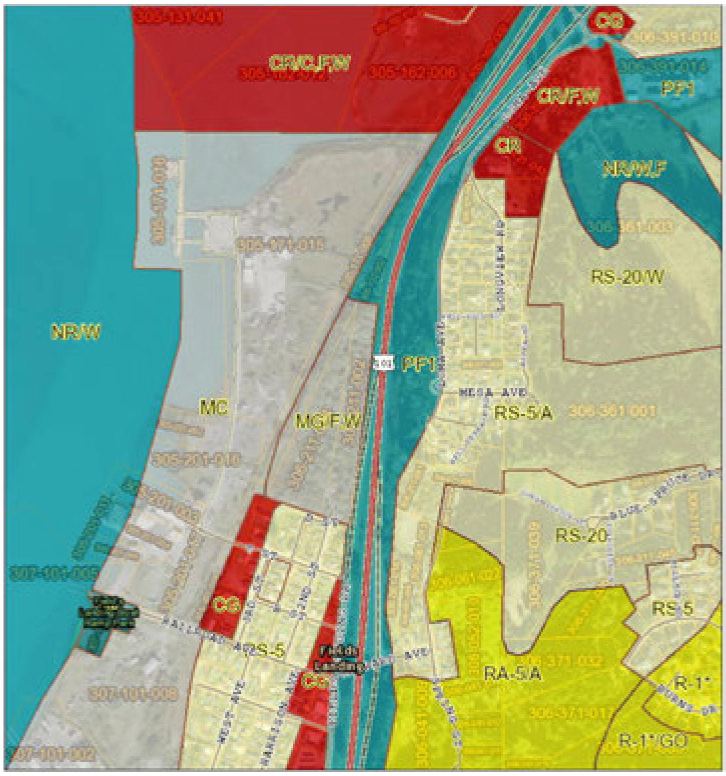
[6] PB Ports & Marine, *Port of Humboldt Bay Harbor Revitalization Plan Final Report*, February 2003.

[7] *ibid*

[8] LACO, *Technical Memorandum, Coastal-Dependent Industrial Site Inventory Review, Assessor's Parcel Numbers 401-301-05, 401-301-09, 401-311-01*, March 26, 2015.

[9] PB Ports & Marine, *Port of Humboldt Bay Harbor Revitalization Plan.*

Figure 2-4: Map of Fields Landing



Source: Humboldt County GIS

2.5 Impacts of Sea Level Rise

Rising sea levels create at the risk of inundation for many of the coastal-dependent industrial properties on Humboldt Bay.

According to a recent report prepared by Trinity Associates, there are approximately 52 miles of shoreline on Humboldt Bay that form a barrier protecting nearly 10,000 acres of low-lying areas from tidal inundation. A New Year's Eve 2005 king tide and storm surge caused sea levels to rise 1.8 feet, the highest water level ever recorded on Humboldt Bay. By 2050 sea level rise may cause king tides to rise as much as three feet, and roughly 35 miles of barrier shoreline (58% of the artificial shoreline) could be overtopped, flooding the areas protected by the barriers. This includes the communities of King Salmon, Fields Landing, and Fairhaven.[10]

The *Sea Level Rise Vulnerability Assessment*, prepared as part of the update of the Humboldt Bay Area Plan, projected the level and timing of the risk from sea level rise. This projections for sea level rise were prepared by Northern Hydrology and Engineering (NHE), based on sea level at the North Spit tide gauge. The projected high sea level rise and the planning horizon is presented in Table 2-5.

[10] Laird, Alderon, *Humboldt Bay Area Plan Sea Level Rise Vulnerability Assessment*, January 2018.

Table 2-5: Potential Tidal Inundation Due to Sea Level Rise

Year	Rise above MMMW	Rise above MAMW
2030	0.9 ft.	1.1 ft.
2050	1.9 ft.	1.6 ft.
2070	3.2 ft.	3.3 ft.
2100	5.4 ft.	4.9 ft.

Note2: MMMW is mean monthly maximum water
MAMW is mean annual maximum water
Source: Northern Hydrology and Engineering

Trinity Associates notes that "All development located in vulnerable areas is at risk of becoming inundated by saltwater, or flooded by rising groundwater. Vulnerable assets include land uses and developments, public coastal access/recreation, natural and cultural resources, transportation facilities, and utility infrastructure."

The Trinity report estimated the potential inundation of all land use types in the coastal zone. Under the high scenario, the amount of Coastal-Dependent Industrial land at risk of inundation rises from 79 acres (8% of total) in 2030 to 400 acres (41% of total) in 2100. (See Table 2-6).

Table 2-6: Potential Tidal Inundation of CDI Land Due to Sea Level Rise

Year	Current Acres	2030	2050	2070	2100
Sea level rise		0.9 Ft.	1.6 Ft.	3.3 Ft.	4.9 Ft.
Acres inundated	968	79	113	278	400
% inundated		8%	12%	29%	41%

Source: Trinity Associates

3 DEMAND – MARINE CARGO

3.1 INTRODUCTION

The purpose of this study is to identify growth trends for maritime industrial uses, refine the inventory of available maritime industrial land on Humboldt Bay, and to determine the current demand for maritime industrial uses and Industrial/Coastal-Dependent land ("MC" zoned land). The study will also determine what maritime industrial support infrastructure is needed to best match this demand, with a special focus on the Redwood Marine Terminal II site on the Samoa Peninsula. The findings of this study may be used to further protect critical lands zoned MC, as well as to rezone other MC zoned land not critical to regional maritime industrial operations.

This document builds on previous analyses, supplementing existing data with additional information gathered through stakeholder interviews, data analysis, and other relevant sources. This section also includes a brief review and forecast of the Humboldt Bay economy.

3.2 HUMBOLDT COUNTY POPULATION AND ECONOMY

Trends and forecasts for Humboldt county are presented in this section. This analysis draws heavily from the county-wide forecasts prepared by the Transportation Economics Branch, Office of State Planning, California Department of Transportation as well as the most recently completed comprehensive economic development report by Humboldt County.[11] As shown in Table 3-1, key findings include:

- Population growth has been relatively slow:
  - Humboldt County's population was 136,100 in 2016, growing at an average annual rate of 0.4% between 2000 and 2016.
  - Future population growth is projected to grow at an average rate of 0.2% per year between 2017 and 2050, with the total population projected to reach 146,500 in 2050.
  - Humboldt County accounts for 0.4% of the population in California.
- Employment has declined slightly during the past 16 years:
  - The employment base stood 51,400 in 2016, which was down approximately 1,000 employees from 2000.
  - Employment is projected to grow at an average rate of 0.3% per year between 2017 and 2050, reaching 58,000 employees in 2050.
  - Humboldt County accounts for 0.3% of California employment.

The sectors of the economy that typically use Coastal-Dependent Industrial land include resource and industrial sectors, such as natural resources and mining, manufacturing, and transportation, as well as farming, construction, warehousing, utilities, and wholesale trade. In Humboldt County these sectors accounted for 12,300 jobs in 2000, but only 8,900 jobs in 2016. Most of the decline was due to falling employment in the forest products industry, which accounts for about half of the manufacturing base.

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[11] Caltrans, Office of State Planning, Transportation Economics Branch, *California County-Level Economic Forecast 2017-2050*. September 2017.

Future employment in these sectors in Humboldt County is projected at grow at an average rate of 0.3% per year, with projected employment reaching 10,000 jobs in 2050.

- The share of jobs from resource and industrial sectors declined from 23% of all employment in 2000 to 17% in 2016, and is expected to remain at this level in 2050.
- There were 5,100 manufacturing jobs in 2000, accounting for 42% of the resource/industrial jobs. The share of manufacturing jobs declined to 23% in 2016 and is projected to remain at this level in 2050.

Table 3-1: Humboldt Bay Economic Forecast

Year	Population (thousands)	Total Employment (thousands)	Resource & Industrial Employment (thousands)	Share of Total Employment
2000	126.7	52.4	12.3	23%
2016	136.1	51.4	8.9	17%
2050	146.5	58.0	10.0	17%
Compound annual growth rate				
2000-16	0.4%	-0.1%	-2.0%	-1.9%
2017-50	0.2%	0.4%	0.3%	0.0%

Source: Caltrans

The Caltrans forecast can be used to rank employment sectors by the number of jobs projected to be created in Humboldt County between 2016 and 2050.

1. Leisure and hospitality
2. Education and healthcare
3. State and local government
4. Retail trade
5. Professional services
6. Natural resources and mining
7. Manufacturing
8. Transportation, warehousing, and utilities
9. Farm
10. Other
11. Information
12. Wholesale trade
13. Financial activities
14. Federal government
15. Construction

Humboldt County's unemployment rate was 3.9% in April 2017, which is considered near full employment.

Humboldt County's most recent Comprehensive Economic Development Study (CEDS)[12] was completed in 2012, with a planning period running from 2012 through 2018. The CEDS identified target sectors for growth based on four criteria:

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[12] Humboldt County, *Prosperity, Comprehensive Economic Development Strategy 2013-2018*. 2012

- Expanding opportunity in job and/or firm growth,
- Growing quality in higher than average or increasing wages,
- Improving competitiveness in California, and
- Career potential.

Six industries were identified as targets of opportunity:

- Diversified Health Care,
- Building and Systems Construction,
- Specialty Food, Flowers & Beverages,
- Investment Support Services,
- Management & Innovation Services, and
- Niche Manufacturing (defined to include light high-value products that can easily be shipped on trucks).

The Prosperity report described the relative disadvantage for high-volume commodity markets that Humboldt County producers face due to the relatively greater distance from markets and resulting higher transport costs than competitors in other parts of California and other U.S. cities and regions.

3.3 Forest Products Industry

The history of the Humboldt Bay region is tied to the forest products industry, and most of the land zoned for coastal-dependent industry was at one time used by forest products.

The California timber industry is much smaller than it was four decades ago. Over the past four decades the state's highest timber harvest was in 1988, with nearly 4.7 billion board feet harvested. This dropped to just 0.8 billion board feet in 2009[13], with the decline most pronounced from 1988 through 1994, a period in which harvest volumes fell by half. After 1994 there were several periods when the decline slowed or stopped for several years (i.e. from 1994 through 1997, and from 2001 through 2007), but there were also periods of decline (i.e. from 1997 through 2001, and from 2007 through 2009. (See Figure 3-1).

The housing market crash and economic recession caused the most recent drop in volume (i.e., from 2007 through 2009). As the market recovered so did harvest volumes; harvest volumes grew from 0.8 billion board feet in 2009 to more than 1.6 billion board feet in 2013, and averaged approximately 1.5 billion board feet per year from 2014 through 2016.

In California, one of the major changes that has occurred is a shift of timber harvest away from public lands. During most of the 1980's more than 40% of the state timber harvest, or as much as 2.0 billion board feet, occurred on public lands. Harvest from public lands began to drop sharply after 1988, and by 1994 less than 0.4 billion board feet of timber came from public lands, or less than 15% of the state total. Between 1994 and 2016 public lands accounted for an average of approximately 12% of total harvest, although from 2012 through 2016 public land averaged closer to 14% of the state timber harvest.

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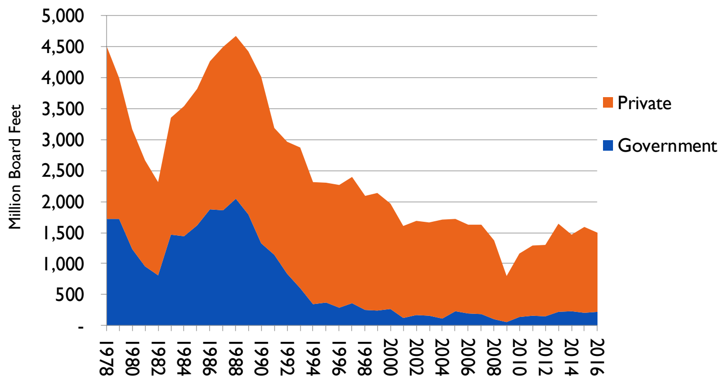
[13] California State Board of Equalization, *California Timber Harvest Statistics*. http://www.boe.ca.gov/proptaxes/pdf/harvyr2.pdf (accessed January 12, 2018).

Figure 3-1: California Timber Harvest Trends



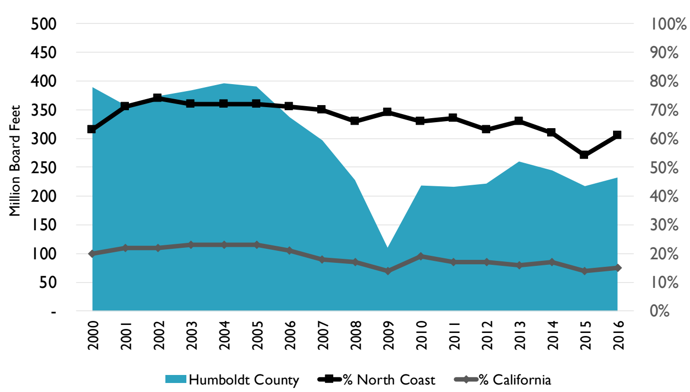
Source: California State Board of Equalization

The timber harvest in Humboldt County grew from approximately 360 million board feet in 2001 to 390 million board feet in 2005, before falling in each of the next four years. Humboldt County's timber industry was hit hard by the housing crash, and by 2009 harvest volumes had dropped to just 110 million board feet. Since the peak of the recession the Humboldt County timber industry has recovered, but harvest volumes remain lower than they were prior to the recession, averaging 230 million board feet per year from 2010 through 2016. (See Figure 3-2)

The California State Board of Equalization groups four counties into the North Coast region (i.e. Del Norte, Humboldt, Mendocino, and Sonoma). Humboldt County is by far the largest producer of timber in the region, accounting for more than 60% of the harvest in 2016. Humboldt County's share has slowly trended lower since 2002, when it accounted for 74% of the region's harvest.

Humboldt County accounted for 15% of California timber harvest volume in 2016. Humboldt County was also the largest producer of timber in the state that year, as it was in most years from 2000 through 2016.

Figure 3-2: Humboldt County Timber Harvest Trends



Source: California State Board of Equalization

The number of mills in Humboldt County declined between 2000 and 2012, as shown in Table 3-2, from 15 operating mills in 2000 to 12 in 2012. The number of sawmills declined from 12 in 2000 to 8 in 2012, and the one medium-density fiberboard and particleboard mill closed[14]. Sierra Pacific Industries explained the reasons behind the closure of its Arcata mill in 2016 as:

> "A fall-off in the amount of suitable timber for sale in this area, coupled with flat home construction in the U.S., and increased lumber imports from Canada have all played a role in our decision to close the mill. But, make no mistake, the largest factor was that the type and size of logs that this mill cuts are simply not available in ample supply to continue to run the mill. When combined, these factors leave us no choice but to close the plant. In an effort to keep the Arcata mill running, SPI has been transporting logs from the interior of California, and has barged logs from British Columbia and Washington. However, those efforts proved to be uneconomical."[15]

The number of biomass operations grew from one operation in 2000 to three operations in 2012, but these plants are also experiencing economic challenges. Utilities are obligated to use renewable energy (including biomass energy), but the amount purchased from various sources depends on the cost of the energy. Biomass power plants are not necessarily the lowest cost renewable energy source, due to the cost of transporting fuel from the source to the plant, the labor costs associated with extraction and production of the fuel material, and other costs.[16] There is also competition for wood chips from export markets, described in more detail later in this report in the section on woodchips.

Table 3-2: Humboldt Bay Forest Product Mills (2000 to 2012)

Year	Sawmills	MDF and particle-board	Bioenergy	Other	Total
2000	12	1	1	1	15
2006	7	1	1	1	10
2012	8	-	3	1	12

Source: USDA[17]

Lumber production in the California Redwood Region (which is dominated by Humboldt County) declined from around 2.2 million board feet (mmbf) in the late 1980s to between 400 mmbf and 550 mmbf from 2008 through 2016, representing a decline of approximately 25%. The California Redwood Region also lost market share during this time period, declining from 9% of West Coast production in the late 1980s to 4% at present. (See Figure 3-3).

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[14] U.S. Department of Agriculture, *California's Forest Products Industry: A Descriptive Analysis, for years 2000, 2006 and 2012*

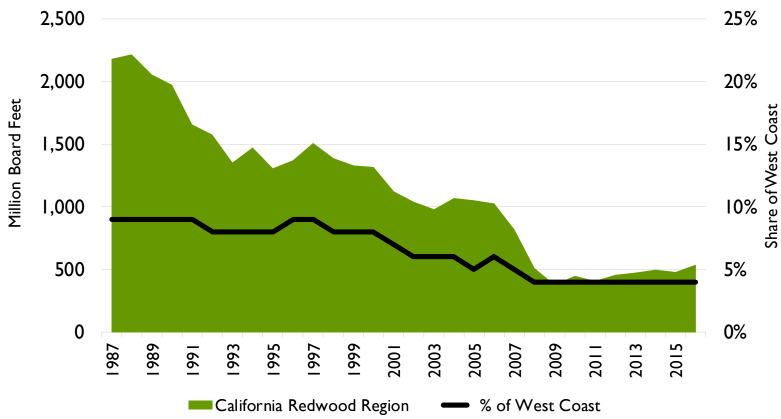
, 2012.

[15] Sierra Pacific Industries, "Sierra Pacific Industries Announces Permanent Closure of Arcata, CA Sawmill", press release, January 25, 2016.

[16] Joyce, Michael, "Does Biomass Still Have A Place In Humboldt County's Energy Future?", *Eureka Times Standard,* May 2, 2016.

[17] U.S. Department of Agriculture, *California's Forest Products Industry*.

Figure 3-3: Lumber Production in California Redwood Region

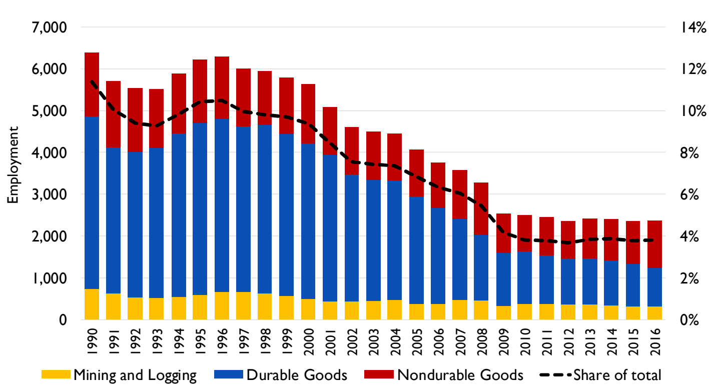


Source: Western Wood Products Association

Employment in forestry-related sectors in Humboldt County has stabilized in recent years, following a long and sustained decline. Three of the main economic sectors related to forest products include mining and logging, manufacturing of durable goods (such as lumber) and manufacturing of non-durable goods (such as paper and pulp). Combined employment in these three sectors dropped from a high of nearly 6,400 jobs in 1990 to approximately 2,500 jobs in 2009, and then averaged approximately 2,400 jobs from 2012 through 2016.

Durable goods manufacturing saw the largest decline in employment; the number of jobs in this category fell from more than 4,100 in 1990 to 930 in 2016, a decline of nearly 78%. Jobs in mining and logging fell from 720 in 1990 to 310 in 2016, a drop of nearly 57%. Non-durable goods manufacturing includes a number of sectors that are not forestry related (such as fish processing); the 26% decline in employment in this category was less than in the others but the number of jobs still fell from more than 1,500 in 1990 to 1,140 in 2016.

Figure 3-4: Forestry-Related Employment in Humboldt County



Source: Bureau of Economic Analysis

Discussions with industry experts suggest that the forest product industry has reached stability at present levels and that little additional growth is expected.[18] Log exports from Humboldt Bay have stabilized in recent years but future volumes are unlikely to grow substantially.

3.4 TRANSPORTATION LINKS

For most Coastal-Dependent Industrial uses, links to transportation infrastructure are a critical factor in determining the utility of any property. These links include navigation channels, rail lines, and highways. This section describes the transportation infrastructure for each of these modes in the Humboldt Bay region.

3.4.1 Waterborne Navigation

3.4.1.1 Description of Humboldt Bay

The following description of Humboldt Bay is excerpted from the *Harbor Safety Plan of the Humboldt Bay Area*.

> Humboldt Bay is a landlocked harbor on the coast of Northern California, about 225 nautical miles north of San Francisco and about 156 nautical miles south of Coos Bay, Oregon.
>
> The greater Humboldt Bay actually consists of two large bays connected by a long, narrow channel and separated from the ocean by two long, narrow spits. From the entrance, Humboldt Bay extends north and south a distance of approximately 14 miles, varying in width from 0.5 to 4 miles, and covering an area of over 17,000 acres. Humboldt Bay is surrounded by rolling terraces, steep mountains and narrow valleys typical of the coast ranges of the region. Dense forests of redwood and Douglas fir cover much of the area. Humboldt Bay is the only harbor between San Francisco and Coos Bay with channels deep enough to permit passage of large, commercial ocean-going vessels.
>
> The entrance to Humboldt Bay is bordered by two rubble mound jetties approximately one-half mile apart and extending perpendicularly from the ends of two long, narrow sand spits that separate the shallow bay from the ocean. The water surface of Humboldt Bay covers over 26 square miles at high tide and about 8 square miles at low tide.
>
> Humboldt Bay is usually divided into three distinct areas: North or Arcata Bay, Middle or Entrance Bay, and South Bay. The southwest ends of Woodley and Indian Islands may be considered the south end of North Bay. South Bay extends south of the South Spit Jetty and King Salmon. (See Figure 3-5).
>
> North Bay covers about 13 square miles and is 5.8 miles at its longest and 4.3 miles at its widest points. It is bounded by North Spit to the west, Arcata Bottoms to the north, Bayside Bottoms and Fickle Hill to the east and Eureka to the south. Indian (formerly Gunther), Woodley, and Daby Islands are all located in the southern portion of North Bay. North Bay is extremely shallow, with over one-half the area (approximately 7 square miles) exposed at low tide. These tidal flats are dissected by several deep channels and numerous shallow channels. Samoa Channel and Eureka Channel are the principal commercial waterways of North Bay. The Arcata Channel located in the extreme North Bay (18 feet deep and 150 feet wide) is no longer used for commercial navigation and has not been maintained since 1931.

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[18] Kelly, Erin, interview with the authors, April 4, 2018. Dr. Kelly is Associate Professor, Forest Policy, Economics and Administration, Humboldt State University.

Entrance Bay is approximately 5 miles long and a maximum of one mile wide. It is bounded by North Spit to the west, and Eureka and the Elk River floodplain to the east. Unlike North and South Bay, it consists of a single deep channel, with generally steep sides.

South Bay covers approximately 7 square miles, with a maximum length of 4 miles and maximum width of about 2.5 miles. It is bounded by South Spit to the west, Humboldt Hill and Beatrice Flats to the east and Table Bluff to the south.

South Bay is similar to North Bay with respect to the broad expanses of tidal flats. These flats are also incised by tidal channels. Only one, the Fields Landing Channel, is used commercially and is maintained by the United States Army Corps of Engineers (USACE).

Separating the Bay from the ocean are two long sand spits with a narrow inlet between them. North Spit is about 10 miles long and 0.5 to 0.9 miles wide. Much of this spit consists of large dunes, up to 50 feet high and heavily forested in places. South Spit is about 4 miles long and varies from 0.1 to 0.7 miles in width; it consists of sparsely vegetated dunes much smaller than those on North Spit.

The commercial/industrial portion of Humboldt Bay is generally located in mid-Humboldt Bay between the southern end of the Fields Landing Channel and the Samoa Bridge to the north. Within this area, coastal-dependent industrial uses exist on the east side of the Samoa Spit, along a one-mile stretch of Eureka's shoreline and along a similar length of the Fields Landing Channel in the community of Fields Landing.[19]

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[19] Humboldt Bay Area Harbor Safety Committee., *Harbor Safety Plan of the Humboldt Bay Area*, revised July 2009.

Figure 3-5: Humboldt Bay

Source: BST Associates, Google Earth image

3.4.1.2 Navigation Channels

The approved navigation project for Humboldt Bay includes: 1) the bar and entrance channel, 2) North Bay Channel, 3) Eureka Channel, 4) Samoa Channel, 5) Samoa Turning Basin, and 6) Fields Landing Channel.

- The bar and entrance channel is approved to a depth of 48 feet below mean lower low water (i.e. -48 MLLW[20]), and tapers from a width 2,100 feet at the ocean end to 750 feet at the bay end of the channel.
- The North Bay Channel, Samoa Channel, and Samoa Turning Basin are authorized to -38 feet MLLW.
- The first 0.4 miles of the Eureka Channel is authorized to -38 feet MLLW, while the final 1.1 mile is authorized to -26 feet MLLW.
- The Fields Landing channel is authorized to -26 feet MLLW.

Details for each of these channels are presented in Figure 3-6 below.

[20] "MLLW" is the average of the lower low water height of each tidal day.

Figure 3-6: Navigation Channel Authorized and Current Dimensions

HUMBOLDT BAY AND HARBOR CHANNEL DEPTHS

TABULATED FROM SURVEYS BY THE CORPS OF ENGINEERS - SURVEYS TO AUG 2017

CONTROLLING DEPTHS FROM SEAWARD IN FEET AT MEAN LOWER LOW WATER (MLLW)						PROJECT DIMENSIONS		
NAME OF CHANNEL	LEFT OUTSIDE QUARTER	LEFT INSIDE QUARTER	RIGHT INSIDE QUARTER	RIGHT OUTSIDE QUARTER	DATE OF SURVEY	WIDTH (FEET)	LENGTH (NAUT. MILES)	DEPTH MLLW (FEET)
BAR CHANNEL	39	43	44	39	8-17	2100-750	1.0	48
ENTRANCE CHANNEL	31	43	42	39	8-17	750	0.8	48
NORTH BAY CHANNEL	34	36	35	24	8-17	400-500	3.0	38
EUREKA CHANNEL								
OUTER REACH	30	29	27	15	3-17	400	0.4	38
INNER REACH	A 13	B 13	C 15	D 10	3-17	400	1.1	26
SAMOA CHANNEL	35	37	36	34	3-17	400	1.3	38
TURNING BASIN	34	35	34	22	3-17	400-1000	0.3	38
FIELDS LANDING CHANNEL	20	26	25	20	3-17	300	1.9	26
TURNING BASIN	16	19	23	23	3-17	300-800	0.1	26

A. SHOALING TO 4 FEET FOR LAST 3,000 FEET OF THE REACH.
B. SHOALING TO 4 FEET FOR LAST 3,000 FEET OF THE REACH.
C. SHOALING TO 7 FEET FOR LAST 2,900 FEET OF THE REACH.
D. SHOALING TO 7 FEET FOR LAST 3,400 FEET OF THE REACH.
NOTE - CONSULT THE CORPS OF ENGINEERS FOR CHANGES SUBSEQUENT TO THE ABOVE INFORMATION

Source: NOAA

The authorized channel depth of 38 feet is similar to the authorized depth at other coastal ports, such as Grays Harbor (36 feet) and Coos Bay (37 feet). In the San Francisco Bay area many ports have similar or less draft, including terminals inside Carquinez Strait (35 feet), Stockton (35 feet), Sacramento (30 feet) Richmond (38 feet), and Redwood City (30 feet). Major container ports are substantially deeper, with depths of 50 feet or more at West Coast ports.

One recurring issue for navigation channels in Humboldt Bay is heavy shoaling that tends to occur following maintenance dredging, and which results in operating restrictions for deep-draft-vessels that adversely affect commerce and limit the Bay's use as a harbor of refuge. Sand accumulates outside of the Bay entrance, and then strong waves and currents eventually transport the sand into the federally-maintained Humboldt Bar and Entrance Channel and into interior channels. The Corps of Engineers has proposed a study that would evaluate long-term solutions to shoaling of the Federal navigation channels, but funding for this study has not been secured.

3.4.2 Rail Transportation

Humboldt Bay is one of the only significant harbors on the U.S. West Coast that does not currently have rail access to inland markets. The rail line that once connected Humboldt Bay to the North American rail system has been out of service since 1998, when it was severely damaged by flooding.

The lack of rail service limits the types and volumes of cargo that might move through marine terminals on Humboldt Bay, and impacts the demand for Coastal-Dependent Industrial land. Most of the dry bulk commodities exported through West Coast ports are transported by rail from inland origins, more than half of container traffic moves by rail, and a significant portion of automobile imports and exports move by rail. Without a rail connection, Humboldt Bay marine traffic will likely be limited to products moving to and from the local region by truck.

The *Humboldt Bay Alternative Rail Corridor Concept Level Construction Cost and Revenue Analysis Final Report*[21], completed for the Harbor District in 2013, analyzed the cost to construct a new east-west rail corridor as well as the cost to reconstruct the existing line, and estimated the volume of cargo that would be needed for the rail line to be financially feasible. This analysis noted that, for most of the commodities and origins studied, the proposed rail routes to Humboldt County did not offer a rail distance advantage over other West Coast ports. In several instances the proposed new Humboldt routes did have a rail distance advantage, but this advantage was small. More importantly, all of these other West Coast ports have rail lines that are already in place and are capable of handling large volumes of heavy rail traffic, without the significant investment needed to construct rail access to Humboldt County (estimated at approximately $1.1 to $1.2 billion for a new east-west route and $0.6 billion for rebuilding the existing route).

3.4.2.1 History of Rail Service

The following description of the out-of-service rail line is taken from the Harbor District's Alternative Rail Corridor analysis.

> Beginning in 1902, the Humboldt Bay Region was served by the former Northwest Pacific (NWP) line of the Southern Pacific (SP). The NWP was an amalgam of over 43 different rail companies, including the Eureka & Oregon, which the SP pieced together with the Santa Fe Railway until that company's ownership was bought out by SP in 1929. The NWP connected the communities of Trinidad, Arcata, Samoa, Korbel, Blue Lake and Eureka with communities in Mendocino, Sonoma and Napa counties as well as the national rail network.
>
> The railroad's alignment generally paralleled the northwest/southeast trending topography that resulted from ancient and on-going geologic processes associated with terrane and marine sediment accretion related to the Gorda Plate Subduction Zone. These processes create a series of ridges and valleys that run parallel to the Pacific Coast. The northern portion of the NWP rail line generally followed the Eel River through one of the valleys then crossed over a divide near Willits eventually dropping in the Russian River drainage until reaching Santa Rosa. US Highway 101 roughly follows this same path.
>
> While owned by Southern Pacific, the primary traffic transported by the railroad was lumber and other forest products generated by the numerous sawmills located in Humboldt County and along the rail corridor. This business was routed south along the NWP to the SP main line near Vallejo, and then routed to the SP yard in Roseville (near Sacramento) for eventual transport to the product's final destination.
>
> Throughout its history, the NWP was difficult to maintain and keep in service. In fact, the rail corridor has been out of service since the portion of the rail line most difficult to maintain (Eel River canyon near Dos Rios) washed out in 1998 and has not yet been placed back in service. Even before that washout, however, the number of carloads moving on the line had decreased, and in the 1980's SP sold portions of the line at various times to a shortline operator.
>
> Even though the NWP continued to generate traffic into the 1990's, SP decided to sell the line due in part to its high maintenance costs. These costs were two to three times higher than on other branch lines owned and operated by SP. Limited shipments continued under the new ownership until the line washed out in the Eel River Canyon. The Federal Railroad

[21] BST Associates, *Humboldt Bay Alternative Rail Corridor Concept Level Construction Cost and Revenue Analysis Final Report*, August 22, 2013.

Administration (FRA) embargoed the railroad in 1999, with only the southern portion south of Windsor reopened in 2011.[22]

3.4.2.2 Potential for Resumption of Rail Service

The most recent regional transportation plan from the Humboldt County Association of Governments includes the following discussion of the potential to re-open the rail line.

> The Northwestern Pacific (NWP) Railroad was acquired by the North Coast Railroad Authority (NCRA) through State and federal funds. The NWP's Eel River Division of rail lines north of Willits was purchased with State funds in 1992. The Russian River Division line south of Willits was purchased with federal funds in 1996. The NWP Railroad line, which formerly served Humboldt Bay, has been out of service since 1998, and service is not expected to resume within the RTP's 20-year planning horizon.[23]
>
> A market and financial analysis completed for the Harbor District in 2003 concluded that reopening of the rail line along the existing corridor would only cover operating costs under the most optimistic scenarios. However, the report further stated that this projection did not address the capital costs of bringing the railroad up to a state of good repair that would allow the operations to begin, and in no way reflected the current outstanding financial commitments of the NCRA or previous operators. These two major cost issues would have to be considered in the final evaluation of the financial feasibility of this railroad.[24]

The 2013 *Alternative Rail Corridor* analysis concluded that a reconstructed north-south rail line or a new east-west rail line would need to move very large volumes of cargo in order to be financially feasible, and that this cargo would primarily be commodities shipped by water to or from Humboldt Bay. A rail line to Humboldt County would face strong competition from existing ports, primarily those on the U.S. and Canadian West Coast, as well as ports on the U.S. East and Gulf Coast and in Mexico, depending on the origin and destination of the cargo. Humboldt County would face several competitive disadvantages relative to these other ports, including the lack of a rail distance advantage to inland markets, and the need to cover the cost of construction. In addition to the lack of rail infrastructure, waterborne exports of large volumes of bulk commodities would likely require substantial investments in new cargo terminals, and substantial investment in navigation channel deepening. The report concluded that development of rail service to Humboldt County is likely to be both high cost and high risk.[25]

A more economically feasible alternative to direct rail service to Humboldt Bay may be the use of rail-barge service. Under this concept, railcars would be loaded onto a rail-barge at a terminal connected with the mainline rail system, and then transported to Humboldt Bay to be unloaded at a rail barge terminal connected to the local rail system. This option would enable rail service to/from points

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[22] BST Associates, *Humboldt Bay Alternative Rail Corridor.*

[23] Humboldt County Association of Governments, *HCAOG 20-Year RTP–2017 Update/Public Draft,* September 2017.

[24] PB Ports & Marine, *The Long Term Financial and Economic Feasibility of the Northwestern Pacific Railroad,* January 2003.

[25] BST Associates. *Humboldt Bay Alternative Rail Corridor.*

throughout the U.S. and would also eliminate the need to transport railcars through the Cities of Eureka and Arcata.

Rail-barge operations are used in difficult water conditions in both Alaska and Western Canada:

- Canadian National Railway has had rail-barge service connecting Whittier, Alaska with the British Columbia mainline rail system in Prince Rupert since 1962. Rail-barges have a capacity of 45 railcars.
- Seaspan Marine service provides service between Vancouver Island (Nanaimo and Swartz Bay) with mainland British Columbia (Fraser River). Rail-barges have a capacity of 22 to 30 railcars.

Figure 3-7 shows a typical rail barge (Seaspan) and a rail-barge terminal (CN rail-barge terminal at Prince Rupert). Canadian National Railroad's Aqua Train provides service to Alaska, while Seaspan Marine provides service to Vancouver Island.

Figure 3-7: Rail-Barge and Terminal

Source: Seaspan, Canadian National

3.4.3 Highway

One issue that Humboldt Bay shippers have historically faced is limits on the size of trucks using the main highways that link the region to the east and south. As noted in the *2003 Port of Humboldt Bay Harbor Revitalization Plan*[26], the competitiveness of trucks moving freight to/from Humboldt Bay was limited by truck length restrictions that did not apply at competing ports. At that time, no portion of Humboldt County was served by truck routes meeting Federal STAA (Surface Transportation Assistance Act) interstate truck length guidelines, which provide for semi-trailer lengths of up to 53 feet.

According to the Goods Movement Element of the *HCAOG 20-Year RTP*[27], the highway system in Humboldt County includes routes designated Terminal Access, California Legal Network, and California Legal Advisory Routes. Terminal Access Truck Routes are portions of State routes or local roads that allow STAA trucks, which are commercial trucks that conform to the weight, width, and length standards allowed by the federal Surface Transportation Assistance Act.

The length restrictions for trucks serving Humboldt County are now being reduced. In 2017, SR 299 was upgraded to Terminal Access status when reconstruction was completed on Buckhorn Grade in Shasta

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[26] PB Ports & Marine, *Port of Humboldt Bay Harbor Revitalization Plan*.

[27] Humboldt County Association of Governments, *Variety in Rural Options of Mobility Semi-Final Draft*, 2017.

County. The route is now free of STAA restrictions between Interstate 5 and U.S. Highway 101. State Route 299 is currently the only STAA route serving the Port of Humboldt Bay.

California Legal Trucks have access to the entire state highway system, unlike STAA trucks, which may be longer than "California Legal" trucks. The California Legal Network highways in Humboldt are:

- SR 299 (Arcata to Trinity County)
- SR 255 (Eureka to Arcata)
- SR 211 (Fernbridge to Ocean Avenue in Ferndale)
- SR 200 (McKinleyville to Blue Lake)
- SR 96 east of Junction Route 169 (Willow Creek to Yreka)
- SR 36 in Humboldt at its eastern end (near Alton) and western end (Van Duzen River Bridge near Dinsmore).

On trucking routes designated as California Legal Advisory Routes, the California DOT (Caltrans) advises that trucks should have semi-trailers shorter than the 40-foot kingpin-to-rear-axle (KPRA) distance that is allowed on the rest of the California Legal Network. KPRA advisories range from 30 to 38 feet. Routes are restricted primarily because they have narrow lanes or tight radius curves. The tight curves make it difficult for longer trucks to stay within their lane while going around tight curves.

U.S. Highway 101 is a Terminal Access Route in Humboldt County, except for a five-mile stretch of California Legal Advisory Route from the Humboldt/Mendocino County line to Richardson Grove State Park. This stretch has a KPRA Advisory maximum of 32 feet long (livestock trucks are exempt from this restriction), which effectively prohibits STAA trucks. To move freight through this five-mile stretch, haulers driving STAA-conforming trucks must unload the cargo and transfer it to shorter trucks that are allowed on this section of highway. This raises the cost for trucking between Humboldt County and the San Francisco Bay Area.

Caltrans has designed upgrades for the section of U.S. 101 through Richardson Grove State Park to allow STAA trucks through the stretch, and the project is in the permitting stage. When this southern segment of U.S. 101 is redesignated as a Terminal Access route, STAA trucks will have uninterrupted access on U.S. 101 from the Oregon border to San Francisco.

3.5 West Coast Marine Cargo Trends

Between 1982 and 2007, West Coast port traffic grew by 350 percent (as seen in Figure 3-8), but after 2007 total tonnage saw little growth. Most of the growth was due to containers, which increased by more than 700 percent between 1982 and 2007. Container volumes dropped substantially during the recession that started in 2008 and remained relatively low for nearly a decade, but finally surpassed the record 2007 volume in 2017.[28]

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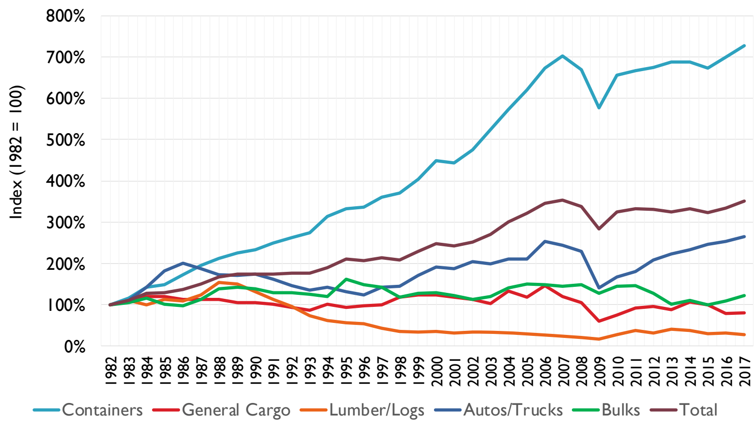
[28] The Pacific Maritime Association (PMA) measures cargo on the basis of revenue tons: container cargo is assessed on the basis of a revenue unit or a TEU (twenty-foot equivalent unit), and Non-Containerized Cargo is reported in revenue tons on the basis of measurement (e.g., on a volume basis where 40 cubic feet equals one revenue ton; on a weight basis where 2,000 pounds equals one revenue ton; or on the basis of board feet where 1,000 board feet equals one revenue ton.

Figure 3-8: Comparison of West Coast Cargo Trends



Source: BST Associates, using data from Pacific Maritime Association

Automobile traffic also grew substantially, but at a much slower rate than containers. Like containers, automobile traffic growth peaked immediately prior to the recession but dropped sharply during the recession; it took until 2015 to fully recover.

Bulk cargo volumes have generally grown over the past 35 years, but this growth has been uneven. In certain years the volume has been up as much as 62 percent above the base year of 1982, but in other years the volume was the same as in 1982. From 2013 through 2016 the volume of bulk cargo was never more than 10 percent higher than in 1982, but in 2017 it was 23 percent higher than in 1982.

General cargo volumes also fluctuated between 1982 and 2017, but have generally trended downward. For the most part, general cargo volumes have not been more than 20 percent higher than in 1982, although in 2004 they were 32 percent higher and at their peak in 2006 they were 46 percent higher. General cargo volumes dropped sharply in 2009 and were 40 percent lower that year than they were in 1982. In both 2016 and 2017 they were still 20 percent lower than in 1982.

Lumber and logs volumes dropped more than other cargo types over the past 35 years and were 70 percent lower in 2017 than they were in 1982. There was a period during the 1980's when the volume of logs and lumber increased to as much as 50% higher than in 1982; by 1992, however, the volume of logs and lumber fell below that of 1982 and continued to fall. Since 2000, the volume of logs and lumber has averaged approximately one-third of the 1982 volume.

Table 3-3 shows cargo volumes and growth rates, by commodity type, for 1982, 2000, and 2017.

Table 3-3: Cargo Growth Trends by Commodity Group

				Average Annual Growth Rate		
Year	**1982**	**2000**	**2017**	**1982-2017**	**1982-2000**	**2000-2017**
Autos	10.31	19.72	27.29	2.8%	3.7%	1.9%
Bulk	41.57	53.81	51.08	0.6%	1.4%	-0.3%
Containers	38.72	174.01	281.27	5.8%	8.7%	2.9%
General	8.08	9.95	6.54	-0.6%	1.2%	-2.4%
Logs & Lumber	5.59	2.11	1.69	-3.4%	-5.3%	-1.3%
Total	104.28	259.60	367.88	3.7%	5.2%	2.1%

Source: Pacific Maritime Association

3.5.1 Humboldt Bay Marine Cargo Trends

According to data from the U.S. Army Corps of Engineers, marine cargo volumes moving into and out of Humboldt Bay fell from approximately 1.5 million metric tons in 1990 to 424,000 metric tons in 2016. This decline was especially strong between 1990 and 2010, a period in which volumes dropped by nearly 75%. (See Table 3-4).

Historically, most of the cargo tonnage was comprised of foreign exports and domestic receipts.

- Between 1990 and 2010 foreign exports dropped sharply and then stopped completely. From 2010 through 2016 foreign exports restarted, but at much-reduced volumes.
- Domestic receipts grew between 1990 and 2000, but dropped between 2000 and 2010, and then fell slightly between 2010 and 2016.
- For the most part foreign imports have not been a major source of marine cargo in Humboldt Bay. As noted later in this section, however, for part of the period from approximately 2000 through 2008 there was a bump in foreign imports.
- Domestic shipments grew slowly over the long run, increasing from 28,000 metric tons in 1990 to 109,000 metric tons in 2016. However, as shown later in this section, there was also a surge of domestic shipments for several years in the mid-1990's.

Table 3-4: Humboldt Bay Cargo Trends

	Metric Tons (1,000's)				Average Annual Growth Rate			
Year	1990	2000	2010	2016	1990-2000	2000-2010	2010-2016	1990-2016
Foreign Imports	11	37	-	-	12.9%	100.0%	nm	10.0%
Foreign Exports	978	366	-	30	-9.4%	100.0%	Nm	-12.5%
Domestic Receipts	462	546	308	286	1.7%	-5.6%	-1.2%	-1.8%
Domestic Shipments	28	40	70	109	3.6%	5.8%	7.7%	5.4%
Total	1,479	989	377	424	-3.9%	-9.2%	2.0%	-4.7%

Source: U.S. Army Corps of Engineers

3.5.1.1 Foreign Exports

Waterborne foreign exports from Humboldt Bay have historically been dominated by forest products, including woodchips, pulp, lumber and logs. While this remains the case, export volumes declined by more than 95% between 1990 and 2016.

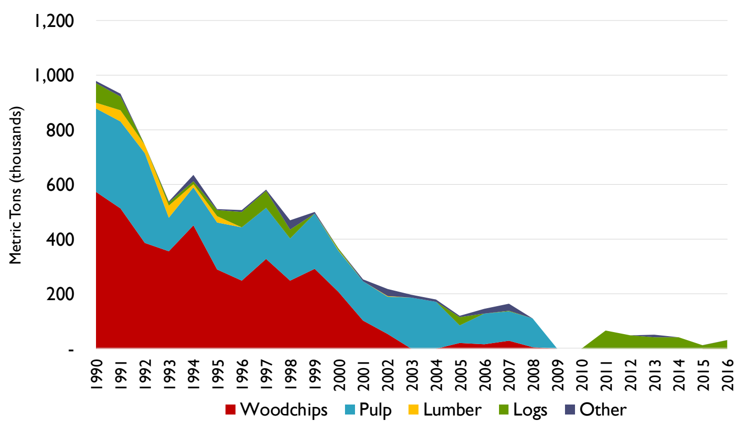
In 1990, marine terminals on Humboldt Bay shipped 573,000 metric tons of woodchips to foreign destinations. From 1990 through 2008 exports of woodchips declined nearly every year (with the exception of three years), before stopping altogether in 2009. Woodchip exports resumed at low levels in 2011 and averaged 42,000 metric tons per year from 2011 through 2016.

Exports of pulp were directly related to the manufacturing operations of the two pulp mills on the Samoa Peninsula, and when pulp manufacturing stopped so did pulp exports. Pulp exports averaged nearly 320,000 metric tons per year from 1990 through 1992. When the Crown Simpson mill closed in 1992 exports fell by nearly two-thirds, to 122,000 metric tons in 1993 and 137,000 metric tons in 1994. Volumes increased in 1995, averaging 170,000 metrics tons per year over the next decade. As production at the remaining pulp mill slowed so did exports of pulp, and exports of pulp finally ceased completely after 2008.

From 1990 through 1998, log exports from Humboldt Bay averaged 36,000 metric tons per year, ranging from a low of zero metric tons to a high of 72,000 metric tons. From 1999 through 2010 log exports were rare, but in 2011 they resumed once more, and averaged 40,000 metric tons per year from 2011 through 2016.

A limited volume of lumber was exported from Humboldt Bay during the early 1990's, but essentially no lumber exports have occurred since 1995. Other commodities are occasionally exported in small quantities, but their volume averaged only 7,000 metric tons per year from 1990 through 2016, and 4,000 metric tons per year from 2007 through 2016. (See Figure 3-9).

Figure 3-9: Humboldt Bay Exports (1,000 Metric Tons)



Source: BST Associates using data from the U.S. Army Corps of Engineers

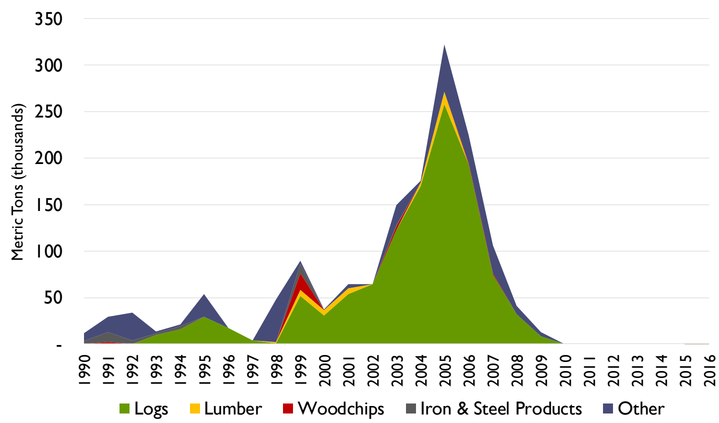
3.5.1.2 Foreign Imports

Waterborne imports to Humboldt Bay exceeded 100,000 metric tons in only five years out of the past 27 years. In most years imports totaled less 50,000 metric tons, and from 2010 through 2016 there were no foreign imports.

Logs accounted for most of the tonnage during high import years. During the mid-1990's imports of logs averaged approximately 18,000 metric tons per year for several years before falling nearly to zero. In 1999 import volumes began to increase, eventually growing from 52,000 metric tons in 1999 to a high of 258,000 metric tons in 2005. From 2006 through 2009 log imports dropped sharply, and since 2010 no logs have been imported into Humboldt Bay from foreign sources.

In addition, Humboldt Bay has received iron/steel and other products from foreign producers to support local construction projects. These imports have been sporadic during the study period and have not occurred since 2009. (See Figure 3-10).

Figure 3-10: Humboldt Bay Imports (1,000 Metric Tons)



Source: BST Associates using data from the U.S. Army Corps of Engineers

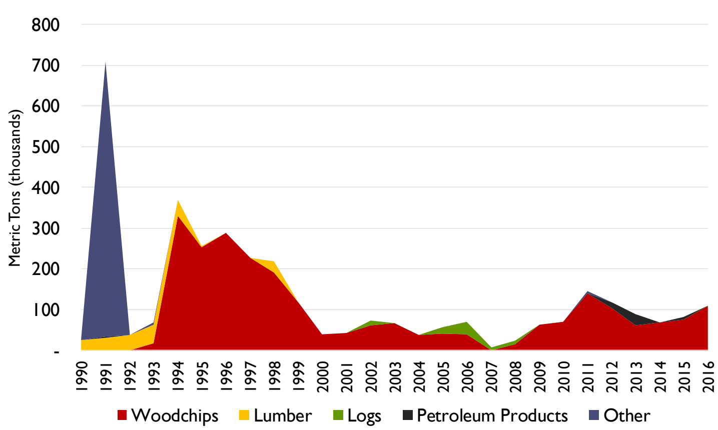
3.5.1.3 Domestic Shipments

The main product shipped by water from Humboldt Bay to domestic locations is woodchips. Since 1994 woodchips have accounted for approximately 90% of domestic shipments, on average, and in many years accounted for 100% of domestic shipments.

One outlier was in 1991, when a high volume of dredge spoils was shipped out of the bay.

Other products that have been shipped in limited volumes to domestic destinations have included lumber, logs and petroleum products. Most domestic lumber shipments occurred from 1990 through 1994, and none have occurred since 1998. (See Figure 3-11).

Figure 3-11: Humboldt Bay Domestic Shipments (1,000 Metric Tons)



Source: BST Associates using data from the U.S. Army Corps of Engineers

3.5.1.4 Domestic Receipts

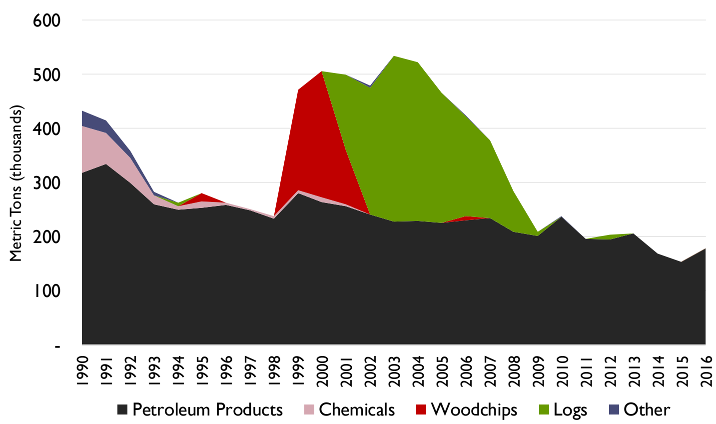
Since 1990, petroleum products have accounted for most of the domestic waterborne receipts. Most of this product is barged in from San Francisco Bay area refineries, for consumption in the local market. Over time the annual volume of receipts has dropped slowly, from more than 300,000 metric tons in the early 1990's to less than 200,000 metric tons in recent years.

In addition to petroleum products there have been occasional receipts of woodchips, logs, and chemicals from domestic sources. Chemical receipts were highest in the early 1990's and ended in

2001, and were related to pulp mill operations. Woodchips for use in pulp production were shipped in by water for several years (primarily 1999 through 2001), but essentially ended when pulp production stopped.

Logs also saw a period of high domestic inbound volumes, especially from 2001 through 2008. Log receipts grew from 140,000 metric tons in 2001 to more than 300,000 metric tons in 2003 and nearly that high in 2004, before tailing off over the next several years. Domestic receipts of logs have been quite limited since 2009. (See Figure 3-12)

Figure 3-12: Humboldt Bay Domestic Receipts (1,000 Metric Tons)



Source: BST Associates using data from the U.S. Army Corps of Engineers

3.5.1.5 Harbor District Records

According to vessel records maintained by the Harbor District, most cargo vessels that call in Humboldt Bay are barges. As shown in Table 3-5, barges accounted for 42 out of 48 cargo vessels in 2017, or approximately 88% of vessel calls. Between 2000 and 2017 barges averaged 86% of yearly vessel calls, with a minimum of 77% and a maximum of 98%.

The total number of vessel calls grew from 135 in 2000 to a peak of 192 in 2003 but dropped to just 54 vessel calls in 2009. From 2010 through 2017 the number of calls averaged 58 per year and ranged between 42 and 78. In 2017 there were 48 calls.

Woodchips, logs, and fuel (petroleum products) account for essentially all cargo vessel calls. Fuel barge calls averaged approximately 31 per year from 2000 through 2017, but from 2014 through 2017 this dropped to approximately 25 calls per year. Woodchip barge calls dropped between 2003 and 2008 but grew again from 2009 through 2016. In addition, from 2014 through 2017 a number of ships carrying woodchips called on Humboldt Bay, and this had not occurred since 2002. Log vessel calls (mainly barges) dropped from a high of 101 in 2003 to just 3 in 2009. From 2010 through 2017 the number of log vessels ranged from one to nine per year.

Different commodities tend to be carried in either barges or ships:

- Woodchips and hog fuel are primarily carried in barges,
- From 2000 through 2009 logs were primarily carried in barges, but since 2010 they have mainly moved in ships, and
- Fuel (petroleum products) is moved by barge.

Table 3-5: Cargo Vessel Calls in Humboldt Bay

Commodity	Vessel Type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Chips	Barge	24	22	23	29	14	21	19	11	4	17	18	34	28	16	17	16	32	10
Chips	Ship	3	5	2												3	2	4	5
Hog Fuel	Barge		1		2		8	7	6	2									
Fuel	Barge	27	36	30	31	33	30	32	35	35	31	37	34	30	31	25	23	25	28
Logs	Barge	47	58	57	100	84	82	78	38	13	3								4
Logs	Ship	2		1	1							1	9	7	7	5	1	2	1
Lumber	Barge	4	2	1															
Lumber	Ship	4	3																
Pulp	Barge	2	2	2		1													
Pulp	Ship	22	29	28	29	32	13	19	15	14									
Other	Ship								1	1	3		1	1		3			
Other	Barge		2																
Total	Barge	104	123	113	162	132	141	136	90	54	51	55	68	58	47	42	39	57	42
Total	Ship	31	37	31	30	32	13	19	16	15	3	1	10	8	7	11	3	6	6
Total	Total	135	160	144	192	164	154	155	106	69	54	56	78	66	54	53	42	63	48

Source: Harbor District

3.5.1.6 Findings

Marine cargo transiting Humboldt Bay terminals consists of local/regional commodities that are:

- Inbound cargoes
  - Consumed by the local population such as petroleum products,
  - Inputs to production comprised mainly of logs, woodchips and chemicals for local mills, as well as steel for local construction products
- Outbound cargoes
  - Outputs of the local forest products industry (logs, woodchips, lumber and pulp) bound for overseas and domestic markets.

As described in the prior chapter, the existing inland transportation infrastructure constrains marine cargo activity to the local/regional market. However, even if the inland transportation infrastructure were to be improved, Humboldt Bay does not offer a distance advantage relative to competing ports.

3.6 Breakbulk & Neobulk Cargo

Breakbulk cargoes include unitized, palletized or packaged general goods, which are not containerized. Neobulk cargoes refer to non-containerized cargoes that require specialized berths and equipment, such as logs, steel, autos, and roll on - roll off (RO-RO) cargoes (mining, agriculture and construction equipment, etc.), among other cargoes.

Prior to containerization, virtually all non-bulk cargoes moved in breakbulk form. Since the 1970s, however, the majority of breakbulk cargo has been converted to containers. As a result of this shift the breakbulk trade has become far more specialized, targeting certain high-volume commodities such as fruit, lumber, woodpulp, paper and some steel products. Based on the high volume and handling uniformity of the commodities involved, ocean carriers have introduced more sophisticated cargo unitization methods and larger vessels with self-contained bridge-type cranes that can handle large, unitized loads of lumber, paper, pulp, etc. quickly and efficiently like containers. In order to maximize use of these ships, ocean carriers prefer to move more cargo through fewer ports.

3.6.1 Logs

3.6.1.1 Historical Trends

United States log exports declined sharply during the 1990's, falling from 16.2 million metric tons in 1990 to just 4.4 million metric tons in 2001. From 2001 through 2009 annual log export volumes were less than 4.7 million metric tons. Log export volumes started to grow in 2010 due to a rapid increase in exports to China and exceeded 9.1 million metric tons in both 2013 and 2014, but were lower again in 2015 and 2016. In 2016 the U.S. exported 7.6 million metric tons of logs, or less than half of what it exported in 1990. (See Figure 3-13).

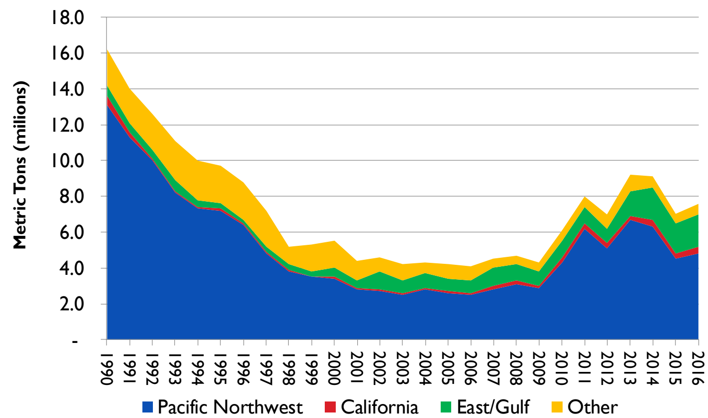
Most U.S. logs are exported from the Pacific Northwest. From 1990 through 2016 the Northwest accounted for at least 70% of exports and as much as 86%; in 2016 the Northwest accounted for 74% of U.S. log exports. Nearly all of the decline in U.S. exports occurred in the Northwest, where exports fell from 13.7 million metric tons in 1990 to less than 4.0 million metric tons during the 2000's. Northwest exports recovered to more than 6.3 million metric tons in both 2013 and 2014 but fell below 5 million metric tons in 2015 and 2016.

California has long been a minor center of log exports. Between 1990 and 2016 the state's share of U.S. exports ranged between 1% and 7%. From 1992 through 2006 California exports never exceeded 150,000 metric tons, but from 2014 through 2016 they were higher than 400,000 metric tons.

East and Gulf Coast states were only minor exporters from 1990 through 2012, never reaching 1.0 million metric tons. This region has seen growth in recent years, however, exporting nearly 1.5 million metric tons in 2014 and more than 1.7 million metric tons per year from 2014 through 2016.

The remaining U.S. log exports were from "Other" regions, essentially all of which is Alaska. Alaska accounted for as much as 29% of U.S. log exports during the late 1990's and early 2000's but accounted for less than 10% from 2014 through 2016. Total volume from Alaska dropped from a high of more than 2.2 million metric tons in 1993 to less than 0.6 million metric tons per year from 2014 through 2016.

Figure 3-13: U.S. Log Export Trends



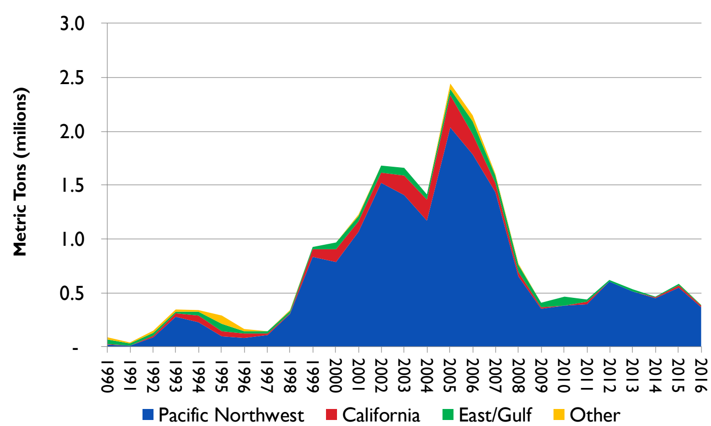
Source: U.S. Census Bureau Foreign Trade Division

The United States imports logs as well as exports, but at a much lower level. For much of the decade of the 2000's, import volumes averaged more than 1.0 million metric tons per year and exceeded 2.1 million metric tons in both 2005 and 2006. In contrast, for most of the 1990's log imports were less than 0.4 million metric tons, and from 2009 through 2016 they exceeded 0.6 million metric tons only once. (See Figure 3-14).

As with exports, most of the log imports moved through ports in the Pacific Northwest. The Northwest saw import volume range from essentially nothing to as much as 2.0 million metric tons, while all other regions combined never saw log import volumes of 0.5 million metric tons.

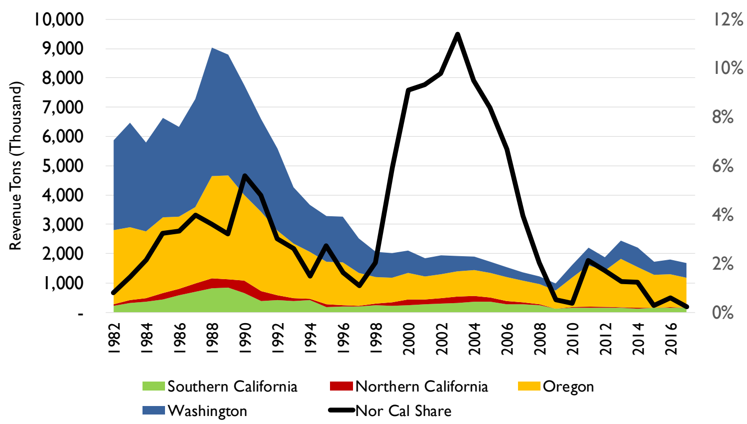
California ports handled small volumes of log imports during the 2000's but saw very few during most of the 1990's, and essentially none after 2009. These imports were driven by local mills trying to maintain production levels as local timber resources declined. However, importing logs proved to be cost prohibitive, and was listed as a key reason for the closure of the Sierra Pacific Industries mill in Arcata.

Figure 3-14: U.S. Log Import Trends



Source: U.S. Census Bureau Foreign Trade Division

Figure 3-15: West Coast Logs & Lumber Trends (1,000 revenue tons)



Source: BST Associates using data from the Pacific Maritime Association

3.6.1.2 Forecast

For the most part, log exports from Humboldt Bay have stabilized in recent years. Future volumes are unlikely to grow substantially.[29]

Future market conditions are clouded by log prices, which are driven by increased U.S. log consumption for the domestic market coupled with the strength of the U.S. dollar. Other unknowns include growth rates in Asian economies and additional competition from other sources such as New Zealand and Canada. Exports of logs from British Columbia increased 14% in 2016 and are now nearly as large as the log exports from U.S. West Coast.

In the longer-term, log exports face many uncertainties. Japan has historically been the largest market for West Coast log exports, but is expected to decline due to an increase in domestic timber harvests in Japan. The Chinese market is expected to grow but at a slower pace than in the past and with significant volatility due to international competition.

3.6.1.3 Potential demand at Humboldt

Logs are currently exported from the Schneider Dock in Eureka. This log export operation uses approximately 11 acres, including acreage on the site as well as log storage on an adjacent property. Future demand is projected to range between 11 acres and 15 acres (See Table 3-6).

Table 3-6: Current CDI Use and Future Demand- Logs

Land Use	Current Acres	Future Acres Low	Future Acres High	Change in Acres Low	Change in Acres High
Logs	11	11	15	11	15

Source: BST Associates

[29] Kelly, Erin, interview with the authors.

3.6.2 Other General Cargo

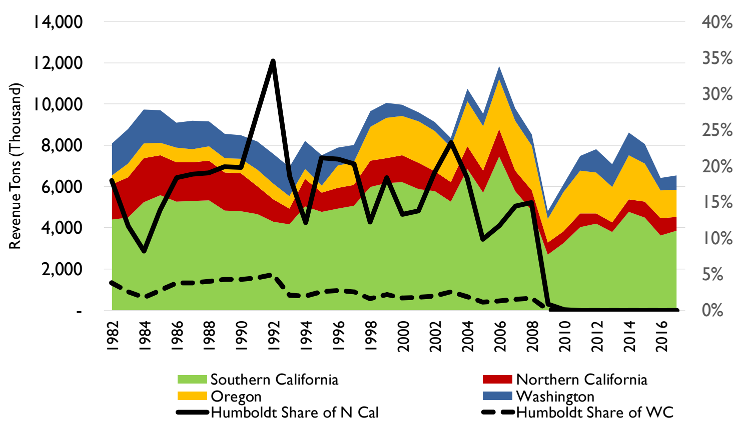
Breakbulk cargoes include unitized, palletized or packaged general goods, which are not containerized.

3.6.2.1 Historical Trends

Data from the Pacific Maritime Association separates breakbulk/neobulk cargoes into two categories, lumber/logs and other general cargo.

Southern California dominates U.S. West Coast ports in other general cargo traffic. This region saw volumes of other general cargo grow from 4.4 million revenue tons in 1982 to 7.5 million revenue tons in 2006. Volumes began to drop sharply in 2007 and reached a low of just 2.7 million revenue tons in 2009. They have since recovered somewhat, but volumes in 2017 were approximately half of what they were at the peak. Much of the general cargo handled in Southern California consists of fruit imports and exports, steel slabs, and other manufactured goods. (See Figure 3-16).

Figure 3-16: West Coast Trends in Other General Cargo Imports



Source: Pacific Maritime Association

Northern California was the second largest load center on the U.S. West Coast for other general cargo during most of the 1980's and 1990's. Volumes from Oregon surpassed those of Northern California in 1996, however, and have been higher since then. (Note that the PMA data groups all ports on the Lower Columbia River as Oregon ports, including Vancouver, Kalama, and Longview, Washington). The volume of other general cargo moving through Northern California ports dropped sharply in 1991, falling from 1.8 million revenue tons in 1990 to 1.3 million revenue tons in 1991. From 1991 through 2008 volumes ranged between 0.8 million and 1.3 million revenue tons, but from 2009 through 2017 these volumes ranged from less than 0.5 million revenue tons to 0.8 million revenue tons.

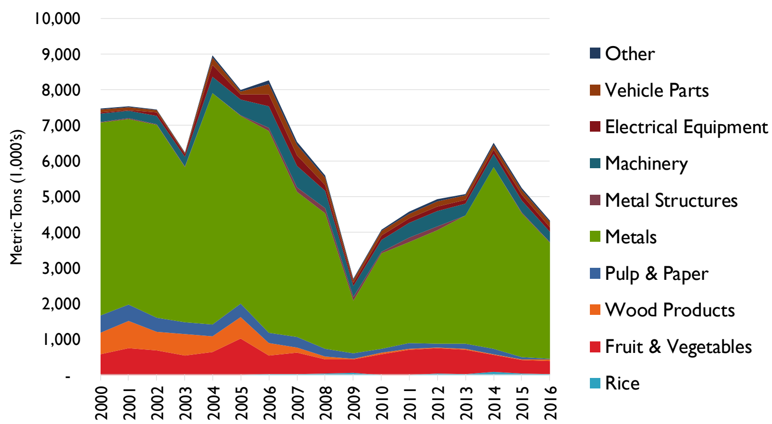
Humboldt Bay marine terminals accounted for a substantial share of Northern California general cargo trade until 2009 (i.e. primarily lumber and pulp), but from 2010 on the Humboldt Bay terminals handled essentially no breakbulk/neobulk cargo other than logs. From 1982 through 1992 Humboldt Bay general cargo volumes averaged 320,000 revenue tons per year. From 1992 through 2002 the average dropped to 200,000 revenue tons, from 2002 through 2008 it averaged 165,000 revenue tons, and from 2009 through 2017 was essentially zero.

West Coast foreign imports of breakbulk/neobulk cargo volumes dropped by more than half between the peak year of 2004 and 2016. Imports dropped from 9.0 million metric tons in 2004 to less than 2.7 million metric tons, at the height of the recession. Following the recession volumes increased until 2014, but dropped again in both 2015 and 2016.

West Coast imports of breakbulk/neobulk cargoes are dominated by metals, especially steel; from 2000 through 2016 metals accounted for an average of 68.7% of breakbulk/neobulks. Much of this steel is used in the construction industry, and the decline in construction during the recession is reflected in the dropping imports of metals. Imported steel is generally used in the market adjacent to the inbound port but a portion also moves on to more distant production centers for use in manufacturing. Non-containerized fruits and vegetables were the second-largest category, accounting for an average of 10.2% of imports, followed by machinery (6.6%) and wood products (3.5%). No other commodity type accounted for an average of more than 3.0% over that time period. (See Figure 3-17)

Humboldt Bay marine terminals handled only occasional imports of other breakbulk/neobulk cargo from 2000 through 2016. Most of this was metals, and essentially all of the imports occurred from 2000 through 2005.

Figure 3-17: West Coast Breakbulk/Neobulk Imports



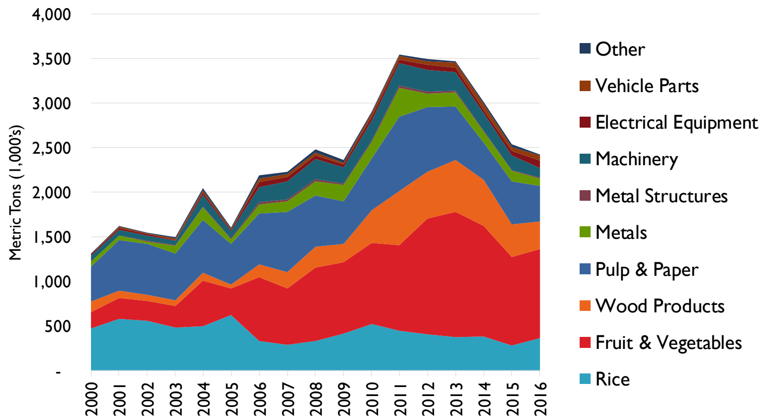
Source: WISERTrade

West Coast exports of breakbulks/neobulks grew substantially between 2000 and 2016; however, volumes peaked from 2011 through 2013 and then dropped in subsequent years. Export volumes grew from 1.3 million metric tons in 2000 to approximately 3.5 million in 2011, 2012, and 2013. Over the next two years export volumes dropped nearly 1.0 million metric tons, and in 2016 the export volume was 2.4 million metric tons. (See Figure 3-18).

Exports of breakbulks/neobulks are led by fruits & vegetables, pulp & paper, wood products, and rice. The volume of non-containerized fruits and vegetables grew from less than 190,000 metric tons in 2000 to more than 1.4 million metric tons in 2013, before dropping to less than 1.0 million metric tons in 2016. Exports of non-containerized wood products grew from less than 120,0000 metric tons in 2000 to 610,000 metric tons in 2011. After averaging more than 500,000 metric tons from 2012 through 2014 volumes dropped to approximately 310,000 metric tons in 2016.

Exports of pulp and paper were essentially the same in 2016 as they were in 2000 (i.e. 390,000 metric tons), but in 2016 were less than half of what they were during the peak year of 2011. The volume of non-containerized rice (i.e. bagged rice) dropped slowly from 2000 through 2016.

Figure 3-18: West Coast Breakbulk/Neobulk Exports



Source: WISERTrade

In Humboldt Bay, woodpulp accounted for nearly all foreign exports of breakbulk/neobulk cargo from 2000 through 2016. With the exception of 2010 these exports essentially ceased in 2006, due to the closure of the last pulp mill in Samoa.

3.6.2.2 Potential demand at Humboldt

Existing facilities are adequate to accommodate existing volumes of breakbulk/neobulk cargoes. The Humboldt Bay region may generate sufficient levels of waterborne cargo to support a general cargo dock if a new industry were to be developed in Humboldt Bay. Offshore wind systems, which are described in greater detail in the next chapter, could generate sufficient volumes to require a more extensive terminal.

The estimated range of CDI land required to meet future general cargo volumes ranges between zero (i.e. the activity does not occur on Humboldt Bay) and 25 acres. (See Table 3-7).

Table 3-7: Current CDI Use and Future Demand, General Cargo

Land Use	Current Acres	Future Acres Low	Future Acres High	Change in Acres Low	Change in Acres High
General Cargo	0	0	25	0	25

Source: BST Associates

3.6.3 Automobiles and Ro-Ro

3.6.3.1 Historical Trends

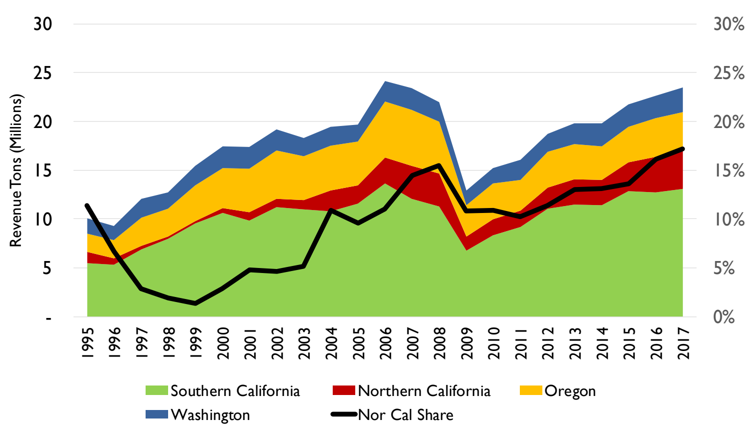
Sales of autos in the U.S. averaged 16 to 17 million units from 2000 to 2007, until the Great Recession drove sales to a low of 10.4 million units in 2009 (a drop of nearly 40%). Restructuring of the auto industry and gradual recovery of the economy led to a rebound in sales. Auto sales reached 16.5 million units in 2014, and exceeded 17 million units in both 2015 and 2016.

In the U.S., the market share of foreign vehicles grew from approximately 17% in 2000 to a peak of 26% in 2009. A growing share of these vehicles is manufactured in Mexico, which has now surpassed Japan as the second largest exporter to the U.S. Canada remains the largest exporter to the U.S., with export volumes that have remained relatively stable.[30]

Exports of autos from the U.S. across all ports and border crossings increased rapidly between 2000 and 2015, growing at an annual rate of 11.4%. Emerging markets in China, India, Brazil, Eastern Europe and South Africa drove much of this growth.[31]

Inbound receipts of automobiles on the U.S. West Coast move primarily through California ports. More than half of West Coast waterborne automobile receipts move through Southern California, but the share moving through Northern California ports grew steadily from 2011 through 2017; Northern California share of West Coast auto receipts climbed from 10.2% in 2011 to 17.2% in 2017. This was Northern California's largest share of automobile receipts since at least 1995, and the 4.0 million revenue tons of automobiles was the highest since at least 1995. (Note that PMA data includes rolling equipment in the autos category, and also includes vehicles bound to and from Hawaii).

Figure 3-19: West Coast Inbound Automobile Trends (1,000 revenue tons)



Source: BST Associates using data from the Pacific Maritime Association

Outbound shipments of automobiles from the U.S. West Coast are much more limited than receipts, but have grown substantially over the past decade. Total shipments more than doubled between 2009 and

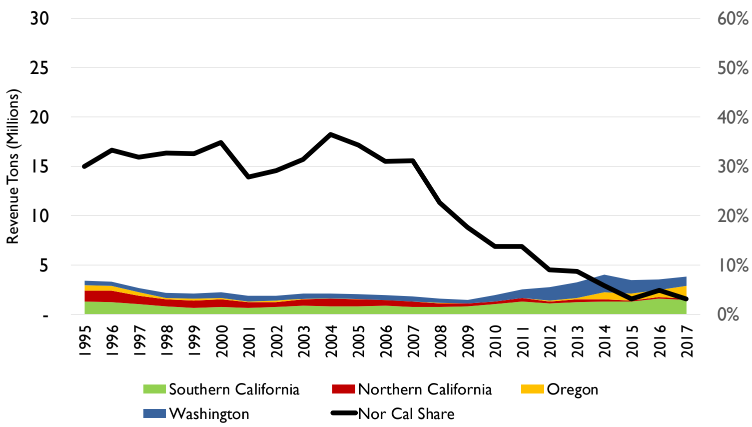
[30] BST Associates, *2017 Marine Cargo Forecast and Rail Capacity Analysis*, August 2017.

[31] ibid

2017, growing from less than 1.5 million revenue tons to more than 3.8 million revenue tons. Outbound shipments were nearly that high in 1995 but fell steadily through 2009.

Northern California ports handled approximately one-third of automobile shipments from 1995 through 2007. Since 2008 that share has fallen, however, and in 2017 Northern California ports accounted for only 3.2% of shipments.

Figure 3-20: West Coast Outbound Automobile Trends (1,000 revenue tons)



Source: BST Associates using data from the Pacific Maritime Association

3.6.3.2 Forecast

According to Mercator[32], vehicles are the only high-volume commodity currently moving through RO-RO terminals on San Pedro Bay. Imports are projected to grow from approximately 600,000 metric tons in 2015 to 1.4 million metric tons in 2040, or at a rate of growth of 3.5% per year[33]. Vehicles are typically distributed to local markets by truck, and to more distant markets by rail or by truck.

Vehicles are also exported to foreign destinations or shipped to domestic markets (mainly Hawaii) from San Pedro Bay ports, but in much smaller volumes than imports. Vehicle exports are projected to grow from 50,000 metric tons in 2015 to 19,000 metric tons in 2040.

Ports in the region that handle vehicle imports and exports include Port of Hueneme in Oxnard (north of Los Angeles), Los Angeles, Long Beach, and San Diego. All of the terminals have direct rail access.

Northern California auto terminals are all in the San Francisco Bay area. Richmond and Benicia have handled vehicles for many years, while San Francisco recently began receiving auto imports again.

Auto imports moving through Pacific Northwest ports fell from 743,000 metric tons in 2000 to 643,000 metric tons in 2010 as a result of the Great Recession. By 2015 import volumes had climbed back to 736,000 metric tons, and through 2035 are projected to grow to between 890,000 metric tons and 1.17 million metric tons.[34]

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[32] Mercator International and Oxford Economics, *Executive Summary for San Pedro Bay Long-term Unconstrained Cargo Forecast*, January 2016.

[33] ibid

[34] BST Associates, *2017 Marine Cargo Forecast.*

Auto exports moving via Pacific Northwest ports were minimal at the beginning of the century but have grown sharply. Exports totaled 16,000 metric tons in 2000 and fell to only 4,000 metric tons in 2005, but grew to 252,000 metric tons in 2015. By 2035, exports of automobiles from the Pacific Northwest are projected to reach from 670,000 metric tons to as much as 876,000 metric tons.

Four ports in the Pacific Northwest handle automobile imports or exports: Portland, Vancouver (Washington), Tacoma, and Grays Harbor. All of these terminals are served by both the Union Pacific and the BNSF railroads.

3.6.3.3 Potential demand at Humboldt Bay

For the most part, automobile port terminals: 1) are located in or near major population centers, and 2) require access to railroads. Vehicles destined for local markets are distributed by truck, while inland markets are generally served by rail.

Figure 3-21: Automobiles and Rail Auto Racks at Grays Harbor

Source: Port of Grays Harbor

Because of the limited population in the Humboldt Bay region, and because of the lack of rail access, Humboldt Bay is not likely to become a vehicle import or export center. Therefore, the future acreage required for this use is zero. (See Table 3-8).

Table 3-8: Current CDI Use and Future Demand, Vehicles

Land Use	Current Acres	Future Acres Low	Future Acres High	Change in Acres Low	Change in Acres High
Vehicles	0	0	0	0	0

Source: BST Associates

3.6.4 Containers

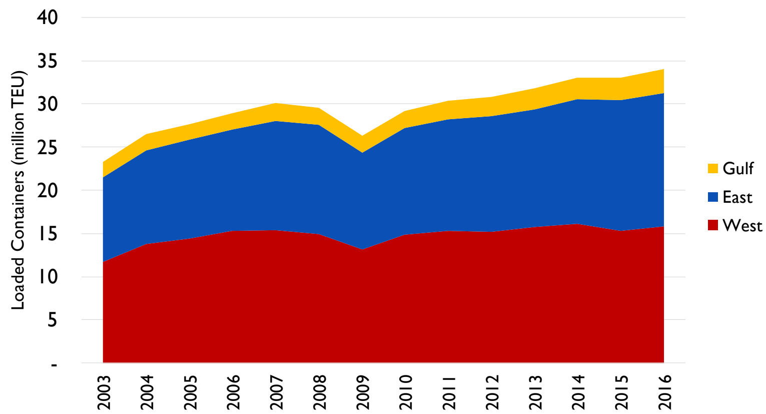
3.6.4.1 Historical Trends

Loaded containers (including both international and domestic) moving through mainland U.S. ports grew from 23.2 million TEU[35] in 2003 to 34.0 million TEU in 2016. This long-term growth trend was interrupted by the recession, which caused container volumes to drop from a peak of 30.0 million TEU in

[35] TEU is twenty-foot equivalent unit

2007 to 26.3 million TEU in 2009. Container volumes began to recover in 2010, and by 2011 they had surpassed the 2007 record. From 2011 through 2016 volumes grew by another 3.6 million TEU. (See Figure 3-22).

Figure 3-22: U.S. West Coast Loaded Container Trends (,1000 TEU)



Source: US Army Corps of Engineers

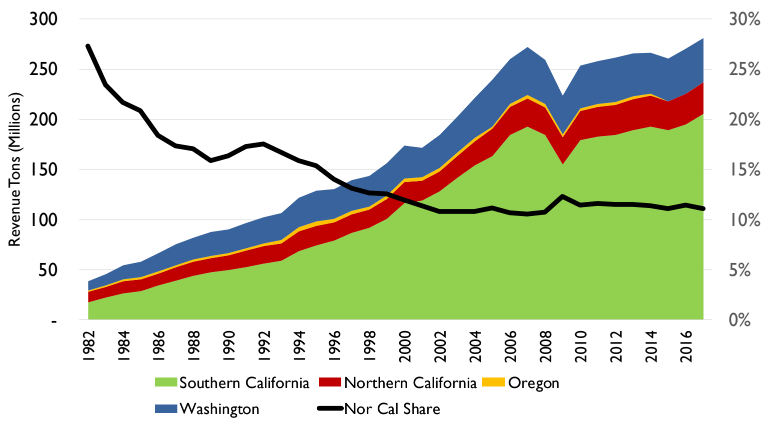
The West Coast handles more containers than either the East Coast or Gulf Coast, but the margin has been dropping. In 2003 the West Coast handled nearly 2.0 million more TEU than the East Coast, but by 2016 that margin had fallen to less than 0.4 million TEU. (See Figure 3-23).

From 2003 through 2016 container volume growth averaged nearly 3.0% per year, even with the drop that occurred in 2009. Growth was much faster before the recession, however, averaging 6.6% per year from 2003 through 2007. After the recession growth averaged 2.6% per year, from 2010 through 2016.

Prior to the recession West Coast container volumes were growing faster than volumes at East Coast and Gulf Coast ports. West Coast growth averaged 7.1% per from 2003 through 2007, compared with 6.6% on the East Coast and 3.7% on the Gulf Coast. This changed after the recession, with West Coast growth averaging just 1.1% per year from 2010 through 2016, compared to 3.8% on the East Coast and 5.1% on the Gulf Coast. Over the entire period (i.e. 2003 through 2016) West Coast growth averaged 2.3% per year, compared to 3.8% on the East Coast and 5.1% on the Gulf Coast.

The West Coast was also more deeply impacted by the recession. On the West Coast container volumes dropped by nearly 2.3 million TEU (excluding empty containers), a decline of 14.6%. East Coast volumes dropped by 1.4 million TEU (i.e. 11.0%) and Gulf Coast volumes dropped by less than 0.2 million TEU (or 6.5%).

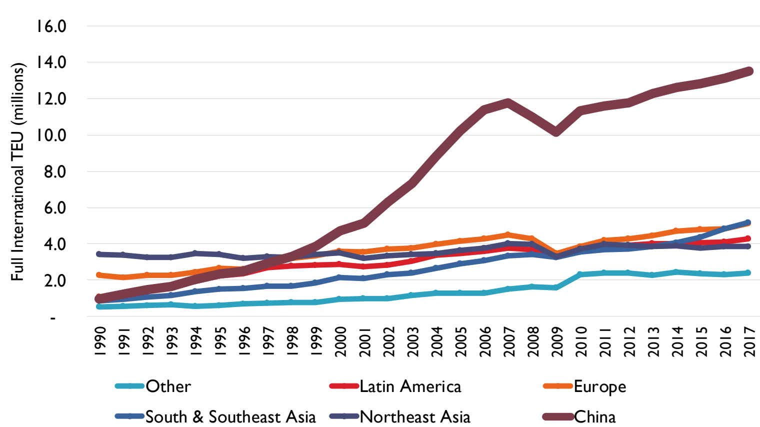
Figure 3-23: West Coast Container Trends (Million revenue tons)



Source: BST Associates using data from the Pacific Maritime Association

Most growth in international container volumes at U.S. ports since 1990 has been due to increasing trade with China. China accounted for less than 11% of the trade in 1990, but accounted for 39% in 2017, and U.S.-China container volume grew from 1.0 million TEU to 13.5 million TEU. Northeast Asia (excluding China) volume grew from 3.4 million TEUs to 3.8 million TEUs, but the region's share of U.S. container trade dropped from 37.3% in 1990 to 11.2% in 2017. The volume from South and Southeast Asia increased faster than the volume from Northeast Asia, growing from 0.9 million TEUs in 1990 to 5.2 million TEUs in 2017, and market share grew from 9.5% to 15.0%. Other trading regions include Europe, which accounted for 15.0% of total volume in 2017, and Latin America/Caribbean, which accounted for 12.5% of volume in 2017. (See Figure 3-24).

Figure 3-24: U.S. International Container Tons (Million Full TEU)



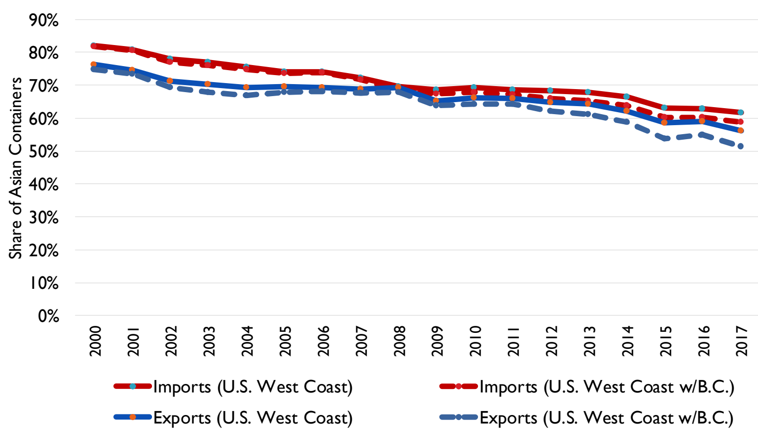
Source: BST Associates using data from PIERS

Since the development of mini-landbridge service (i.e., ocean containers carried by rail), shippers on the East and Gulf Coasts have had some ability to choose between the relatively higher speed and higher cost of shipping via rail through West Coast ports, and the relatively lower speed and lower cost of all-water routings. West Coast ports handle the majority of containerized cargo that moves from Asia to the United States, but the U.S. West Coast market share has declined steadily since 2000 as ports on the East Coast, Gulf Coast, and British Columbia have attracted cargo from Asia.

Between 2000 and 2017, the share of U.S.-Asia containerized imports that moved through U.S. West Coast ports declined from 82.1% to 61.7%, and the share of exports fell from 76.2% to 56.1%, as shown on Figure 3-25. When U.S. cargo moving through British Columbia ports is included, the U.S. West Coast share of Asian imports fell from 81.7% to 58.8%, while U.S. West Coast share of exports fell from 74.8% to 51.4%.

U.S. East Coast market share of the U.S.-Asia import container trade grew from 17.3% in 2000 to 32.3% in 2017, U.S. Gulf Coast market share grew from 0.2% to 3.8%, and Western Canada market share grew from 0.5% to 4.8%. For containerized exports, the U.S. East Coast market share grew from 22.3% to 34.5%, U.S. Gulf Coast market share grew from 0.4% to 4.9%, and Western Canada market share grew from 1.9% to 8.5%.

Figure 3-25: West Coast Share of Asia-North America Container Market



Source: Source: PIERS, IANA

Container traffic on the U.S. West Coast is concentrated in three port regions: San Pedro Bay (i.e. Los Angeles and Long Beach), San Francisco Bay (i.e. Oakland), and Puget Sound (i.e. Seattle and Tacoma). Other ports in California and in the Pacific Northwest also handle limited volumes of containers, but these are generally for small, niche markets. For shippers and carriers, the size of the local/regional market historically has been the most important factor used in deciding which ports to use. In terms of population and consumption, the largest local markets are the Los Angeles region and the San Francisco Bay Area, with the Puget Sound port market area being much smaller.

Approximately 65% of the containers imported via Los Angeles and Long Beach moves by rail to inland destinations such as the Midwest, while at the Port of Oakland only 20% to 30% of import containers move out of that region by rail. In the Puget Sound region less than half of the inbound cargo is distributed within the local market area, and approximately 60% of imports from Asia are shipped by rail to inland destinations.

In Western Canada, Vancouver, B.C. serves as the primary gateway for Asian cargo destined for all of Canada and also competes with U.S. West Coast ports for imported Asian container traffic destined for the U.S. Midwest. This is reflected in the relatively high level of intermodal traffic at Vancouver, where approximately 70% of total imports is shipped inland. At Prince Rupert, located in northern British Columbia approximately 565 miles north of Seattle, nearly 100% of containers move by intermodal rail service to inland points in Canada and the United States.

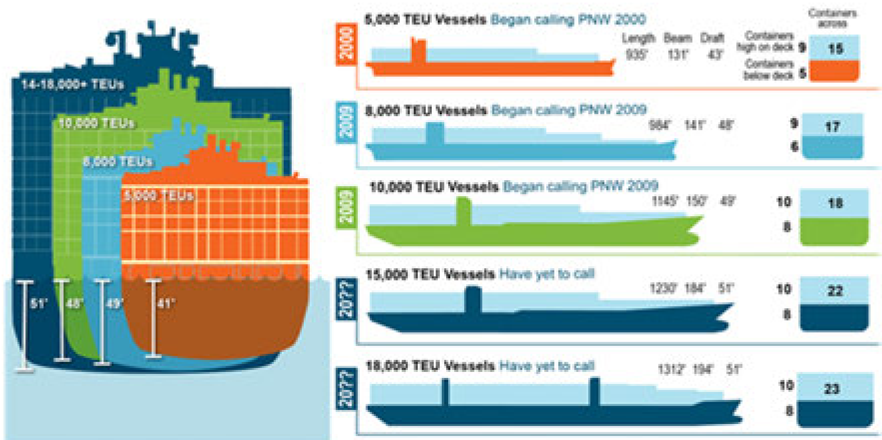
The main impediment to growth in the Asia to East/Gulf Coast container trade has been the size and capacity of the Panama Canal. With the existing Canal reaching capacity in the number of ships that can pass through daily, and new ships being built that are too big for the original locks, Panama made the decision to construct third, larger set of locks. The new locks, which opened in 2016, allow ships up to 150 feet wide and 1,200 feet long, compared with the original maximum width 106 feet and length of 965 feet.

One of the most significant changes affecting selection of container ports is the deployment of ultra large container ships ("ULCS"). This trend has been developing for years but has accelerated in the recent past, and this trend is expected to continue into the future. In the 1970s, the largest containerships had a capacity of 1,800 TEUs. In the early 1980s, the largest ships had a capacity of 4,000 TEUs. By the mid-1990s, the largest ships reached 8,200 TEUs. The Maersk Triple E class vessels introduced in the mid-2000s, have a capacity of 18,000+ TEUs. The move toward even larger vessels continues, with orders for vessels with 24,000 TEUs of capacity.

In order to accommodate the new ULCS, the burden is placed on port operators to invest in:

- Linear berth space exceeding 2,600 feet for two ULCS berthed at the same time
- Container cranes capable of accommodating the ULCS (with an outreach of 18 containers or more)
- On-dock rail of sufficient size to accommodate intermodal traffic generated by ULCS (24,000 feet of rail trackage)
- Sufficient water depth in navigation channels and at berth to accommodate a 51 foot draft

Figure 3-26: Evolution of Container Ships



Source: Mercator International[36]

[36] Mercator International, *Seaport Alliance Strategic Business Plan*, May 16, 2015.

3.6.4.2 Potential demand at Humboldt Bay

Humboldt Bay is not likely to play a significant role in West Coast container markets with the possible exception of a potential marine highway operation. The West Coast market is increasingly concentrated at the San Pedro Bay ports, with significant new competition from British Columbia ports.

Significant changes in the container industry also make it more difficult for smaller ports to compete for container traffic. These changes include consolidation of shipping lines, larger ships, and growth in the size of terminals.

Portland is a prime example of the issues facing smaller ports. Portland has a significantly larger population base than Humboldt Bay, and has excellent rail connections from the two major western railroads. Portland is also served by a 43-foot deep navigation channel, compared with the 38-foot channel in Humboldt Bay. At one time three container shipping lines operated from Portland, and annual container volumes were as high as 330,000 TEU in 1995. However, by 2014 this number had dropped to just 165,000, and in 2015 it fell to less than 23,000 TEU as two of the three carriers pulled out of the market. A recent analysis for the Port of Portland[37] concluded that "The trend toward larger ships in the transpacific will continue and there will be limited opportunities for Portland to attract a transpacific service due to vessel size limitations. Alliances control almost 90% of the transpacific freight. This is not a favorable condition for a smaller port like Portland."

While Humboldt Bay is unlikely to become a regional container port, there is potential for a multi-use terminal to handle some container traffic, as well as breakbulks and other container types.

3.6.4.3 Potential demand at Humboldt

There may be opportunity to handle limited volumes of containers moving in domestic trade. Cargo might include municipal solid waste (i.e. garbage) and forest products. The U.S. Maritime Administration has promoted the concept of "marine highways" to shift freight traffic from roads to water, as discussed in the following section.

It is unlikely that Humboldt Bay will become a container load center due to:

- limits on the size of ship that can transit the navigation channels,
- the lack of railroad connections, and
- the limited local population base.

The projected future demand from CDI land for container shipping is zero acres. (See Table 3-9).

Table 3-9: Demand for CDI Land – Containers

Land Use	Current Acres	Future Acres Low	Future Acres High	Change in Acres Low	Change in Acres High
Containers	0	0	0	0	0

Source: BST Associates

3.6.5 Marine Highway / Domestic

The U.S. Maritime Administration has extensively studied the potential for barges and/or vessels to move cargo along inland and coastal waterways, creating an alternative to conventional freight and

[37] Advisian, *Terminal 6 Business Study*, January 2018.

cargo movement by trucks and rail. Several of the potential routes identified are located on the West Coast.

In 2014, a MARAD-funded study identified three potential West Coast routes with the best chances of supporting a short-sea service, e.g., San-Pedro Bay Ports (Ports of Los Angeles and Long Beach) to the Port of Oakland; San-Pedro Bay Ports to Pacific Northwest Ports (Ports of Seattle and Tacoma); and Port of Oakland to Pacific Northwest Ports. Other options that were not included in the expanded analysis included: San Diego/San Pedro, San Pedro/Port Hueneme, Oakland/ Redwood City, and Humboldt Bay/Crescent City); these were not included because the relatively short-distance between the port pairs was not cost or time competitive with truck transportation. The report identified the best opportunity as "international cargoes that are bulky and heavy, are not time-sensitive, and will load in 20-, 40- or 45-foot container assets." [38]

> There are several potential social and environmental benefits from developing marine highways, including: creating and sustaining jobs in U.S. vessels and in U.S. ports and shipyards; increasing the state of good repair of the U.S. transportation system by reducing maintenance costs from wear and tear on roads and bridges; increasing our nation's economic competitiveness by adding new, cost-effective freight and passenger transportation capacity; increasing the environmental sustainability of the U.S. transportation system by using less energy and reducing air emissions (such as greenhouse gases) per passenger or ton-mile of freight moved.
>
> Further environmental sustainability benefits come from the mandatory use of modern engine technology on designated projects; increasing public safety and security by providing alternatives for the movement of hazardous materials outside heavily populated areas; increasing transportation system resiliency and redundancy by providing transportation alternatives during times of disaster or national emergency; and increasing national security by adding to the nation's strategic sealift resources.[39]

One of the West Coast corridors that was studied is the M-5 Marine Highway Corridor, which runs north-south along the coast. The M-5 corridor is described as:

> The corridor includes the Pacific Ocean coastal waters, connecting commercial navigation channels, ports, and harbors from San Diego, CA to the US-Canada border north of Seattle, WA. It spans Washington, Oregon and California along the West Coast.
>
> Several areas along the corridor have considerable annual truck hours of delay, most notably in the urban areas of California, Portland, OR, and Seattle, WA; as well as rail congestion in that Southern California and the Pacific Northwest are also plagued with freight rail congestion.
>
> Navigable coastal waters that parallel the entire I-5 Corridor, combined with numerous deep and safe rivers, bays, and ports, can help to accommodate some of this expected increase in traffic, reducing landside travel delays and greenhouse gas emissions along this essential freight corridor.

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[38] Cardno TEC Inc., *West Coast Marine Highway Market Analysis Project*, April 2014. Prepared for the West Coast Corridor Coalition through a cooperative agreement with United States Department of Transportation – Maritime Administration.

[39] U.S. Maritime Administration, "America's Marine Highway Program", https://www.marad.dot.gov/ships-and-shipping/dot-maritime-administration-americas-marine-highway-program/ (accessed 3-22-2018).

Sponsors include the California Department of Transportation (Caltrans), the Oregon Department of Transportation (ODOT), the Washington State Department of Transportation (WSDOT)) and supporters (Pacific Northwest Waterways Association, California Marine Affairs and Navigation Conference, Humboldt Bay Harbor, Recreation, and Conservation District / Port of Humboldt Bay, Port of Skagit County, WA, Skagit County Board of Commissioners, Town of La Conner, WA, and Swinomish Tribal Community). [40]

Figure 3-27: M-5 Marine Highway Corridor

In 2010, the California Green Trade Corridor / Marine Highway Project was created to link the Ports of Stockton and Sacramento with the Port of Oakland via the "M-580" route. MARAD awarded a $30 million Transportation Investment Generating Economic Recovery (TIGER 1) to upgrade the port facilities and purchase the equipment needed to transport containers. It was projected that this container-on-barge service could eliminate 180,000 truck trips from I-580, I-80, and I-205 corridors primarily for consumer goods and agricultural products grown in Central California and Northern California. The "M-580" barge service operated between Stockton and Oakland for fourteen months in 2013-2014 as a pilot project. The test was considered to be a qualified success, shifting 7,259 containers to barge over 116 barge trips.[41]

The Port of Stockton announced it would end the weekly container-on-barge service to and from the Port of Oakland in 2014 because it only attracted half of the expected volume. The reasons for the cessation of service included higher cost of operation than for trucking, and difficulty in convincing shippers to terminate contracts with trucking firms. In order for this barge service to be viable there must be sufficient sustainable cargo volume for the service. If the distance from the shipper to the port is minimal, the cost of accessing the terminal may be acceptable but as the distance increases, the

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[40] U.S. Maritime Administration, marine highway corridor descriptions, https://www.marad.dot.gov/wp-content/uploads/pdf/Click-here-for-Route-Descriptions.pdf (accessed 3-22-2018).

[41] CalTrans, *Long Term Implementation of the M-580 Marine Highway*, December 2015.

overall costs may exceed the other options for shippers. Trucking is also more flexible in that it minimizes delays waiting for service.

3.6.5.1 Potential demand at Humboldt

Marine highway systems need an anchor user with sufficient volumes to drive an acceptable level of service and to minimize per unit costs. Cargoes in Humboldt Bay that have been considered for such service include municipal solid waste and lumber. Marine highway service could also accommodate breakbulk and container cargoes.

If an offshore wind program were initiated in Humboldt Bay, a marine highway service could link Humboldt Bay with the Port of Oakland or San Francisco. A similar service operated on Puget Sound, to transport airliner components from Seattle to the Boeing assembly plant near Everett. In 2005, Boeing began to outsource certain oversized airplane components to a manufacturer in Japan. These components were carried in oversize containers aboard container ships that offloaded in Seattle, and then loaded onto barges for transport to a Port of Everett dock in Mukilteo, near the assembly plant. Once container volumes reached a sufficient level, however, the ships carrying the oversize containers began calling directly at the Port of Everett.

The potential for success of such a program in Humboldt Bay is uncertain until more is known about the scale and on-shore infrastructure requirements of the offshore wind energy industry.

The projected demand for CDI lands from marine highway service is zero acres. (See Table 3-10). If such a service were to be created, however, it could likely be accommodated at a multi-purpose terminal that handles breakbulk and other cargo types.

Table 3-10: Demand for CDI Land – Marine Highway

	Current	Future Acres		Change in Acres	
Land Use	**Acres**	**Low**	**High**	**Low**	**High**
Marine Highway	0	0	0	0	0

Source: BST Associates

3.7 Dry Bulk Cargo

Dry bulk cargoes are those that can be handled with a system of conveyor belts, hoppers and other equipment between trucks, railcars, storage facilities and ships. The bulk cargo market is actually not a single market, but rather a collection of individual commodity markets, each subject to its own set of market dynamics and trade trends based on supply, demand and other variables. They generally include commodities and basic materials with a low unit value moving in very high volume, such as coal, iron ore, various forms of semi-processed iron, minerals, cement, grains, and woodchips.[42]

3.7.1 Overview

Dry bulk commodities are shipped by water to and from foreign ports as well as to and from domestic ports. Dry bulk movements on the U.S. West Coast are dominated by foreign trade, and essentially all of the growth in dry bulk movements since 1990 was due to increasing foreign trade.

Foreign exports are the largest type of movement, accounting for two-thirds of dry bulk movements in 2016. Exports actually trended downward from 1990 through 2002, but since then have risen substantially. Exports averaged approximately 50 million tons per year from 1990 through 1994, increased substantially from 1995 through 1997, and then dropped to an average of 46 million metric tons from 1998 through 2003. After 2003 the volume exports started a long period of growth, reaching nearly 76 million metric tons in 2016 and averaging more than 70 million metric tons per year from 2012 through 2016. (See Figure 3-28)

Foreign imports also grew over the long run (i.e. from 1990 through 2016) but saw higher volumes in the middle of that period than at the end. Overall, imports grew from less than 14 million metric tons in 1990 to more than 18 million metric tons in 2016, an increase of 34%. Imports grew slowly from 1992 through 2000 and then again from 2003 through 2006, reaching a peak of more than 25 million metric tons. Imports dropped sharply during the recession, falling to just 11 million metric tons in 2009. After 2009 import volumes grew each year, exceeding 18 million metric tons in 2016.

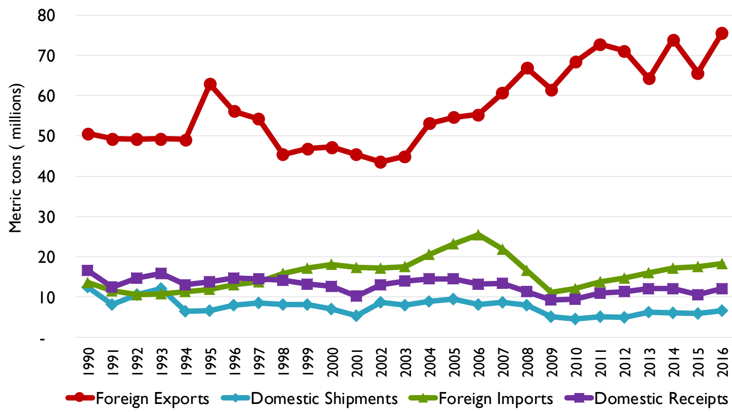
Domestic shipments and domestic receipts of dry bulks move in smaller volumes than in foreign trade, with domestic shipments accounting for approximately 6% of dry bulk movements and domestic receipts accounting for 11%. Volumes of both dropped between 1990 and 2016, but much of this decline occurred early in the period.

Domestic receipts have run through several cycles of growth and decline, reaching lows of 13 million metric tons in 1994, 10 million metric tons in 2001, and nine million metric tons in 2009. High volumes included 16 million metric tons in 1993, 15 million metric ton in 1996, and more than 14 million metric tons in 2004 and 2005. From 2013 through 2016 domestic receipts were approximately 12 million metric tons per year, except in 2015.

Domestic shipments essentially followed the same cycles as domestic receipts, while averaging approximately 5 million metric tons less than domestic receipts. Domestic shipments dropped from a high of more than 16 million metric tons in 1990 to a low of less than five million metric tons in 2010. From 2013 through 2016 domestic shipments averaged six million metric tons per year.

[42] PB Ports & Marine, Inc., *Port of Humboldt Bay Harbor Revitalization Plan*.

Figure 3-28: West Coast Dry Bulk Trends (Million Metric Tons)

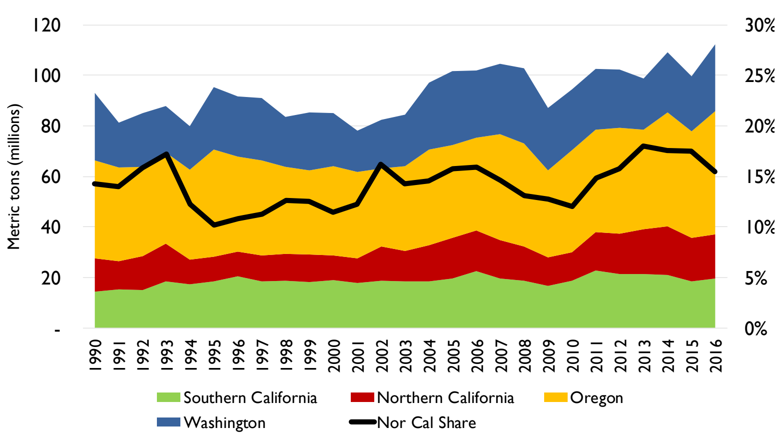


Source: US Army Corps of Engineers

Northern California's share of U.S. West Coast dry bulk movements averaged 14% from 1990 through 2016; in the most recent five years this average was closer to 17%. Northern California's share dropped from 17% in 1993 to less than 11% in 1995 and 1996 but has trended upward since then. (See Figure 3-29).

Total dry bulk tonnage for Northern California grew from approximately 13 million metric tons in 1990 to 15 million metric tons in 1993 and then remained near 10 million metric tons from 1994 through 2001. Since 2002 Northern California dry bulk tonnage has trended upward, never dropping to less than 11 million metric tons and averaging more than 17 million metric tons per year over the most recent five years. In 2014 Northern California ports handled a record 19 million metric tons of dry bulks.

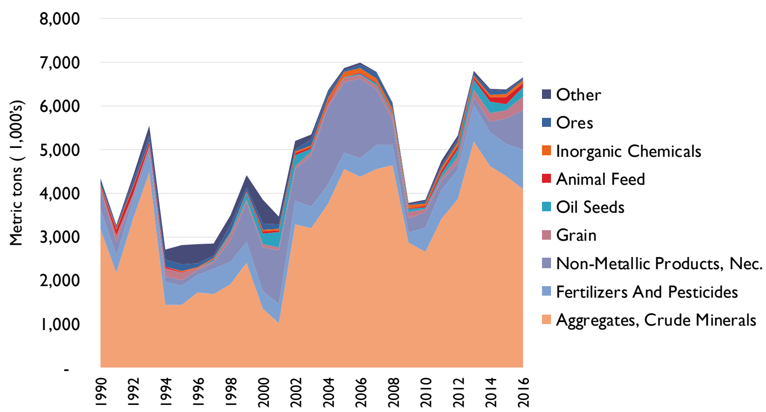
Figure 3-29: West Coast Dry Bulk Trends by Region (Million Metric Tons)



Source: US Army Corps of Engineers

In Northern California, aggregates and crude minerals (primarily gypsum) account for more than half of waterborne dry bulk receipts (both domestic and foreign traffic). Fertilizers and pesticides account for nearly 14% of inbound tonnage, and non-metallic products (primarily cement and concrete) also account for 14%. Other products account for a total of less than 12% of inbound dry bulk tonnage. Humboldt Bay is a minor player in dry bulk receipts and accounted for less than 1% of Northern California tonnage from 1990 through 2016, except during the period of 1998 through 2001, when local pulp mills received woodchips by water. (See Figure 3-30).

Figure 3-30: Northern California Dry Bulk Receipts (1,000 Metric Tons)

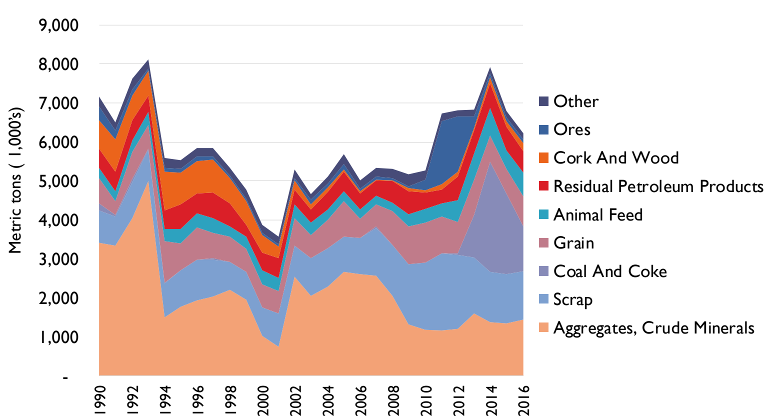


Source: US Army Corps of Engineers

In Northern California, for most of the period from 2000 through 2016 three commodity groups accounted for most dry bulk shipments: aggregates and crude minerals (mainly sand/gravel and sulphur), scrap (i.e. iron and steel), and grain. In 2013, however, the Port of Richmond began exporting coal, and coal has since become one of the top three outbound dry bulks.

During the 1990's one of the major outbound dry bulk commodities was cork and wood (essentially all of which was woodchips), and Humboldt Bay accounted for the majority of this tonnage. Woodchip shipments dropped sharply from 2000 through 2007, and although volumes have increased since then, the volume is still approximately one-quarter of what is was during the 1990's.

Figure 3-31: Northern California Dry Bulk Shipments (1,000 Metric Tons)



Source: US Army Corps of Engineers

3.7.2 Aggregates

Aggregates are a critical input to the construction industry, but in California it has become increasingly difficult to access supplies of this material close to population centers. Aggregates are low-value commodities that move in large volumes, and increasing distance greatly increases the delivered price. Humboldt Bay is a relatively long distance from population centers but it has significant supplies of aggregates. Humboldt Bay may be able to supply markets such as the San Francisco Bay area or the Los Angeles area if the delivered price is competitive with other suppliers.

The California Geological Survey (CGS) describes aggregates as follows:

> Sand, gravel, and crushed stone are 'construction materials.' These commodities, collectively referred to as aggregate, provide the bulk and strength to Portland Cement Concrete (PCC), Asphaltic Concrete (AC, commonly called 'black top'), plaster, and stucco. Aggregate is also used as road base, subbase, railroad ballast, and fill. Aggregate normally provides from 80 to 100 percent of the material volume in the above uses."
>
> The building and paving industries consume large quantities of aggregate and future demand for this commodity is expected to increase throughout California. Aggregate materials are essential to modern society, both to maintain the existing infrastructure and to provide for new construction. Therefore, aggregate materials are a resource of great importance to the economy of any area. Because aggregate is a low unit-value, high bulk weight commodity, it must be obtained from nearby sources to minimize economic and environmental costs associated with transportation. If nearby sources do not exist, then transportation costs can quickly exceed the value of the aggregate. Transporting aggregate from distant sources results in increased construction costs, fuel consumption, greenhouse gas emissions, air pollution, traffic congestion, and road maintenance.[43]

3.7.2.1 Historical Trends

According to the California Geological Survey, from 1981 to 2010 California consumed an average of about 180 million tons of construction aggregates (all grades) per year. In order to meet the demand, aggregates suppliers are increasingly turning to alternative sources, including sources from out of state or out of the country. For example, the San Diego area imports aggregates from sources in Mexico, while the San Francisco Bay area and now the Los Angeles area import aggregates from Canada.

In the Bay Area, Cemex Aggregates operates an 8.2 acre marine terminal at the Port of Redwood City that receives building materials such as sand and aggregates. These materials are transported via ship from British Columbia and are used for construction projects in the South Bay area.

According to a recent Port of Redwood City press release, "over the past three years Cemex has imported nearly four million metric tons of building materials."[44] According to the Port, there is a dwindling local supply of these materials being mined locally, because quarries are unable to expand.

The construction aggregates arrive at the Port on ships that contain self-unloading features, operated by Canadian Steamship Lines. Eagle Rock Aggregates is the supplier to Cemex of these construction

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[43] California Geological Survey Department of Conservation, *Aggregate Sustainability in California*, 2012.

[44] Port of Redwood City, "Port, Cemex Aggregates Reach New 10-Year Deal" port press release, June 26, 2017.

aggregates. Eagle Rock operates the Orca Quarry, located on the northeast coast of Vancouver Island, BC, which is a very first-rate sand and gravel resource with significant long-term capacities.

Southern California also started receiving aggregates from the same quarry in 2016, using the same type of ship. Like the terminal in Redwood City, the Long Beach terminal is approximately eight acres.

The inability to permit expanded or new quarries in Southern California is similar to that in Northern California, and has led construction material firms to look for new sources of sand and gravel. According to a recent article in the Los Angeles Times, "a 2012 report from the California state geologist estimates that quarries in Los Angeles County and the Bay Area have permits to produce less than one-third of the aggregate that will be needed over the next 50 years. San Diego, which already imports aggregate from Mexico, is in even worse shape."[45]

Total transportation cost is what makes shipping aggregates by water make sense. According to the article in the Los Angeles Times, aggregates are moved by conveyor belt from the mine to the ship loader in Canada, then is loaded in ships that can carry about 75,000 tons of material. The total cost to move the material from the quarry in Canada to a construction site in Los Angeles is $16.00 per ton, compared to nearly $23.00 per ton for trucking 65-miles from an inland quarry to Los Angeles.

3.7.2.2 Forecast

The CGS projects that California's 50-year demand for aggregates was more than 12 billion tons, as of January 2011. Statewide, currently permitted reserves are only capable of meeting 34% of that demand, and in some areas the situation is much worse. Many of these areas with permitted reserves that are substantially lower than forecast demand are located on navigable waterways, and may be capable of receiving aggregates by water. (See Table 3-11).

For example, in the San Francisco Bay Area (and connecting waterways) the North San Francisco Bay P-C (production-consumption) region has permitted reserves capable of meeting just 21% of 50-year demand, in the South San Francisco Bay P-C region the supply is equal to 29% of demand, in Sacramento County reserves may only meet 6% of demand, and in Stockton-Lodi reserves may meet 53% of demand.

[45] Koren, James Rufus, "Why builders of big L.A. projects are making concrete with gravel and sand shipped from Canada", *Los Angeles Times*, November 4, 2017.

Table 3-11: Comparison of 50-Year Demand to Permitted Aggregate Reserves

Aggregate Study Area	50-Year Demand (million tons)	Permitted Aggregate Reserves (million tons)	Permitted Reserves Compared to 50-Year Demand	Projected Years Remaining
Bakersfield P-C Region	438	143	33%	21 to 30
Barstow-Victorville P-C Region	159	124	78%	31 to 40
Claremont-Upland P-C Region	203	109	54%	21 to 30
El Dorado County	76	18	24%	11 to 20
Fresno P-C Region	435	46	11%	10 or fewer
Glenn County	59	33	56%	21 to 30
Eastern Merced County	100	50	50%	21 to 30
Western Merced County	28	Proprietary	>50%	31 to 40
Monterey Bay P-C Region	346	323	93%	41 to 50
Nevada County	100	26	26%	11 to 20
Palmdale P-C Region	577	152	26%	11 to 20
Palm Springs P-C Region	295	152	52%	21 to 30
Placer County	151	152	101%	More than 50
North San Francisco Bay P-C Region	521	110	21%	11 to 20
Sacramento County	670	42	6%	10 or fewer
Sacramento-Fairfield P-C Region	196	128	65%	11 to 20
San Bernardino P-C Region	993	241	24%	11 to 20
San Fernando Valley / Saugus-Newhall	476	77	16%	10 or fewer
San Gabriel Valley P-C Region	809	322	40%	11 to 20
San Luis Obispo-Santa Barbara P-C Region	240	75	31%	11 to 20
Shasta County	93	52	56%	21 to 30
South San Francisco Bay P-C Region	1,381	404	29%	11 to 20
Stanislaus County	214	45	21%	11 to 20
Stockton-Lodi P-C Region	436	232	53%	31 to 40
Tehama County	62	32	52%	21 to 30
Temescal Valley-Orange County 3	1,077	297	28%	11 to 20
Northern Tulare County	124	27	22%	11 to 20
Southern Tulare County	73	Proprietary	<50%	21 to 30
Ventura County 3	298	96	32%	11 to 20
Western San Diego County P-C Region	1,014	167	16%	10 or fewer
Yuba City-Marysville P-C Region	403	392	97%	41 to 50
Total	12,047	4,067	34%	

Source: California Geological Survey

3.7.2.3 Potential demand at Humboldt

According to the 2003 *Port of Humboldt Bay Harbor Revitalization Plan* "There appear to be significant opportunities for domestic aggregates and rock from the Humboldt County area to be barged or railed down to the Bay Area (especially North Bay locations) to meet a looming shortage of construction materials. Based on extraction reports, interviews with Humboldt County officials, and interviews with landowners and permit holders, it is evident that significant volumes could be produced from the Eel River and potentially lesser amounts from the Van Duzen River for shipment to the Bay Area by barge or rail."

The Humboldt Bay region is home to a number of aggregates quarries, especially along the Mad River and Eel River drainages. The *Revitalization Plan* notes that "Forty-eight Humboldt County sites are currently permitted for in-stream mining of over 2.5 million cubic yards per year. Volumes of 600,000 to 1 million tons per year appear to be within the range of possibility. In addition, 26 sites are permitted for hard rock mining of over 800,000 cubic yards annually. In addition to aggregates, these hard rock sites could produce larger-dimension rock for San Francisco Bay markets. Success in the bulk aggregate and rock markets will depend on transportation costs and potential environmental constraints on harvest volumes."

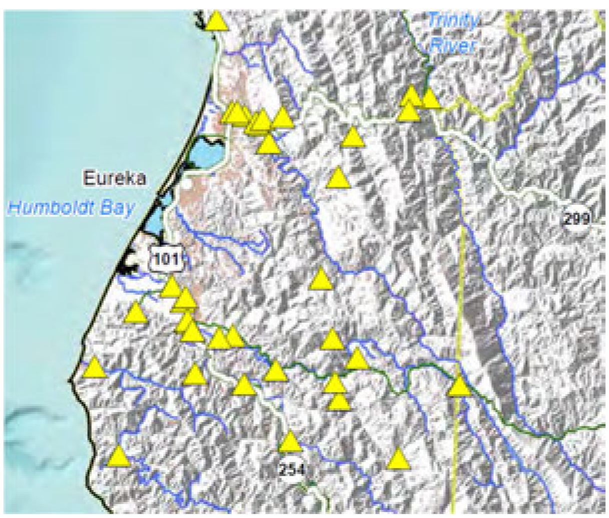
As described above, total transportation cost is a key factor in determining what markets can be economically served from which quarries. Trucking is typically the most expensive option on a ton-mile basis, while shipping by water is the least expensive. In order for quarries in Humboldt County to compete in distant markets, such as Southern California or the San Francisco Bay Area, the inland distance from quarry to shipping terminal and from receiving terminal to final destination must be minimized.

The current operation on Vancouver Island is able to use conveyor belts to move aggregates one mile from the quarry to the ship loading terminal, which minimizes the inland transportation cost on the shipping end. The water distance from the quarry to Redwood City is approximately 1,115 miles, and to Long Beach is 1,450 miles. In a recent article[46], the total cost to transport aggregates from the Vancouver Island quarry to a construction site 25 miles inland from the terminal in Long Beach included:

- Water transportation – 1,465 miles, 75,000 tons per load, $7.25 per ton, or $0.005 per ton-mile
- Trucking – 25 miles, 25 tons per load, $220 per load, or $0.35 per ton-mile
- Total cost of $16.05 per ton

A number of quarries on the Mad River are approximately 15 miles by road from terminals in Eureka and on the Samoa Peninsula, while several quarries on the Eel River are less than 15 miles from Fields Landing and less than 20 miles from Eureka. (See Figure 3-32).

Figure 3-32: Aggregate Production Areas in Humboldt Bay Region



Source: California Geological Survey, portion of Map Sheet 52

Humboldt Bay is 721 miles closer to both Redwood City and Long Beach. Using the same cost per ton-mile for water transportation, the waterborne move from Humboldt Bay to either Redwood City or Long Beach would be $3.57 lower than from the Canadian quarry. Assuming the same trucking cost per ton-mile, this savings on the water transportation would offset approximately 10 miles of the 15 miles for trucking from Humboldt Bay area quarries to a shipping terminal. As a result, Humboldt Bay area

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[46] Koren, November 4, 2017.

quarries might be able to compete for this business. Using the same factors as in the Los Angeles example, the total cost to move aggregates from Humboldt Bay quarries through Long Beach to a site 25 miles inland would be $17.75 per ton.

Alternatively, a number of the quarries in the Humboldt Bay area are located adjacent to or near the inactive NCRA rail line, and several quarry owners have expressed interest in transporting aggregates by rail. According to one recent estimate[47], the cost to ship by rail is approximately one-third the cost of transporting by truck, while another[48] estimated that rail transportation was $5.00 per ton less than truck transportation. The potential cost savings from rail may increase the competitiveness of Humboldt Bay aggregates in the distant markets.

The 8.2-acre Redwood City terminal imported four million tons over three years, or an average of 1.33 million tons per year. Based on the estimate of 1 million tons per year from the *Revitalization Plan,* a terminal in Humboldt Bay of eight acres to twelve may be capable of handling the potential demand. (See Table 3-12).

Table 3-12: Demand for CDI Land – Aggregates

	Current	Future Acres		Change in Acres	
Land Use	**Acres**	**Low**	**High**	**Low**	**High**
Aggregates	0	8	12	8	12

Source: BST Associates

[47] Robinson, Gilpin R. Jr., and Brown, William M, *Sociocultural Dimensions of Supply and Demand for Natural Aggregate— Examples from the Mid-Atlantic Region, United States*, U.S. Geological Survey Open-File Report 02-350, September 2002.

[48] Pincomb, Art, "Mineral Appraisals: What is the Value of a Quarry or Mine?", *The M&TS Journal, Volume 32, Issue 2*, 2nd Quarter 2016.

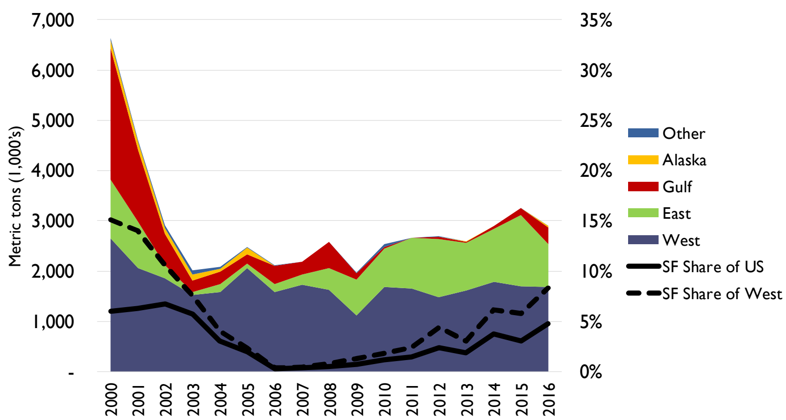
3.7.3 Woodchips

Woodchips are the main inputs to pulp and paper manufacturing. Woodchips are largely a by-product of lumber mills, and the supply of chips is related to output of mills.

3.7.3.1 History

United States exports of woodchips dropped from 6.6 million metric tons in 2000 to just 2.0 million metric tons in 2003, a fall of nearly 70%. Most of drop was due to declining exports from Gulf Coast ports, which saw woodchip tonnage drop by more than 90%. (See Figure 3-33).

Figure 3-33: United State Woodchip Exports



Source: U.S. Census Bureau Foreign Trade Division

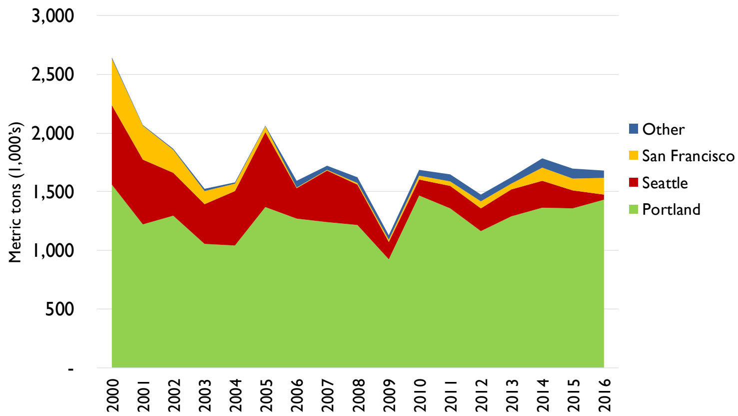
The West Coast has been the largest exporter in the U.S. of woodchips since at least 2000, and in every year since 2002 it has accounted for more than half of all woodchips exports. Gulf Coast exports have remained relatively low, while East Coast exports saw strong growth after 2005.

The San Francisco Customs District, in which Humboldt Bay is located, is a relatively small exporter of woodchips, but market share saw strong growth from 2006 through 2016. In 2006 and 2007 the San Francisco Customs District accounted for less than 1.0% of U.S. exports and also less than 1.0% of West Coast exports. Market share climbed over the next decade, and in 2016 the San Francisco Customs District accounted for 4.8% of U.S. woodchip exports and 8.3% of West Coast exports.

West Coast exports of woodchips generally range between 1.5 million metric tons and 1.7 million metric tons from 2003 and 2016. The primary exceptions were in 2005, when volumes exceed 2.0 million metric tons, and in 2009, when they dropped to 1.1 million metric tons.

The Portland Customs District includes ports on the Columbia River in both Oregon and Washington, as well as ports on the Oregon Coast. The Portland District is by far the largest exporter of woodchips, accounting for 75% or more of West Coast exports from 2008 through 2016. From 2010 through 2016, Portland District woodchips exports averaged 1.6 million metric tons. In contrast, woodchip exports from the San Francisco Customs District averaged less than 170,000 during the same period. (See Figure 3-34).

Figure 3-34: U.S. West Coast Woodchip Exports



Source: U.S. Census Bureau Foreign Trade Division

In addition to exports, for a period in the late 1990's and early 2000's woodchips were received by water. These inbound receipts were used as an input to pulp manufacturing and were imported to make up for a shortage of locally produced woodchips. This was relatively short-lived, however, and woodchips have not moved inbound to Humboldt Bay in more than a decade.

3.7.3.2 Forecast

According to a recent report, there are potential export options resulting from the need to remove trees that were killed by drought, beetles, wildfire, and other damaging agents, which are estimated to include an estimated 102 million standing dead trees. Options to utilize these assets include 350,000 BDT[49] from log exports, up to 250,000 BDT from wood chips, as much as 300,000 BDT from low capital, simple product mix sawmills, and 1.1 million BDT from large scale biomass plants. The dead tree problem is centered in the Southern Sierra Range and the nearest ports are Stockton and West Sacramento. These ports have a maximum draft depth of 35' and 30' respectively. A fully loaded chip vessel requires 38' to 39' of draft. Thus, any vessels originating from either of those ports could only be partially filled. In the past, chip exporters using those ports have dealt with this problem by sending partially loaded vessels to deeper ports in Samoa, California or Coos Bay, Oregon to be fully filled. This practice is costly, but per industry contacts may not be cost prohibitive.[50]

3.7.3.3 Future Acreage

Humboldt Bay currently has two facilities that that ship woodchips, the Eureka Forest Products terminal in Eureka and the California Redwood Chip Export Dock in Samoa. The Eureka Forest Products property encompasses 19.5 acres, of which 15.3 acres is land. The California Redwood property encompasses 23.7 acres, of which 19.3 acres is land.

According to vessel data maintained by the Harbor District, the Eureka Forest Products terminal has handled as much as 9,600 metric tons of woodchips per acre of land, and the California Redwood

[49] "BDT" means bone dry tons, a measurement of biomass that has zero percent moisture content.

[50] The Beck Group, *Dead Tree Utilization Assessment*, May 2017. Completed for CALFIRE & California Tree Mortality Task Force.

terminal has handled approximately 11,100 metric tons per acre of land. Based on these tonnage factors and the existing acreage, the active terminals have a combined throughput capacity of at least 361,000 metric tons per year.

The highest combined woodchips tonnage that these terminals have handled in the past is approximately 251,000 metric tons in 2016 and 253,000 metric tons in 2017. This implies that the existing terminals have the capacity to export 43% more, or 108,000 metric tons.

Some other ports on the West Coast have demonstrated much higher throughput, and the Humboldt Bay woodchip terminals may be capable of handling higher volumes. For example, Coos Bay has an estimated 40 acres of woodchip terminals which have handled combined volumes of nearly 30,000 metric tons per acre. The Fibreco Terminal in Vancouver, BC, is capable of 3 million metric tons of throughput with approximately 12 acres of woodchip storage, or 245,000 metric tons per acre.

There does not appear to be future demand for additional CDI lands for woodchip terminals. Given the throughput at the two existing terminals, it may also be feasible to consolidate all woodchip shipments into a single terminal. Current usage of CDI lands is 36 acres, and projected demand ranges from 20 acres to 36 acres. (See Table 3-13).

Table 3-13: Demand for CDI Land – Woodchips

	Current	Future Acres		Change in Acres	
Land Use	**Acres**	**Low**	**High**	**Low**	**High**
Woodchips	36	20	36	-16	0

Source: BST Associates

3.7.4 Grain and Oilseeds

U.S. grain terminals export a variety of grains, oilseeds, and related products. These include wheat, corn, barley, soybeans, grain sorghum, and some animal feeds such as beet pulp pellets and DDGS.[51]

Wheat is primarily used for human consumption, as opposed to the coarse grains (corn, barley, sorghum), which are primarily used as animal feed. Demand for human food is less affected by changes in personal income than demand for animal feed, but currency exchange rates do have a strong impact on wheat sales. Competition for wheat exports is intense, particularly with Canada and Australia, among other countries.

Soybeans are used both for animal feed and for human consumption. The export markets are large and growing, particularly in China. As with other crops, there is strong international competition (mainly from Brazil and Argentina).

Coarse grains, including corn and sorghum, are used primarily for animal feed. Competition is intense in the world coarse grain market, and U.S. exporters vie for sales against Brazil, Argentina, and others. West Coast ports also face competition from other U.S. regions, specifically ports on the Gulf Coast.

Most West Coast exports of grain and oilseeds are shipped through ports in the Pacific Northwest. Pacific Northwest exports grew from less than 20 million metric tons in 2000 to nearly 35 million metric tons in 2015. Volumes fluctuate from year to year, depending on annual harvest and other factors, but the long-term trend has been one of strong growth.

On the West Coast, essentially all grain moves to export terminals by train or barge. In the Pacific Northwest, much of the exported wheat is grown in the Great Plains and shipped to port by rail. In addition, substantial volumes of wheat are grown in the Pacific Northwest and shipped to port by rail, or by barge on the Columbia-Snake River system.

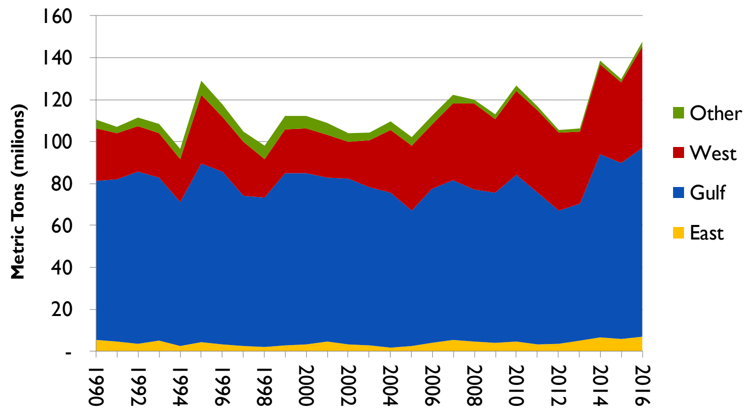
A significant deepening of the Columbia River navigation channel was completed in recent years, which has led to significant investments grain terminals expansions. These investments have increased annual export capacity from approximately 21 million metric tons to more than 37 million metric tons.

In addition to bulk shipments of grain, an increasing volume of grain is loaded into containers for export. Although the volume of this type of movement is still small relative to bulk shipments, it does provide shippers with additional options. Grain can be loaded into containers near the farming areas if empty containers are available, or it can be shipped by rail to the vicinity of container ports (such as Los Angeles / Long Beach), where empty containers are available for transloading.

The recent opening of the larger third set of locks at the Panama Canal also increases the competition for West Coast ports. The new locks allow significantly larger vessels to transit the seaway, which reduces transportation costs and from Gulf Coast and South American ports. In addition, the Corps of Engineers is studying the potential to deepen the Mississippi River channel as far upstream as Baton Rouge, thereby allowing larger, more efficient vessels.

[51] DDGS is distiller's dried grains with solubles, the nutrient rich co-product of ethanol production used as a feed ingredient.

Figure 3-35: U.S. Grain and Oilseed Export Trends



Source: BST Associates using data from the Pacific Maritime Association

3.7.4.1 Forecast

Bulk shipments of grain and oilseeds from the West Coast are likely to continue to be concentrated in the Pacific Northwest.

3.7.4.2 Future Acreage

Humboldt Bay is unlikely to become a bulk export facility for grains and oilseeds. The primary reason for this is that essentially all grain and oilseed exports are shipped to export terminals by rail, or by barge on the Columbia-Snake River system. Humboldt Bay does not have a rail connection to grain growing regions, and is not located on the Columbia-Snake River system. Future acreage needed for this use is zero. (See Table 3-14).

Table 3-14: Demand for CDI Land – Grain and Oilseeds

	Current	Future Acres		Change in Acres	
Land Use	**Acres**	**Low**	**High**	**Low**	**High**
Grain & Oilseeds	0	0	0	0	0

Source: BST Associates

3.8 Other Cargo Types

3.8.1 Liquid Bulk Cargo

Waterborne liquid bulk traffic on the West Coast is dominated by crude oil and refined petroleum products. A variety of other liquid commodities (e.g. animal fats, vegetable oils, chemicals, and fertilizers) are also handled, but in much smaller volumes.

3.8.1.1 Historical Trends

Liquid bulk movements through West Coast ports dropped steadily from 1992 through 2016. From a high of more than 146 million metric tons in 1992, total volume dropped to less than 112 million metric tons in 2016, a decline of 24%.

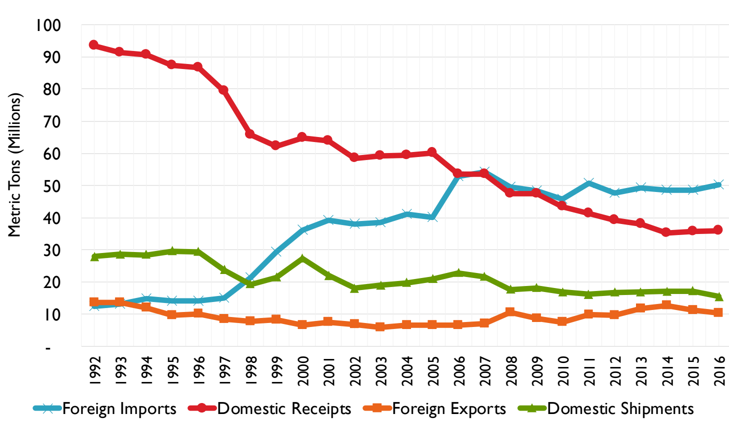
Liquid bulk cargo moving inbound from domestic locations (i.e. domestic receipts) fared the worst, dropping by more than 16% over the period. Domestic inbound tonnage fell from 93 million metric tons in 1992 to 26 million metric tons in 2016, and domestic receipts share of total liquid bulk tonnage fell from 63% in 1992 to 32% in 2016. (See Figure 3-36).

Foreign imports of liquid bulks increased sharply over the period, particularly during the period of 1997 through 2006, and are now the highest-volume liquid bulk movement on the West Coast. Foreign imports totaled approximately 12 million metric tons in 1992 and averaged less than 15 million metric tons from 1992 through 1997. From 1997 through 2007 the volume of imports jumped to more than 54 million metric tons. Imports dropped 49 million metric tons in 2008 and averaged 49 million metric tons from 2008 through 2016.

Outbound movements of liquid bulks (both domestic and foreign movements) are substantially smaller than inbound movements. Domestic shipments represent the third-largest liquid bulk movement on the West Coast, with approximately 15 million metric tons shipped in 2016. This figure represents a decline of nearly 45% from 1992, when nearly 28 million metric tons were shipped.

Exports to foreign destinations declined 24% from 1992 through 2016, falling from approximately 14 million metric tons to less than 11 million metric tons. However, export volumes were actually lower from 1997 through 2007, averaging 7 million metric tons per year; from 2011 through 2016 exports averaged 11 million metric tons.

Figure 3-36: West Coast Liquid Bulk Trends (Million metric tons)



Source: BST Associates using data from the U.S. Army Corps of Engineers

In Southern California liquid bulks are primarily composed of crude oil (inbound) and petroleum products (outbound).

The increase in domestic and Canadian oil production has caused a drop in the importation of crude oil. There is only one high-volume commodity associated with liquid bulk exports, which is refined products that are exported from the local refineries in Southern California.[52]

In Northern California waterborne liquid bulk traffic is dominated by crude oil and refined petroleum products, which account for a 96% of all liquid bulk movements. A variety of other liquid commodities (e.g. animal fats, vegetable oils, chemicals, and fertilizers) are also handled, but in much smaller volumes.

Between 1990 and 2016 the volume of liquid bulks moving through Northern California ports dropped by approximately 30%, due to declining crude oil receipts. Crude oil from domestic sources (primarily Alaska) dropped from more than 27 million metric tons in 2000 to less than 4 million metric tons in 2016 as production in Alaska continued a long-term decline. This drop was partially offset by an increase in imports from foreign sources, which grew from less than 2 million metric tons in 1990 to nearly 18 million metric tons in 2016.

Petroleum products peaked in 1993 at more than 23 million metric tons before dropping to less than 12 million metric tons in 1998. By 2006 and 2007 volumes had increased to nearly 20 million metric tons, but after 2007 they declined slowly, reaching less than 18 million metric tons in 2016.

In the Pacific Northwest waterborne liquid bulk traffic is dominated by crude oil and refined petroleum products, which account for a 98% of liquid bulk movements. A variety of other liquid commodities (e.g. animal fats, vegetable oils, chemicals, and fertilizers) are also handled, but in much smaller volumes.

Between 2000 and 2015 the volume of liquid bulks moving through Pacific Northwest ports dropped substantially, due to a decline in crude oil. Crude oil receipts by water declined due to increased imports of crude by pipeline, and from receipts of crude by rail from North Dakota and Canada.

In Humboldt Bay waterborne movements of liquid bulks have trended downward for more than 25 years. Total volume dropped from approximately 400,000 metric tons in 1990 to less than 180,000 metric tons in 2016.

Much of the decline was due to the closures of the pulp mills on the Samoa Peninsula. As illustrated in Figure 3-37, essentially all waterborne liquid bulk movements on Humboldt Bay are now comprised of petroleum products, primarily gasoline and diesel fuel. Early in the period, however, terminals in Humboldt Bay received sodium hydroxide and inorganic chemicals for use in the mills. These receipts dropped sharply between 1990 and 1993, and then continued at limited volumes until 2002.

Since 2002 the only liquid bulk movements on Humboldt Bay have been petroleum products. Between 2002 and 2016 the volume of petroleum products trended downward, dropping from 241,000 metric tons to as little at 160,000 metric tons in 2015.

All of the petroleum products are received at the Chevron Eureka Terminal.

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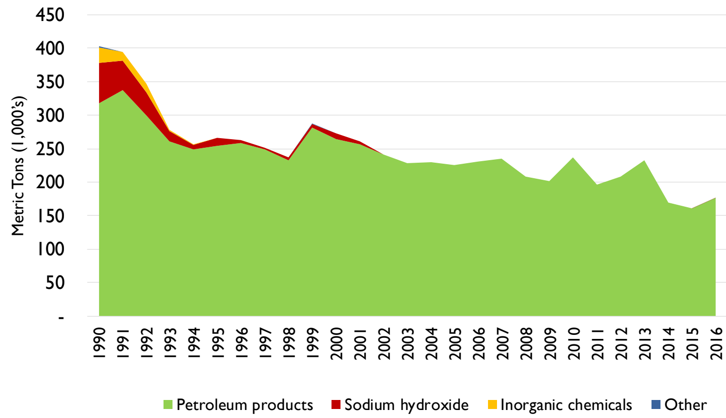
[52] Mercator International and Oxford Economics, *Executive Summary for San Pedro Bay.*

Figure 3-37: Humboldt Bay Liquid Bulk Trends (1,000 metric tons)



Source: BST Associates using data from the U.S. Army Corps of Engineers

3.8.1.2 Forecast

Under its mid-case forecast, the California Energy Commission projects that statewide demand for gasoline peaked in 2016 and will trend downward from 2017 through 2030 while demand for diesel fuel will remain flat.[53]

Assuming that demand in the Humboldt Bay region for these fuels changes at a rate similar to that of the rest of the state, the volume of petroleum products shipped by water to the region is likely to slowly decline.

3.8.1.3 Potential demand in Humboldt Bay

As discussed previously, the Chevron Eureka Terminal dock is a 3.5-acre site south of downtown Eureka, located on the 38-foot North Bay Channel. This terminal receives refined petroleum products via ocean barge for Chevron and other fuel companies, with barges arriving every 10 to 12 days. Approximately 80% of the fuel used by the greater Eureka area is delivered via barge to the Chevron Terminal.[54]

Previously there was a second 4-acre petroleum products terminal operated by Philips Petroleum, also located on the Eureka waterfront. This terminal was inactive at the time of the 2003 *Port of Humboldt Bay Harbor Revitalization Plan*.[55] It has since changed ownership several times, the storage tanks and equipment have been removed, and contamination on the site has been remediated.

Given the forecast of falling demand, the existing Chevron terminal should be able to handle the necessary volumes of fuels. As a result, the existing terminal (or one of similar size) is sufficient to meet demand, and no additional CDI lands will be needed in the future. Current and projected demand is four acres of CDI land. The existing Chevon terminal is capable of handling current volumes, and has handled higher volumes in the past.

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[53] California Energy Commission, *Transportation Energy Demand Forecast, 2017-2030*, June 20, 2017.

[54] Pacific Affiliates, *Chevron Eureka Terminal MOTEMS Inspection Repairs*, May 15, 2015.

[55] PB Ports & Marine, *Port of Humboldt Bay Harbor Revitalization Plan.*

In addition to the liquid bulks historically handled at marine terminals in Humboldt Bay (i.e. petroleum products, chemical for pulp manufacturing) there was a proposal in the early 2000's to construct a terminal for receiving liquefied natural gas ("LNG"). This terminal would have been located on the Samoa Peninsula. However, the project was cancelled in 2004, and this forecast assumes that LNG will not move via Humboldt Bay in the future. (See Table 3-15).

Table 3-15: Current CDI Use and Future Demand, Liquid Bulk

	Current	Future Acres		Change in Acres	
Land Use	**Existing**	**Low**	**High**	**Low**	**High**
Liquid Bulk	4	4	4	0	0

Source: BST Associates

4 DEMAND – OTHER

4.1 CRUISE

Humboldt Bay has hosted cruise ship calls in the past and is expected to continue to do so in the future.

Humboldt Bay is one of several areas that serve as ports of call during what are known as "repositioning" trips. Repositioning trips occur when a cruise ship is moved from one seasonal homeport to another. Cruise ship calls in Humboldt Bay typically occur in the spring or fall, when vessels shift between southern itineraries and the Alaska market.

The Alaska cruise market is based in Vancouver, British Columbia and Seattle, Washington. At the beginning of the season and the end, each vessel must be repositioned from or to its winter homeport. These repositioning cruises that present an opportunity to coastal ports such as Humboldt Bay, Coos Bay, and Astoria.

Cruise line itinerary directors are constantly seeking new ports to offer to their passengers, and coastal ports such as Humboldt Bay, Astoria, and Grays Harbor have been successful in attracting calls. A port call typically lasts for eight hours. During this time, passengers typically have between three and seven hours to participate in local activities. At the same time, the ship will often take on fresh water and dispose of trash.

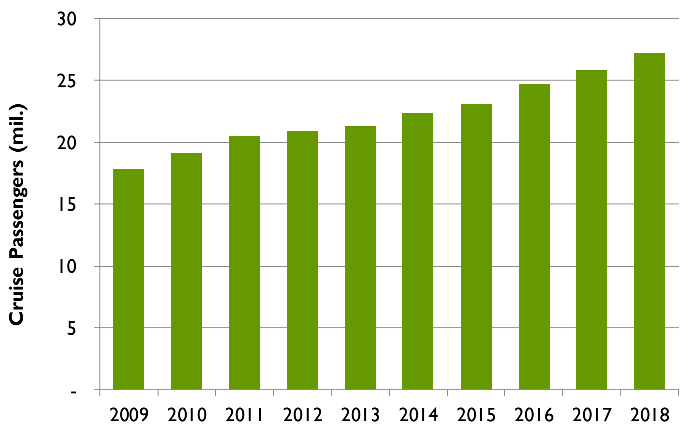
Activities are what draw the cruise lines to a port and proximity to the Redwoods is the primary draw for Humboldt Bay. Local attractions are also critical, especially an attractive town within walking distance for elderly people, with shops selling local goods near the dock. Old Town Eureka provides such an attraction.

4.1.1 Historical Trends

According to the Cruise Lines International Association, the world cruise market has seen substantial and sustained growth for nearly a decade[56]. Total cruise passenger counts jumped from 17.8 million in 2009 to 25.8 million in 2017 and is expected to reach 27.2 million in 2018. Annual growth averaged 4.8% per year, and passenger counts increased in each year.

[56] Cruise Lines International Association, *2018 Cruise Industry Outlook*, December 2017.

Figure 4-1: World Cruise Market Trends

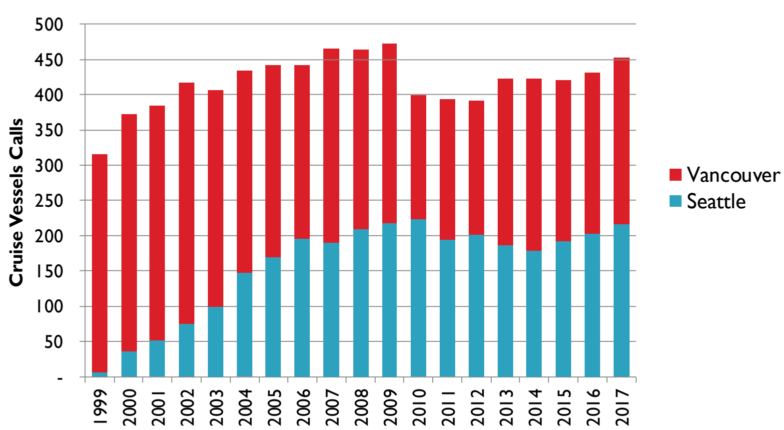


Source: Cruise Lines International Association

During the 1990's nearly all Alaska cruises were based out of Vancouver. Seattle's first homeport cruises occurred in 1999, when the port saw a total of six vessel calls; that year Vancouver hosted 309 vessels calls. From 1999 through 2009 the market saw strong growth, with total vessel calls rising from 315 to 472 calls.

The Alaska cruise market was strongly impacted for several years due to the economic recession, with vessel calls averaging fewer than 400 per year from 2010 through 2012. Recovery in the market started in 2013 and continued through 2017, when Seattle and Vancouver handled a combined 452 vessel calls. (See Figure 4-2).

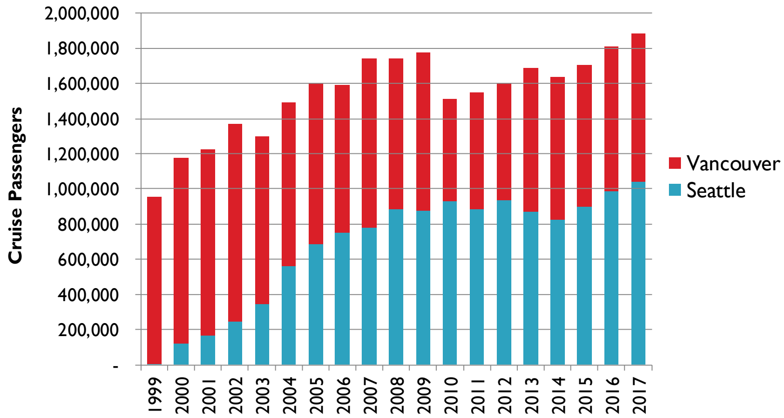
Figure 4-2: Northwest Cruise Trends – Vessel Calls



Source: Port of Seattle, Port Metro Vancouver

Passenger counts rose from fewer than 1.0 million in 1999 to a peak of nearly 1.8 million in 2009. In 2010 the number of passengers dropped to approximately 1.5 million, a decline of nearly 15%. Passenger counts started to recover in 2011 and, with the exception of 2014, grew in each year through 2017. In 2016 the passenger count exceeded the 2009 record and exceeded 1.8 million for the first time, and in 2017 the passenger was nearly 1.9 million. (See Figure 4-3).

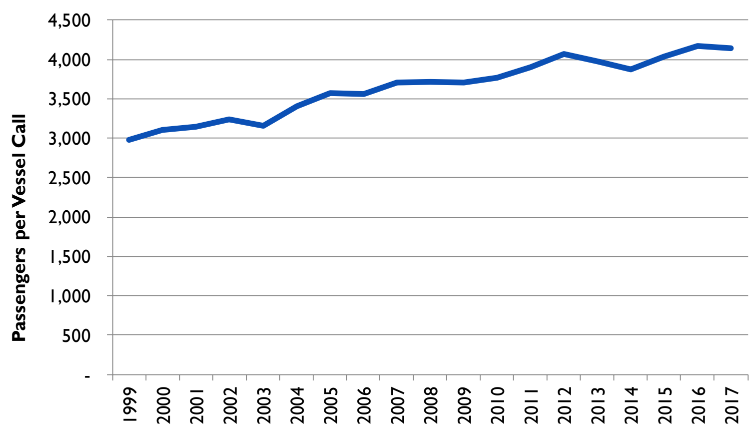
Figure 4-3: Northwest Cruise Trends – Passengers



Source: Port of Seattle, Port Metro Vancouver

A major trend in the cruise industry is the move to larger ships with greater passenger capacity. As illustrated in Figure 4-4, the average number of passengers per vessel call rose from approximately 3,000 in 2009 to more than 4,100 in 2016 and 2017. It should be noted that these passenger counts include both embarking and disembarking passengers and are therefore approximately double the ship capacity.

Figure 4-4: Northwest Cruise Trends – Passengers per Vessel Call



Source: Port of Seattle, Port Metro Vancouver

As shown in Table 4-1, the number of vessels based in Seattle and Vancouver has not changed substantially over time but the average capacity of vessels has. In 2004 there were a total of 35 vessels that operated out of Seattle or Vancouver. This dropped to 29 vessels during the recession-caused downturn in cruise traffic in 2010, but the forecast for 2018 is for 35 to again operate in the Alaska market.

The Alaska cruise fleet is comprised of a variety of vessel sizes, which can be grouped into three general categories. The largest vessels are 700 feet or longer, the mid-size fleet includes vessels between 400 feet and 700 feet, and the small vessels are less than 400 feet.

Large vessels account for most of the fleet operating from Seattle and Vancouver. Of the 35 vessels projected to operate in 2018, 29 are 700 feet or longer; this is unchanged from 2004. Mid-size vessels are a relatively small part of the fleet, accounting for five vessels in 2018, but this represents an increase over both 2004 and 2010. The number of small vessels operating from Seattle and Vancouver dropped from four in 2004 to two in 2010, and just one small vessel is scheduled to operate from the two ports in 2018.

The number of vessels in the fleet directly impacts the number of potential vessel calls for Humboldt Bay. Because each vessel makes two repositioning trips per year (i.e. one in spring and one in fall) the number of potential calls for Humboldt Bay is equal to the fleet size times two.

Across the entire fleet the average number of passenger berths per vessel grew from 1,542 in 2004 to 1,864 in 2018. This means that the same number of ships operating in 2018 as in 2004 can carry nearly 21% more passengers per trip.

Table 4-1: Cruise Fleet Trends in Seattle and Vancouver

	2004	2010	2018
Homeported Vessels			
Small (Under 400')	4	2	1
Mid-Size (400' to 700')	2	2	5
Large (700' and longer)	29	25	29
Total	35	29	35
Average # of Berths			
Small (Under 400')	146	115	144
Mid-Size (400' to 700')	470	436	398
Large (700' and longer)	1,808	1,823	2,176
Total	1,542	1,610	1,864
Average Length			
Small (Under 400')	284	261	354
Mid-Size (400' to 700')	586	579	550
Large (700' and longer)	849	883	914
Total	769	820	846
Average Draft			
Small (Under 400')	12.2	11.0	14.3
Mid-Size (400' to 700')	18.5	21.8	23.5
Large (700' and longer)	26.3	26.4	26.3
Total	24.5	25.0	24.9

Source: Port of Seattle, Port Metro Vancouver

Two key dimensions of the Humboldt Bay navigation channel that potentially limit the size of cruise vessels that can are the channel depth and the size of the turning basin.

The turning basin at the upper end of the Samoa Channel 1,000 feet deep by 1,100 feet long. According to the local harbor pilot[57], the maximum length for cruise vessels to use the turning basin is currently limited to 800 feet, but could potentially be higher with additional assist from tugboats. Based on the projected fleet for the 2018 Alaska cruise season, 23 of the 29 large vessels are 800 feet or longer, and six are less than 800 feet. The number of vessels 800 feet or longer has grown over time, from 19 out of 35 vessels in 2004 to 20 out of 29 vessels in 2010, and to 23 out of 35 vessels in 2018. The number of

[57] Petrusha, Tim, interview with the authors, January 25, 2018.

vessels less than 800 feet fell from 16 in 2004 to nine in 2010 (at the height of the recession) but rose to 12 vessels in 2018. (See Table 4-1)

The Samoa Channel and most of the Eureka Channel have authorized depths of 38 feet. This is not a limiting factor, as cruise ships typically draw less than 30 feet of water. Only two of the ships scheduled for the 2018 Alaska cruise season draw more than 28 feet of water, and this has not changed substantially over time. Over the entire fleet (including small, mid-size, and large vessels), the average draft ranged from 24.5 feet in 2004 to 25.0 feet in 2010, and is 24.9 feet in 2018. For large vessels the average draft of 26.3 feet in 2018 is the same as in 2004, despite the fact that the passenger capacity has continued to increase.

4.1.2 Forecast

According to one cruise industry analyst, Humboldt Bay could potentially see 10 vessels or more per year over the long run.

4.1.3 CDI Land Required

Most ports that handle limited numbers of cruise ship calls do not have a dedicated facility for cruise ships, but instead are able to use existing terminals on a temporary basis. For example, in Astoria cruise ships call at Pier 1, which is also used for lay berthing of ships, topside repair berthing, and also serves the seasonal fishing industry. Pier 3 has approximately three acres of uplands. If one vessel is in port at Astoria it ties up at the pier, and if a second arrives the passengers are carried between ship and shore using the ship's tender vessels. Astoria typically see approximately 20 cruise vessel calls per season.

In Humboldt Bay, cruise ships typically tie up at the Schneider dock, but will use tenders if necessary. The main requirement for a temporary cruise facility include: 1) the ability to physically separate the cruise operation from other activities in order to provide the required marine security (MARSEC), 2) sufficient room for shuttle busses to pick up and drop off passengers, and 3) clean and safe ramps, walkways, etc.

With a forecast of 10 vessels per season it is unlikely that Humboldt Bay requires an additional cruise ship berth. Based on the three acres used for cruise ships in Astoria, the same acreage should be sufficient in Humboldt Bay. (See Table 4-2).

Table 4-2: Current CDI Use and Future Demand, Cruise Ships

	Current	Future Acres		Change in Acres	
Land Use	Existing	Low	High	Low	High
Cruise ships	3	3	3	0	0

Source: BST Associates

4.2 Commercial Fishing & Recreational Boating

This section addresses the facility requirements of commercial fishing and recreational boating, which share moorage and repair facilities.

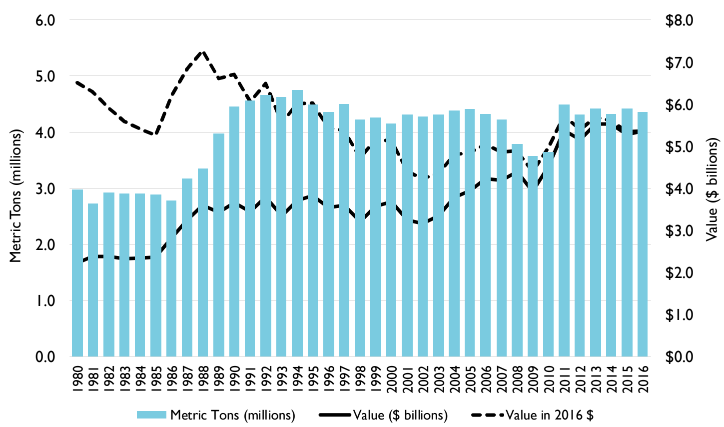
4.2.1 Historical Trends

4.2.1.1 Commercial Fishing

In the United States, the annual commercial fish harvest was 4.1 million metric tons or more per year in all but three years from 1990 through 2016. This level was relatively consistent from 1990 through 2016 and represented a major increase over earlier years. From 1980 through 1986 the harvest averaged less than 3.0 million tons per year.

The nominal value of the national fish harvest grew from approximately $2.2 billion in 1980 to more than $5.5 billion in both 2014 and 2015 and was nearly $5.4 billion in 2016. Adjusted for inflation (to 2016 dollars) the national harvest value peaked in 1998 at nearly $7.3 billion (2016 dollars), and then started a slow decline; by 2002 the value had dropped to a low of $4.2 billion (2016 dollars). Since 2002 the value has trended upward, reaching as high as $5.7 billion in both 2011 and 2013, and was nearly $5.4 billion in 2016. (See Figure 4-5).

Figure 4-5: U.S. Commercial Fish Harvest



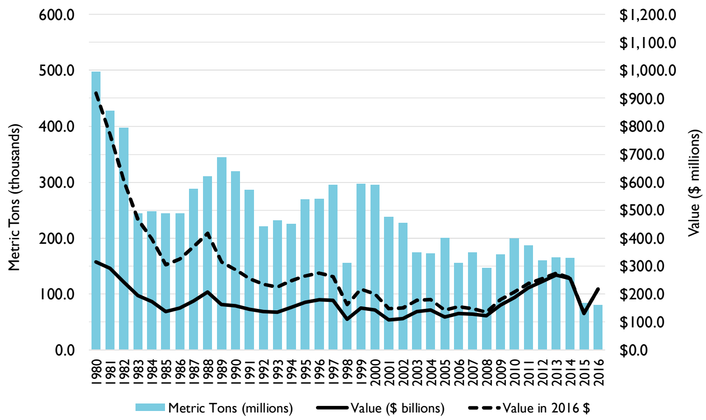
Source: NMFS

In contrast to the national figures, in California the commercial fish harvest has been declining for nearly four decades. California's annual harvest dropped from nearly 500,000 metric tons in 1980 to just 80,000 metric tons in 2016, the lowest level in the past 37 years. During that time there were periods where volumes recovered somewhat, but the long-term trend has been one of steep decline. (See Figure 4-6).

The value of the California commercial fish harvest has also dropped sharply since 1980, falling from $315 million dollars (in current dollars) to $216 million in 2016. However, the lowest value (i.e. $108 million) was reached in 2001. After 2001 the harvest value remained relatively stable for several years, then climbed each year from 2009 through 2013 and reached $266 million, fell in 2014 and 2015, and climbed again in 2016 to $216 million.

Adjusted for inflation (in 2016 dollars), the California harvest value fell from $918 million in 1980 to a low of $135 million in 2008, a drop of 85%. Inflation-adjusted harvest values climbed back to $275 million in 2013, but dropped back to $131 million in 2015, the second lowest inflation-adjusted value since 1980.

Figure 4-6: California Commercial Fish Harvest

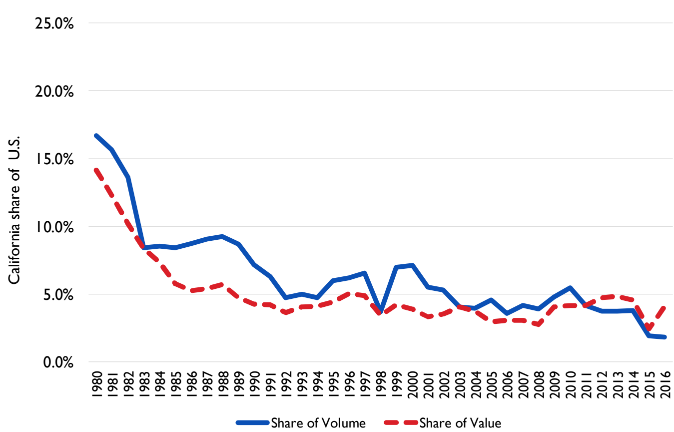


Source: NMFS

California's share of U.S. commercial fishing harvest has dropped sharply, in terms of both volume and value. In terms of volume, California's share of U.S. harvest dropped from 16.7% in 1980 to just 1.8% in 2016. As recently as 2010 California's share was 5.5%, but it fell in all but one year after that.

California's share of harvest value fell from a high of 14.1% in 1980 to a low of 2.4% in 2015. Most of the decline in share of harvest value occurred during the 1980's; since 1988 California's share has generally varied fluctuated between 3.0% and 5.0%. In 2016 California accounted for 4.0% of U.S. commercial fish harvest value. (See Figure 4-7).

Figure 4-7: California Share of U.S. Commercial Fish Harvest

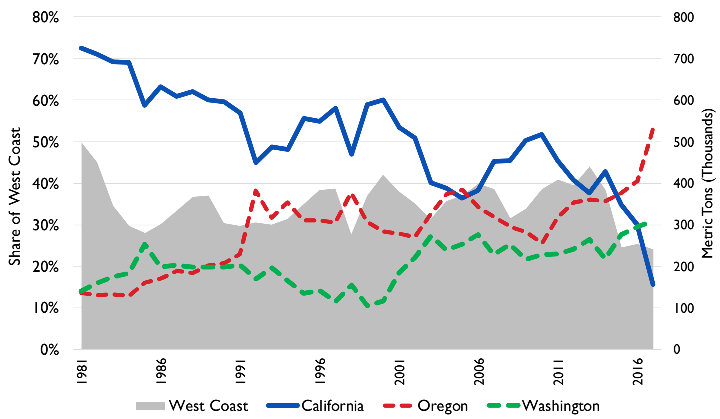


Source: NMFS

California's share of the U.S. West Coast commercial fish harvest declined from approximately 73% in 1981 to just 30% in 2016, and to 15% in 2017. At the same time, Oregon's share grew from less than 14% in 1981 to 40% in 2016 and 53% in 2017, and Washington's share grew from 14% in 1981 to 31% in 2017.

For most of that period, the total volume of fish commercially harvested on the West Coast generally fluctuated between 300,000 and 400,000 metric tons. Volumes were greater than 450,000 metric tons at the beginning of the period (i.e. in 1981 and 1982) and dropped below 300,000 in only three years between 1983 and 2014. Despite the relatively steady harvest during this time, California's share continued to decline. (See Figure 4-8).

Figure 4-8: California Share of West Coast Commercial Fish Harvest

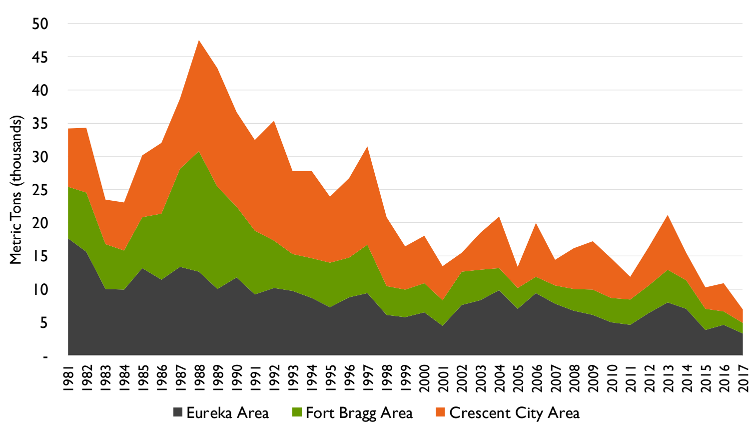


Source: PacFIN

Fish landings at the three port regions on the Northern California Coast (i.e. Eureka area, Fort Bragg area, and Crescent City area) have dropped significantly over the past several decades. From a high of 47,500 metric tons in 1998, landings in the region dropped to just 18,000 metric tons in 2000, a decline of more than 62%. Landings fluctuated over the next decade, averaging approximately 16,000 metric tons per year. Volumes jumped to 21,100 in 2013 but dropped to less than 11,000 in 2015 and 2016, and to 7,000 metric tons in 2017. (See Figure 4-9).

Eureka-area ports accounted for an average of 38% of regional landings from 1981 through 2017. During this period landings in the Eureka area fell from a high of 17,500 metric tons in 1981 to less than 5,000 metric tons per year from 2015 through 2017.

Figure 4-9: Fish Landings in Northern California



Source: PacFIN

The number of fishermen active at Eureka area ports peaked at 540 in 1994, and then fell steadily over the next 12 years. By 2006 the number of active fishermen had dropped to just 143, a decline of more than two-thirds. After increasing in 2007 the number of active fishermen fell to 135 in both 2008 and 2009, but then grew during most subsequent years, nearly reaching 200 in 2013.[58] (See Figure 4-10).

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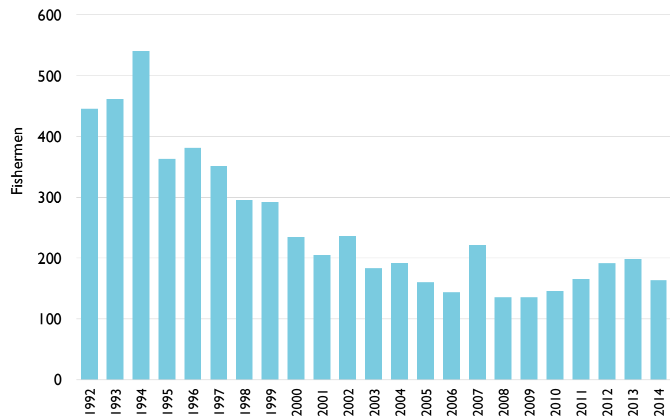
[58] Oceanspaces, http://oceanspaces.org/, (accessed February 12,2018).

Figure 4-10: Number of Fishermen, Eureka Area Ports



Source: oceanspaces.org

The local fishery is changing from a focus on large volume / low value species to lower volume but higher value species. According to a recent report prepared for the City of Eureka:

> Declining oceanic resources, strict fishing quotas and increasing costs have significantly reduced the size and changed the character of Eureka's fishing fleet. Rather than providing inexpensive, bulk products, the industry has shifted to specialty and "sustainably harvested" products. Oysters and other seafood stocks such as squid are also gaining market share.[59]

4.2.1.2 Recreational Boating

The number of recreational boats registered in Humboldt County increased rapidly from the early 1980s until 2007, growing from approximately 4,000 boats to approximately 7,700 boats. The recession had major negative impact on boating throughout the country, and Humboldt County was not immune from the decline. Boating is a discretionary activity, and boat ownership rates are sensitive to changes in household income. Recreational boat ownership in Humboldt County has not recovered from the recession, and in 2017 there were 12% fewer boats registered in the county than there were in 2007.

The rate of boat ownership has also declined in Humboldt County. In 2007 there were 58 boats registered per 1,000 residents in Humboldt County, but in 2017 there were just 50 boats per 1,000 residents in 2017.[60] One of the issues facing recreational boating throughout the U.S. is that as older boaters (baby boomers and older) give up boating they are not being replaced with younger boaters (i.e. Generation X and Millennials).

Humboldt County has consistently accounted for around 11% of the registered boats in the Northern California region. Most of the boats moored at Humboldt Bay marinas are from Humboldt County (estimated at 85% from the County) with the remaining 15% from counties to the east, particularly the Redding area in Shasta County.

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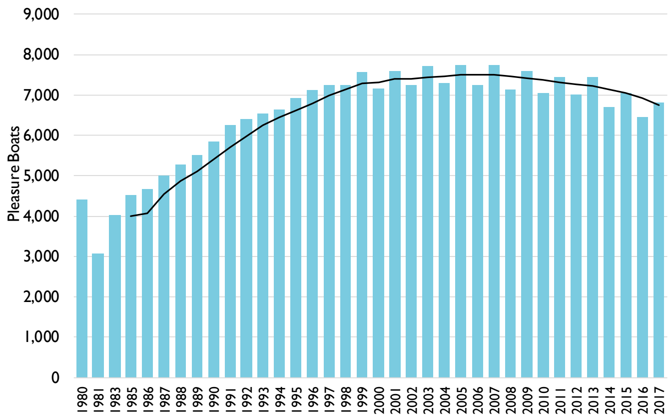
[59] Greenway Partners, *Regional Cold Storage Facility, Technical Study*, September 15, 2015. Prepared for the City of Eureka.

[60] California Department of Boating and Waterways; includes all boat lengths.

Figure 4-11: Recreational Boats in Humboldt County



Source: California Department of Boating and Waterways

4.2.2 Existing Facilities

Humboldt Bay has a number of shoreside facilities that support commercial fishing and recreational boating, most of which are located in CDI areas.

4.2.2.1 Marinas

Two small boat harbors provide moorage for commercial boats: Woodley Island Marina, owned by the Harbor District, and the Eureka Public Marina, owned by the City of Eureka.

Most of the Humboldt Bay commercial fishing fleet is based at Woodley Island Marina. This marina has room for approximately 240 boats and is used by both commercial and recreational vessels. Approximately 120 commercial vessels and 120 recreational boats are currently based at Woodley Island.

The marina sits on two tax parcels of approximately 40 acres each and that contain a total of approximately 80 acres. A substantial portion of the one of these parcels (405-031-009) consists of tidelands, as does a smaller portion of the other parcel (405-031-010). The marina moorage basin is located on approximately 20 acres of tidelands, while parking, buildings, and other developed upland facilities use approximately 15 acres. The remaining acreage is predominantly undeveloped, with the exception of a portion used for roadway. Woodley Island is zoned “Public Facilities – Marina”, as opposed to “MC”, or coastal-dependent industrial.

Dredged material disposal is a critical issue at the Woodley Island Marina. The boat basin tends to silt in without regular dredging, and the loss of water depth can make certain slips unusable. In past years the material dredged from the boat basin has been disposed on the beach on the Samoa Peninsula, where tidal action then disperses it. However, beach disposal has not been permitted in recent years and dredge spoils have been barged to an offshore location, which substantially increases the cost of disposal. In order to minimize the cost of maintenance, a disposal site nearby is needed where dredge spoils can be pumped from the Harbor District’s suction dredge.

The Eureka Public Marina provides 150 moorage slips that accommodate vessels from 20 to 70 feet in length. Approximately 10 commercial fishing vessels are based there, a number that has remained relatively steady. These commercial boats are 40 to 70 feet long, and all participate in the crab fishery, and a number of the vessels also participate in other fisheries. The rest of the moorage slips are used by recreational boats. This marina has a two-lane boat ramp with vehicle and trailer parking. The Public Marina is also home to two oil spill response vessels, and is the operating base for a tour boat from April through October.

The Eureka Public Marina is located on one tax parcel of approximately 11.5 acres (#003-011-001) and another of 1.5 acres (#003-021-007). Approximately one acre of the large parcel is used by the Commercial Street Wharf and the EDA Fish Plant building, and one acre of the smaller parcel is also used by the EDA Fish Plant building. Net acreage of the marina is approximately 11 acres. These parcels are zoned for CDI use.

Moorage occupancy is full during the period from May to September and declines during the off-peak season as boats are removed from the water and trailered to storage or home.

4.2.2.2 Processing

Commercial Street Wharf is a 660-foot city-owned dock located at the foot of Commercial Street used by commercial fishing vessels to offload fish and to load supplies. The only vessel fuel facility on Humboldt Bay is located at the wharf.

Adjacent to Commercial Street wharf is the EDA Fish Plant building, which sits on approximately two acres. The EDA building is a fish processing facility that is currently leased to Pacific Choice Seafood. This plant has been in operation for more than 30 years, and processes a wide variety of species, including bottomfish, salmon, shrimp, crab, and albacore tuna in a 50,000 sq. ft. operation center. Pacific Seafoods also acquired Eureka Fisheries in 2001, which included numerous West Coast landing stations in Brookings OR, Crescent City, Bodega Bay, Fort Bragg, and San Francisco.

Fishermen's Terminal is located on a 2.5-acre site at the foot of C Street. Two seafood processors use this building (Coast Seafoods and Wild Planet foods). The building also houses Jack's Seafood restaurant. The building is adjacent to a new dock that was constructed in 2005-2006, and which consists of a 460-foot by 40-foot concrete wharf with jib cranes, as well as a 920 square foot floating dock with gangway.

Caito Seafoods operates a facility leased from the City located on Commercial Drive at the foot of I Street. This facility is located on approximately one acre, and is adjacent to a 160-foot dock used for receiving fish.

4.2.2.3 Fishing Gear Storage

Currently the City rents space at the foot of C Street for fishing gear storage, this is a popular service used by many fishermen. Rental includes free usage of a high capacity hoist at the Fishermen's Terminal.

There is a seasonal opportunity to create a similar program at the parking lot near the EDA Plant. Tenants there use a City-owned parking lot for gear storage, although this usage is not authorized and tenants are not paying rent for the space.[61]

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[61] City of Eureka Harbor Division, *Leveraging Waterfront Assets into Revenue and Cost Saving Opportunities*, March 2017.

4.2.2.4 Cold Storage

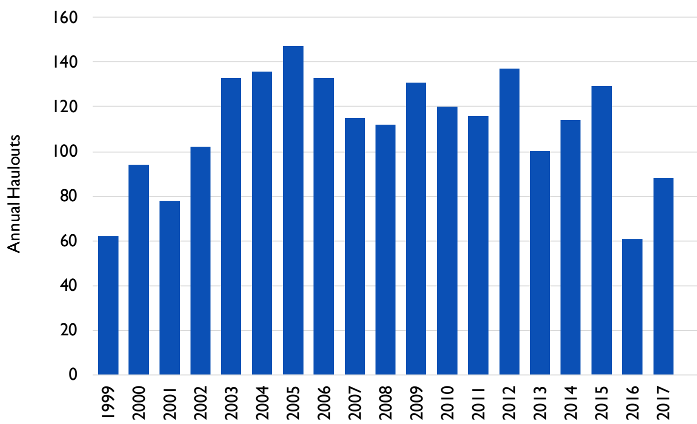
According to a recent analysis of a proposed cold storage facility, demand for cold storage of fish products is expected to vary throughout the season.[62] This analysis assumed a facility with a maximum capacity of 800 tons of cold storage, resulting in excess capacity in some months, and excess demand in others. The facility would require a site of one to three acres site with a boat dock or a site where a dock could be constructed. The frozen/cold storage rooms would occupy the bulk of the facility, which would have the capacity to hold approximately 200 tons of product. This number was chosen because that is approximately the current, base, unmet demand for fish/seafood storage and for cube and block ice storage.

4.2.2.5 Boat Repair

There are two boat repair facilities on Humboldt Bay, the Fields Landing Boatyard and the Zerlang and Zerlang (Z&Z) yard.

The Fields Landing boatyard, owned by the Harbor District, is available for owners to perform their own work vessels. There is also one commercial boat repair operation at the yard. Lifting equipment is a 150-ton mobile hoist. The yard encompasses approximately seven acres. The boatyard accommodates between 61 and 147 boats per year, with an average of 111 boats per year. Most of the boatyard activity is by commercial fishing boats undertaking necessary do-it-yourself improvements.

Figure 4-12: Number of Haulouts at Fields Landing Boatyard



Source: Humboldt Bay Harbor, Recreation and Conservation District

The Zerlang and Zerlang boatyard is located on the Samoa Peninsula, in the Finntown area. Z&Z concentrates on wooden boats, including both commercial and recreational vessels. The yard encompasses approximately two acres and has three marine rails for moving boats into and out of the water. Interviews with boat repair operators suggested that there may be demand for two to three more acres of boatyard space.

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[62] Greenway Partners, *Regional Cold Storage*.

4.2.3 Forecast

The local fishery has declined in vessel numbers and catch but appears to have reached a level of stability.[63] The utilization rate of the marinas has been consistent over the past decade and there are no plans to expand facilities.[64,65]

4.2.4 CDI Land Required

Estimated current acreage in the Humboldt Bay area for commercial fishing and recreational boating is 60. In the future, the addition of a cold storage facility may increase demand for CDI land by four acres. Total long-term demand for CDI land is 64 to 65 acres. (See Table 4-3).

Table 4-3: Current CDI Use and Future Demand, Commercial Fishing & Recreational Boating

	Current	Future Acres		Change in Acres	
Use	Acres	Low	High	Low	High
Moorage	46	46	46	0	0
Processing	5	5	5	0	0
Cold Storage	0	3	3	3	3
Gear Storage	0	1	1	1	1
Vessel Repair	9	9	12	0	3
Total	60	64	65	4	5

Source: BST Associates

[63] Hackett, Steven and Richmond, Laurie, interview with the authors, January 22, 2018. Dr. Hackett and Dr. Richmond are with Humboldt State University.

[64] Raimey, Jeff and Wilkes, Donald, interview with the authors, January 24, 2018. Raimey and Wilkes are employed by the City of Eureka.

[65] Petrusha, Tim and Howser, Suzie, interview with the authors, January 25, 2018. Petrusha and Howser and employed by the Humboldt Bay Harbor, Recreation and Conservation District.

4.3 MARICULTURE

Mariculture is a specialized branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater.[66] Marine aquaculture offers many environmental benefits compared to other forms of animal proteins: generates fewer greenhouse gas emissions, has a smaller carbon footprint, uses less land and fresh water, and is efficient at converting feed into edible protein.[67]

Humboldt Bay has a well-established mariculture industry focusing on mollusks (oysters and clams) and expansion of this activity is underway. In addition, there is interest in developing finfish mariculture. This section reviews trends and forecasts for mariculture and evaluates the opportunities for mariculture in Humboldt Bay and specifically for use of coastal-dependent industrial land.

The NOAA Office of Aquaculture describes the farming process for shellfish and fish as follows:

> The farming of shellfish is typically done by placing bivalves, such as oysters and clams, in bags set in tidelands, bays, or rivers. Usually these come from a hatchery, but some operations rely on a natural "set" of wild larvae. These shellfish are left to grow for a year or more in suspended bags or on the bottom. Mussels, another type of shellfish, are grown on ropes hanging off rafts in rivers or bays and on submerged lines anchored to the bottom of the ocean. In order to grow, shellfish feed on microscopic plankton that they filter out of the water. When the shellfish reach market size, they are harvested and sold to seafood processors, grocery stores, seafood markets, restaurants, or directly to consumers.
>
> A variety of techniques and technologies – each with its own advantages and disadvantages – can be used to raise finfish:
>
> - Hatcheries – most aquaculture fish begin their lives in a hatchery. In fact, the populations of many fish caught by traditional fishing are augmented in hatcheries, then released.
> - Pond culture – one or many earthen ponds are used to culture freshwater fish, shrimp, and some marine species.
> - Cage culture – enclosed cages are submerged in aquatic environments. Careful protocols and monitoring help to minimize potential interactions with the environment.
> - Recirculating systems – fish, shellfish, and or plant-life are raised in "closed-loop" production systems that continuously filter and recycle water and waste.
> - Integrated Multi-Trophic Aquaculture – several species are raised together in a way that allows one species' by-products to be recycled as feed for another.
> - Integrated agriculture & aquaculture –ponds or recirculating systems are used to raise both seafood and other organisms (for example, fish and lettuce).[68]

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[66] U.S. Department of Agriculture, *Census of Agriculture*.

[67] National Oceanographic and Atmospheric Administration, SeaGrant and the Aquarium of the Pacific, *Offshore Aquaculture in the Southern California Bight*, April 2015.

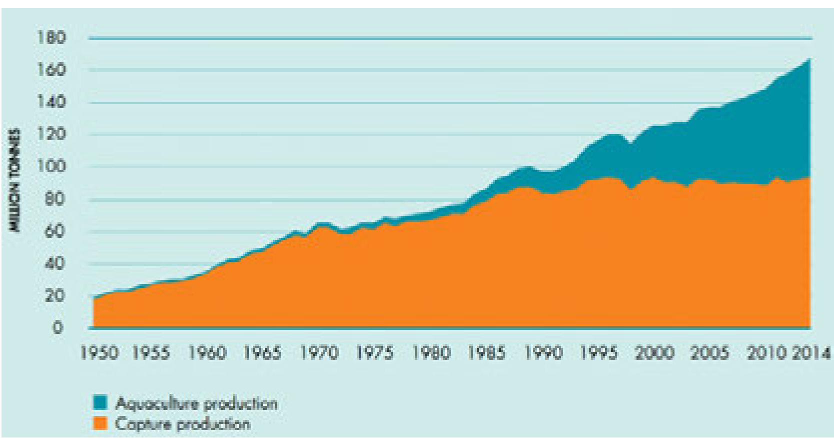
[68] National Oceanographic and Atmospheric Administration, *Basic Questions about Aquaculture,* https://www.fisheries.noaa.gov/topic/aquaculture (accessed February 15, 2018).

4.3.1 International Trends

According to the U.S. Department of Agriculture, "Seafood (fish and shellfish) is a nutrient-dense source of dietary protein, which is relatively low in calories and saturated fat, compared to some other protein sources, and rich in key nutrients, including vitamins A, B12, and D; iron; zinc; magnesium; phosphorous; and potassium. Seafood is the primary food source of the beneficial omega-3 fatty acids, EPA and DHA."[69] As discussed in greater detail below, aquaculture (and mariculture) represents the best opportunity for producing fish and seafood. Due to these beneficial traits, the global demand for fish for human consumption has increased rapidly, averaging annual growth of 3.2% from 1961 to 2013, which is approximately twice the rate of growth of the population base. Per capita consumption of fish has increased from an average of 9.9 kg in the 1960s to 19.7 kg in 2013, driven largely by growing demand linked to population growth, rising incomes, urbanization and increases in international trade.

However, the sources of the supply of fish has changed markedly. According to the United Nations Food and Agriculture Organization (FAO), production from the capture fishery has remained relatively static since the mid-1980s.[70] A 2016 report from the United Nations found that the capture fisheries are under pressure, with 31.4% of the world's stocks overfished and another 58.1% fully fished.[71] Nearly all of the increased production over the past 25 years has come from aquaculture.

Figure 4-13: World Capture Fisheries and Aquaculture Production



Source: U.N. Food and Agriculture Organization

Worldwide aquaculture production increased from 24.3 million tons in 1995 to 73.8 million tons in 2014 or at an average annual rate of 6.0%. All regions exceeded 3% annual growth between 1995 and 2014 but growth was fastest in Africa, the Americas and Asia. In the Americas, aquaculture production increased most rapidly in Chile (11.4% per year from 1995 to 2014) and the rest of Latin America (9.9% per year from 1995 to 2014). Trends in the U.S. are examined in greater detail below.

[69] U.S. Department of Agriculture, *Americans' Seafood Consumption Below Recommendations*, October 2016

[70] U.N. Food and Agriculture Organization, *The State of World Fisheries and Aquaculture*, 2016.

[71] Shanker, Deena, "How We'll Eat Fish in the Future", *Bloomberg News*, May 26, 2017.

Table 4-4: Trends in Aquaculture Production by Region (1,000 tons)

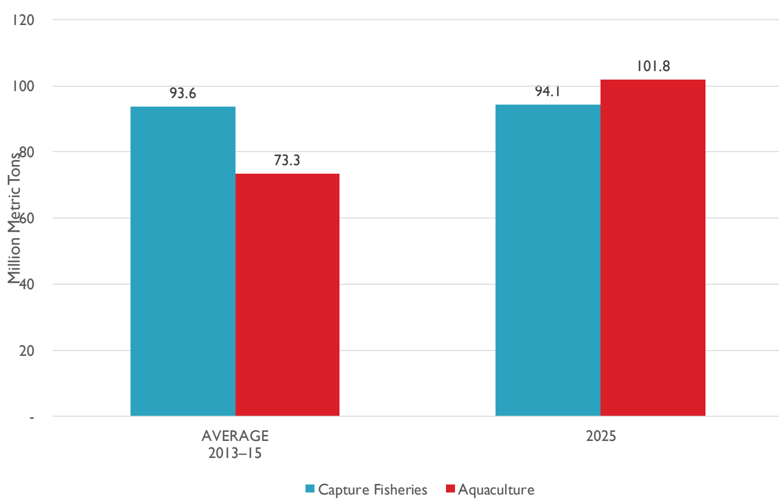
Regions	1995	2000	2005	2010	2012	2014	CAGR 1995 – 2014
Africa	110	400	646	1,286	1,484	1,711	15.5%
Americas	920	1,423	2,177	2,514	2,988	3,352	7.0%
Asia	21,678	28,423	39,188	52,439	58,955	65,602	6.0%
Europe	1,581	2,051	2,135	2,544	2,852	2,930	3.3%
Oceania	94	122	152	190	186	189	3.7%
WORLD	24,383	32,418	44,298	58,973	66,466	73,784	6.0%

CAGR is compound annual growth rate

Source: UN Food and Agriculture Organization

The FAO is projecting that capture fisheries are expected to remain constant at approximately 94 million tons from 2013-2015 to 2025. Aquaculture is projected to grow at 3.0% per year on average from 2013-2015 to 2025; from 73.3 million tons in 2013-2015 to 101.8 million tons in 2025. As a result, aquaculture is projected to increase from 43.9% of total production in 2013-15 to 51.9% in 2025.

Figure 4-14: World Fish Production



Source: UN Food and Agriculture Organization

Most aquaculture production is expected continue to occur in Asian countries, which are projected to account for 90% of total production by 2026 (e.g., China alone is expected to account for 63% of total aquaculture production by 2026). Fish consumption is expected to increase at a faster pace in developing countries than in developed countries, where the overall slowdown in consumption growth will continue.

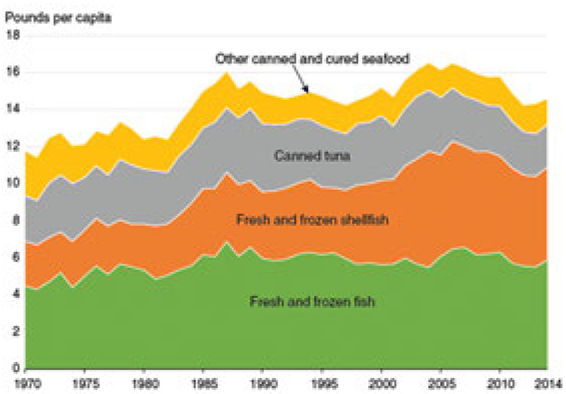
The potential for aquaculture is under-scored by industry experts. Árni M. Mathiesen, Assistant Director-General of FAO's Fisheries and Aquaculture Department, asserts that unlocking the potential of aquaculture could have long-lasting and positive benefits: "With the world’s population predicted to increase to 9 billion people by 2050 - particularly in areas that have high rates of food insecurity -

aquaculture, if responsibly developed and practiced, can make a significant contribution to global food security and economic growth".[72]

4.3.2 U.S. Trends & Forecast

The U.S government recommends that Americans eat at least two servings of seafood per week (8 ounces), or about 20% of total consumption from the protein foods group[73]. The U.S. Department of Agriculture Economic Research Service (USDA ERS) estimates that the average American is eating less than the recommended amount. Fish consumption increased from 12 pounds in 1970 to a peak of 16.5 pounds in 2006, then declined to 14.5 pounds in 2014. This represents about one-third of recommended levels.[74]

Figure 4-15: US Consumption of Fish and Seafood



Source: USDA, Economic Research Service, Food Availability data

The USDA identified five fish/seafood products that accounted for 75% of US consumption in 2014: shrimp, salmon, canned tuna, tilapia, and Alaska pollock. These choices were largely made due to lower product prices, particularly for imports (farm-raised shrimp, salmon, and tilapia) and wild-caught Alaska pollock in a variety of products (fast-food fish sandwiches, frozen fish sticks, and imitation crab meat, among others). NOAA estimates that, on a value basis, imported products account for a large share of U.S. consumption. Approximately 50% of the imported fish is produced in aquaculture facilities.[75]

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[72] World Bank, *Fish Farms to Produce Nearly Two Thirds of Global Food Fish Supply by 2030, Report Shows,* press release, February 5, 2014. http://www.worldbank.org/en/news/press-release/2014/02/05/fish-farms-global-food-fish-supply-2030 (accessed February 15, 2018).

[73] U.S. Department of Health and Human Services and U.S. Department of Agriculture, *2015 – 2020 Dietary Guidelines for Americans*, 8th Edition, December 2015.

[74] U.S. Department of Agriculture, *Americans' Seafood Consumption Below Recommendations*.

[75] National Oceanographic and Atmospheric Administration, *Fisheries of the US*., 2016. NOAA estimates that imported products may account for 90% or more of US consumption. However, this includes US seafood products that are processed overseas and shipped back to the US as finished consumer products.

According to the US Department of Agriculture, sales of aquaculture products in the United States totaled $1.37 billion in 2013, up 26 percent since 2005.[76]

U.S. aquaculture products ranked by sales were as follows:[77]

- Food fish, which includes fish raised for consumption (catfish, tilapia, trout, salmon and other species) as well as fish eggs, accounted for more than 50% of aquaculture sales in 2013, with a sales value of $732 million, up 9% from 2005.
- Mollusks production (oysters, clams and mussels) reached $329 million in 2013, an increase of 62% from 2005. Oysters represent approximately 55% of mollusk production by value.
- Crustacean sales (shrimp, prawns, crayfish, lobster and crab) totaled $85 million in 2013, up 59% from 2005. Saltwater shrimp accounted for just over half of 2013 crustacean sales.
- The remaining aquaculture included ornamental fish, baitfish, sport fish and miscellaneous aquaculture (algae, alligators, caviar, eels, frogs, sea urchins, snails, tadpoles and turtles, among other products).

Table 4-5: Aquaculture Sales by Type of Product, 2005 and 2013 ($millions)

	$ millions		
Group	**2005**	**2013**	**% Change**
Food fish	672.4	732.1	9%
Mollusks	203.2	328.6	62%
Crustaceans	53.4	84.9	59%
Ornamental fish	51.3	41.5	-19%
Baitfish	38.0	29.4	-23%
Sport fish	18.1	23.8	32%
Miscellaneous	56.0	131.4	135%
Total	1,092.4	1,371.7	26%

Source: 2013 Census of Agriculture Highlights

Forty-eight states produce and sell aquaculture products. However, the top ten states account for more than three-fourths of sales, ranked as follows:

- Washington - $233 million (17.0% of US)
- Mississippi - $203.6 million (14.9%)
- Alabama - $111.2 million (8.1%)
- Louisiana - $90.6 million (6.6%)
- California - $83.6 million (6.1%)
- Florida - $77.9 million (5.7%)
- Texas - $69.8 million (5.1%)

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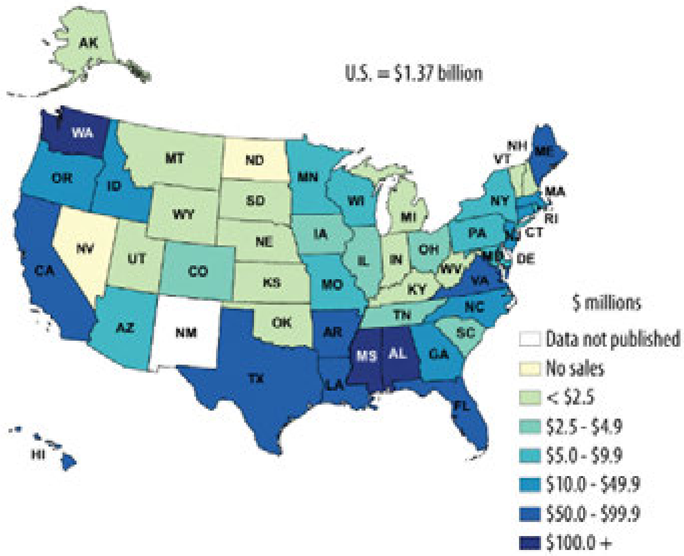
[76] U.S. Department of Agriculture, National Agricultural Statistics Service, *2013 Census of Agriculture Highlights, ACH12-21*, February 2015. The aquaculture census defines an aquaculture farm as any place from which $1,000 or more of aqua-culture products were produced and sold, or distributed for conservation, recreation, enhancement, or restoration purposes, during the census year.

[77] National Marine Fisheries Service Office of Science and Technology, Fisheries Statistics Division, *Fisheries of the United States, Current Fishery Statistics No. 2016*. August 2017.

- Arkansas - $61 million (4.5%)
- Hawaii - $58.7 million (4.3%)
- Maine - $57.3 million (4.2%)
- Other - $323.3 million (23.6% of US)

Figure 4-16: Aquaculture Sales by State, 2013



Source: National Marine Fisheries Service Office of Science and Technology

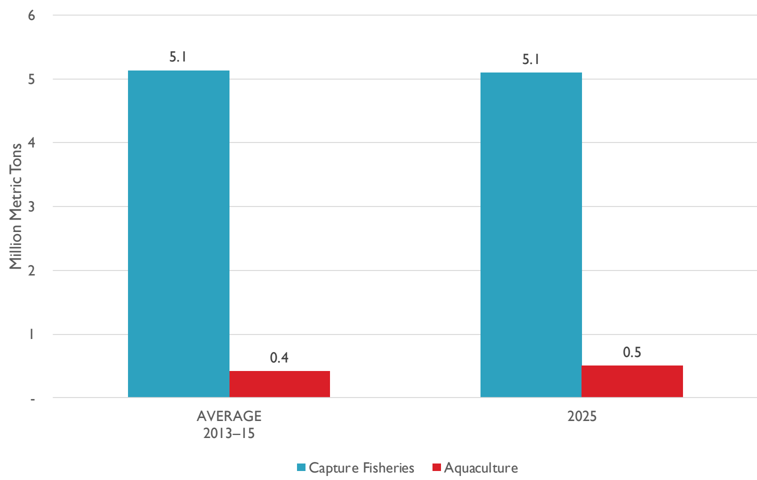
According to NOAA Office of Aquaculture, there are several reasons to support aquaculture:[78]

- Marine aquaculture in the United States contributes to seafood supply, supports commercial fisheries, restores habitat and at-risk species, and maintains economic activity in coastal communities and at working waterfronts in every coastal state.
- The United States is a minor aquaculture producer, on a global scale—but it is the leading global importer of fish and fishery products. Driven by imports, the U.S. seafood trade deficit grew to $14 billion in 2016.
- In the United States, marine aquaculture production increased an average of 3.3% per year from 2009-2014, however, globally, the U.S. remains a relatively minor aquaculture producer. The United States is a major player in global aquaculture, supplying advanced technology, feed, equipment, and investment to other producers around the world.

The FAO projects that U.S. capture fisheries will remain stable at approximately 5.1 million tons. Aquaculture is projected to increase at an average annual rate of 1.6% per year from 2013-2015 to 2025, increasing from 425,000 tons (average of 2013 to 2015 volumes) to 568,000 tons in 2025. As a result, U.S. aquaculture is expected to increase from 7.6% of total production in 2013-15 to 9.0% in 2025.

[78] National Oceanographic and Atmospheric Administration Office of Aquaculture, "U.S. Aquaculture", https://www.fisheries.noaa.gov/national/aquaculture/us-aquaculture (accessed February 15, 2018).

Figure 4-17: Fish Production in the United States



Source: U.N. Food and Agriculture Organization

Further development of aquaculture is expected to continue to be slow due to a cumbersome permitting process. According to experts in the field, designation of a lead federal agency to address issues could increase aquaculture production.[79]

4.3.2.1 California

As noted above, California was the fifth largest aquaculture producer in the U.S. with sales of $85.6 million in 2013. Aquaculture sales increased by 2.3% per year between 2005 and 2013, up from $69.6 million in 2005. The number of aquaculture farms also increased slightly between 2005 and 2013, from 118 farms in 2005 to 124 farms in 2013. In 2013, California accounted for 41% of the farms along the US mainland West Coast (California, Oregon and Washington) but only accounted for 25% of aquaculture sales. The number of aquaculture farms declined along the U.S. West Coast from 359 in 2005 to 304 in 2013 as farms became larger.

Sales on the U.S. West Coast, driven largely by growth in Washington, increased significantly from $175.3 million in 2005 to $328.7 million in 2013. As a result, California's share of value along the U.S. West Coast dropped from 40% in 2005 to 25% in 2013.

California accounted for 2% of the U.S. aquaculture farms in 2013, up from 1% in 2005; by sales value, California has remained at 3% of the U.S.

[79] Schubel, Jerry R. and Thompson, Kimberly, *Marine Finfish Aquaculture in the U.S. and California: A Story of Lost Opportunities for Leadership and Economic Development*, December 2, 2016. Jerry R. Schubel is president and CEO, Aquarium of the Pacific and Kimberly Thompson is program manager, Seafood for the Future.

Table 4-6: California Aquaculture Production

	Number of Farms			Sales ($1,000s)		
Total	**2005**	**2013**	**CAGR**	**2005**	**2013**	**CAGR**
California	118	124	0.6%	$69,607	$83,583	2.3%
US West Coast	359	304	-2.1%	$175,288	$328,676	8.2%
United States	8,618	6,186	-4.1%	$2,182,640	$2,741,386	2.9%
California % of						
USWC	33%	41%		40%	25%	
US	1%	2%		3%	3%	

Source: Census of Aquaculture 2013, USDA

In California aquaculture occurs throughout the state and across several diverse product groups. Sacramento County, the largest producer of caviar in the U.S., is the leading California county by sales value. Imperial County producers use geo-thermal energy to raise catfish and bass among other species. Humboldt, San Luis Obispo and Marin counties were third, fourth and fifth largest by value in 2012, based primarily on production of shellfish. The value of production in Riverside County is sixth largest, and is based on production of catfish, tilapia, goldfish and koi, among other species. Stanislaus County (7th highest value) produces catfish and bass, while Shasta, Kern and San Bernardino Counties (8^{th}, 9^{th} and 10^{th}, respectively) produce food fish. The remaining counties of California accounted for 43% of the sales in 2012; these producers focus on all aquaculture categories with the exception of food fish.

Table 4-7: California Aquaculture Production by County – number of farms and reported sales value ($millions) in 2012

		Number of Farms						
Rank by Value	**County**	**Food Fish**	**Mollusks**	**Ornamental Fish**	**Other Aquaculture Products**	**Other**	**Total**	**Estimated Sales $mils**
1	Sacramento	11	1	2	-	3	17	$15.0
2	Imperial	3	-	-	6	-	9	$11.4
3	Humboldt	2	7	1	1	-	11	$7.5
4	San Luis Obispo	-	7	-	2	-	9	$6.9
5	Marin	2	5	-	-	-	7	$4.8
6	Riverside	17	-	10	4	-	31	$4.2
7	Stanislaus	16	-	3	5	-	24	$3.5
8	Shasta	9	-	-	-	3	12	$3.2
9	Kern	7	-	-	-	-	7	$1.5
10	San Bernardino	3	-	-	-	-	3	$1.0
	Other	-	7	30	18	9	152	$44.0
	Total	158	27	46	36	15	282	$103.0

Notes: Other aquaculture products include: alligators, frogs, leeches, eels, salamanders, and turtles.
Other includes: bait fish, sport fish and crustaceans.
Source: California Census of Agriculture 2012, USDA, County Agriculture Reports

4.3.2.2 Opportunities for growth in California

Opportunities to increase aquaculture in California appear to be positive with "favorable oceanographic conditions, proximity to markets, and scientific expertise necessary to support environmentally responsible aquaculture."[80] Aquarium of the Pacific President and CEO Jerry Schubel said:

[80] White, Cliff, "Aquaculture in California Has Promising Future", seafoodsource.com, September 29, 2016, https://www.seafoodsource.com/news/aquaculture/report-aquaculture-in-california-has-promising-future (accessed February 21, 2018).

With our planet's growing human population and rising demand for food, aquaculture will play a pivotal role in increasing the safe supply of healthy protein in our global food systems, and California could serve as a model for states looking to develop a robust aquaculture industry.

"However, development opportunities are currently constrained by problems associated with obtaining necessary permits. According to experts: California "has some of the strongest opposition from a misinformed public and a permitting process that discourages innovation and investment."[81]

4.3.2.3 Humboldt Bay

Oysters have been cultivated in Humboldt Bay since the early to mid-1900s, utilizing as much as 1,000 acres. These historical operations used "on-bottom" methods that relied on the placement of loose oysters and shell directly on intertidal mudflats with subsequent harvest via suction dredging and excavation. This style of aquaculture continued until the late 1990s, when it was replaced with more environmentally friendly methods "off-bottom" methods for growing oysters (i.e., rack-and-bag culture, long-line culture, and basket culture).

The value of aquaculture production in Humboldt County has increased nearly every year, growing from $6.7 million in 2011 and reaching $10.3 million in 2016, most of which is attributed to shellfish production.

Table 4-8: Humboldt County Aquaculture Production –reported sales value ($millions) 2011-2016

Year	$ Millions in Sales
2011	$6.7
2012	$7.5
2013	$7.6
2014	$9.7
2015	$17.5
2016	$10.3

Source: Humboldt County Agriculture Reports, various years

According to the Pacific Shellfish Institute, there were 16 shellfish aquaculture farmers in 2013 that operated along the California coast. Including shellfish growers and seed producers, these firms reported $25.9 million worth of total revenue and $23.9 million worth of revenue from shellfish sales in 2011.[82] As indicated in Table 4-9, there were 6,201 acres available for use in 2013 but only 740 (i.e. 12%) were actually in use for shellfish cultivation. Humboldt County had the most reported acreage (4,577 acres) but only 343 acres were actually being farmed (i.e. 7% of available acres). These industry conditions were verified in 2015.[83]

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[81] Schubel and Thompson, December 2, 2016.

[82] Northern Economics, *The Economic Impact of Shellfish Aquaculture in Washington, Oregon and California*, April 2013. Prepared for Pacific Shellfish Institute. The report excluded abalone growers.

[83] JSI, *Coast Seafoods Company Recirculated Draft EIR Appendix J Economic Impacts*, July 2016. Prepared for the Humboldt Bay Harbor District.

Table 4-9: California Aquaculture Production by County 2013

County	Reported Acres	Not Farmed Acres	Farmed Acres	Farmed Acres (%)
Humboldt	4,577	4,234	343	7%
Marin	1,413	1,071	342	24%
San Luis Obisbo	135	120	15	11%
Santa Barbara	70	35	35	50%
Other	6,036	0	6	99%
Total	6,201	5,460	740	12%

Source: Pacific Shellfish Institute

4.3.2.4 Coast Seafood Company

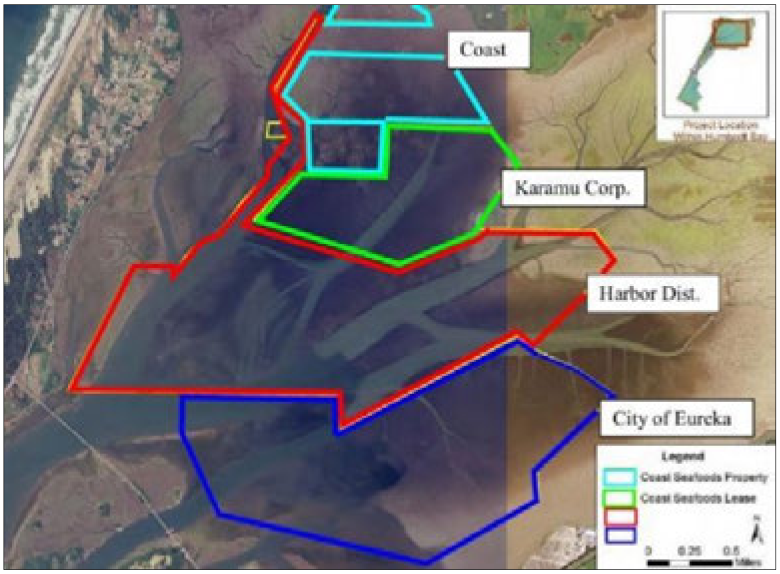
Pacific Seafood Company, which purchased Coast Seafood Company in 2011, has extensive mariculture operations throughout the U.S. West Coast. Pacific Seafood farms more than 17,000 acres in California, Oregon and Washington, and also operates hatcheries and research facilities in California, Washington, and Hawaii that produce oyster, clam, and mussel larvae and seed for company operations.

The Coast Seafood Eureka operation has existed since the 1950s, and is focused on growing and harvesting Pacific and Kumamoto Oysters, and Manilla clams on federal and state certified shellfish growing areas of Humboldt Bay. The company's area of operation encompasses 4,313 acres in Arcata Bay, including nearly 3,300 acres of public trust land managed by the City of Eureka or the Humboldt Bay Harbor District, over 500 acres of privately owned lands primarily held by the Karamu Corporation, and 514 acres of intertidal and submerged lands owned by Coast Seafood. The 4,313 acres is roughly half of the total intertidal area of Arcata Bay.[84] Coast Seafood utilizes three "off-bottom" methods for growing oysters including rack-and-bag culture, long-line culture and basket culture.

Coast Seafoods proposed to expand its overall cultivation area from 300 acres to about 560 acres in 2016/7. However, after an extensive permit process, Coast Seafoods agreed to limit farming of shellfish to 279 acres. The new permit expires in 2025.

[84] California Coastal Commission, *Report W22b, Applicant: Coast Seafood Company*, August 14,2017.

Figure 4-18: Project Area showing Coast Seafood's Owned and Leased Areas



Source: Humboldt Bay Harbor District[20]

Coast Seafood's operations also include two *FLUPSYs (Floating Upwell System).* One FLUPSY for oysters is located south of the Simpson wood chip loading dock in Fairhaven and another for clam seed is located at Redwood Marine Terminal 2.

Coast Seafood has an oyster nursery (approximately 4.8 acres) in Humboldt Bay on mudflats north of Gunther Island and along Arcata Channel. The nursery is used to allow the shellfish seed to gain size and strength prior to planting, a process called "beach hardening".

4.3.2.5 Taylor Shellfish

Taylor Shellfish produces Manila clams, Mediterranean mussels, and geoducks, as well as a variety of oysters on approximately 11,000 acres of tidelands on the Washington Coast and in British Columbia. Taylor also operates seed hatcheries in Washington, California, and Hawaii. Products are shipped to domestic and international markets.[85]

Taylor Mariculture, LLC. (Taylor) established an aquaculture operation to support shellfish seed cultivation operations in Humboldt Bay in 2013. The facility is located at Redwood Marine Terminal 2, which is owned by the Harbor District. The berth was improved to allow safe transit by the equipment needed to move products from the building to the waterside activities. The operation takes free-swimming oyster and clam larvae (spawned in a hatchery at a separate location) and grows them to between four and twelve millimeters in size. The shellfish seed operation includes: a seed setting facility, nursery rafts, FLUPSYs, pier upgrades, a seed wash facility, a wash water discharge system, parking and storage, and an access road. (See Figure 4-19).

[85] California Coastal Commission, *Application No. E-11-029, Applicant: Taylor Mariculture LLC*, 2013.

Figure 4-19: Taylor Mariculture Co Facilities in Humboldt Bay

Source: California Coastal Commission

The nursery rafts and FLUPSYs encompass approximately 44,000 square feet, and are connected to the existing pier by a gangway. The seed wash system is located onshore near the base of the pier. The wash water discharge/disposal system is located in an upland area near the base of the pier.

4.3.2.6 Hog Island Oyster Company

Hog Island Oyster Co. currently leases one hundred and sixty acres in Tomales Bay and sells over 5 million oysters, Manila clams, and mussels per year. Hog Island developed their first California-based oyster seed hatchery and nursery in Humboldt Bay, CA in 2014.[86] (See Figure 4-20). Hog Island Oyster Co. also operates restaurants in San Francisco and Napa.

The Humboldt Bay operation focuses on Manila clams, Pacific oysters, and Kumamoto oysters. The project was constructed on a previously undeveloped 3.5-acre parcel and adjacent to a pier owned by Sequoia X, LLC. The tidelands around the pier are owned by the Harbor District. Hog Island has ten-year leases from the Harbor District and Sequoia X LLC.

The shellfish hatchery is used to breed adult shellfish in order to generate large numbers of larvae that can be grown to larger sizes or transported and sold to aquaculture operations offsite. The hatchery, seed setting operation, storage tanks and office facility are housed in a mariculture building. Other facility components (i.e., covered work area, algae greenhouse, septic system, shellfish seed wash facility, parking area, and access road) are constructed on the 3.5 acre project site. The nursery rafts and FLUPSYs (approximately 16,500 square feet) are connected to the pier by way of the 40-foot long floating gangway. Proposed rafts would allow the shellfish seed to be submerged in the waters of Humboldt Bay during grow-out.

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[86] Hog Island Oyster Co. Inc., "*About Hog Island Oyster Co. Inc*.", https://www.bcorporation.net/community/hog-island-oyster-co-inc (accessed February 23, 2018).

Figure 4-20: Hog Island Company Facilities in Humboldt Bay[87]

Source: Hog Island Company

4.3.2.7 Harbor District

The Harbor District worked with local shellfish companies and regulatory agencies to pre-permit aquaculture activities in Humboldt Bay. This effort included subtidal areas and tidal areas.

In 2016, the Harbor District sought the necessary state and federal authorization to allow shellfish and macroalgae aquaculture on three areas of submerged lands within Humboldt Bay.[88] The three project areas, shown in Figure 4-21, are comprised of:

- Subtidal 1 (located north of Redwood Marine Terminal Berth 2) consists of 6.6 total acres proposed to support a maximum of 0.87 acres of aquaculture activities,
- Subtidal 2 (located north of Redwood Marine Terminal Berth 2) consists of 8.6 total acres proposed to support a maximum of 0.96 acres of aquaculture activities, and
- Subtidal 3 (located at the southside of Redwood Marine Terminal Berth 2) consists of 6.0 total acres proposed to support a maximum of 1.25 acres of aquaculture activities.

The three project areas include existing pier or wharf structures and are located within a ¾ mile stretch of subtidal waters within Humboldt Bay adjacent to the Samoa Peninsula. Shellfish structures are expected to include: FLUPSYs for growing young shellfish and nursery rafts for growing small, immature shellfish that would be sold or transferred elsewhere for grow-out to consumer sizes, rafts and macroalgae longline processes. The Coastal Commission approved Coastal Development Permit 9-16-0204 on November 4, 2016 with special conditions.

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[87] California Coastal Commission, *Application No. 9-13-0500, Applicant: Hog Island Oyster Company*, November 2013.

[88] California Coastal Commission, *Application No. 9-16-0204, Applicant: Humboldt Bay Harbor, Recreation, and Conservation District*, May 2016.

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Figure 4-21: Sub-tidal Sites proposed by Harbor District

Source: Harbor District

The Harbor District also sought the necessary state and federal authorization to allow shellfish and macroalgae aquaculture on four intertidal areas within Humboldt Bay.[89] The three project areas, shown in Figure 4-22, are comprised of:

- Intertidal 1 consists of 99 total acres with use of up to 30 acres of surface waters,
- Intertidal 2 consists of 364 total acres with use of up to 109.2 acres of surface waters,
- Intertidal 3 consists of 14 total acres with use of up to 4.2 acres of surface waters, and
- Intertidal 4 consists of 50 total acres with use of up to 15 acres of surface waters.

The general types of aquaculture expected to occur in these areas includes rack-and-bag, cultch-on-longline, and basket-on-longline methods.

Figure 4-22: Intertidal Culture Sites proposed by Harbor District

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[89] Humboldt Bay Harbor, Recreation and Conservation District, *Final Environmental Impact Report for the Humboldt Bay Mariculture Pre-Permitting Project, Volume 1, SCH #2013062068*. February 8, 2016.

Source: Harbor District

4.3.3 Finfish Mariculture

The Harbor District is also evaluating opportunities for upland finfish mariculture at Redwood Berth 2. The scale of these facilities is not yet known.

4.3.4 Potential Demand in Humboldt Bay

4.3.4.1 Subtidal

Subtidal aquaculture operations that include hatcheries and nurseries using FLUPSYs, rafts, and macroalgae longline processes appears to be an acceptable (permittable) activity in Humboldt Bay, as evidenced by the current operations of Hog Island Oyster and Taylor Mariculture as well as approvals by the California Coastal Commission to allow these activities in certain subtidal areas in Humboldt Bay. As described below, Humboldt Bay has a potential future in exporting shellfish seed and larvae.

> Humboldt Bay is one of the few places that can export seed and larvae of oysters and clams anywhere on the West Coast, thanks to a monitoring program called the High Health Plan that ensures bivalves grown there are free of damaging parasites and diseases. Larvae, which are produced in hatcheries, are the earliest life-history stage of oysters and clams, and are especially susceptible to ocean acidification.
>
> Humboldt Bay is an excellent place to be doing this work because aquaculture is already a major, important industry here. It's got really good growing conditions for oysters, and based on measurements taken in the region, we believe the acidity of seawater in the Bay is somewhat buffered – likely by eelgrass," said Tyburczy, noting that shellfish hatcheries in other locations must often resort to artificially buffering acidic water with chemical additives to keep their larvae alive. "We hope to get a handle on how buffered the Bay is, how much of that buffering is done by eelgrass, and how oyster growers can get the most benefit from this natural buffering and protect their product."[90]

The footprint of existing facilities includes:

- Harbor District Redwood Marine Terminal 2:
  - Taylor Shellfish - 14,000 square feet of building space with 8 acres of subtidal land.
  - Coast Seafood- 20,000 square feet of building space with 6 acres of subtidal land.
- Sequoia Investment Fairhaven Terminal:
  - Hog Island Oyster Company – 20,000 square feet of building space on 3.5 acres of uplands with 8 acres of subtidal land.

Future upland demand that is currently permitted includes 21.2 acres of subtidal area with an allowed surface area of 3.08 acres. If these sites are developed it could require up to 10 acres of uplands (three projects at an average of 3.5 acres per project).

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[90] California Sea Grant, "Changing waters in Humboldt Bay: Extension Specialist Joe Tyburczy awarded funds to track ocean acidification", California Sea Grant website, December 2016. https://caseagrant.ucsd.edu/news/changing-waters-in-humboldt-bay-extension-specialist-joe-tyburczy-awarded-funds-to-track-ocean (accessed March 2, 2018).

4.3.4.2 Intertidal

The limits that Coast Seafood agreed to in their recent permit process application indicate that development of additional shellfish growing areas in Humboldt Bay may be difficult.

As described above, Coast Seafoods proposed to expand its overall cultivation area from 300 acres to about 560 acres in 2016/7 but was granted approval for 279 acres. The new permit, which expires in 2025, included a number of special conditions. These included:

- creation of monitoring plans for eelgrass, black brant and herring in coordination with regulatory agencies,
- limiting operations during brant hunting season,
- submission of an annual report to the state on the status of oyster beds,
- monitoring, marking and cleanup of equipment, and
- creating a plan for transit lanes to reduce potential impacts of boats and barges on wildlife et al).

One condition would also require Coast Seafood to maintain its extensive lease-holdings (approximately 3,800 acres) for eight years but to only make use of the small fraction of them. This would effectively limit the possibility of other development in these areas and therefore protect them for shorebirds and other wildlife and habitats.

The status of the Harbor District’s efforts to expand intertidal growing areas is uncertain at this date.

4.3.5 Finfish

The status of finfish projects in unknown at this time.

4.3.6 CDI Land Required

Current upland mariculture operations use approximately seven acres of CDI land. Planned expansion could raise this to a total of 10 to 20 acres. In addition, in-water operations (i.e. FLUPSYs) occupy approximately 21 acres of CDI water area. (See Table 4-10).

Table 4-10: Current CDI Use and Future Demand, Mariculture

	Current	Future Acres		Change in Acres	
Land Use	Existing	Low	High	Low	High
Shellfish	6	9	17	3	11
Finfish	1	1	3	0	2
Total	7	10	20	3	13

Source: BST Associates

4.4 Marine Research

This chapter reviews the use of CDI lands by marine research facilities. It includes an overview of selected U.S. West Coast marine research facilities as well as descriptions of potential marine research facilities in Humboldt Bay.

4.4.1 U.S. West Coast Marine Research Facilities

According to the National Association of Marine Laboratories (NAML), there are 16 marine research facilities located on the U.S. West Coast. (See Table 4-11). These facilities range from:

- Operations with small land areas that have extensive building space on a small footprint (e.g., the Monterey Bay Aquarium Research Institute has 175,000 square feet of space on just 3.3 acres) to
- Operations with extensive property but little building space (e.g., Blakely Island Field Station is a marine reserve with little building space). The facilities with larger acreages are largely, if not entirely, used as a reserve.

Table 4-11: Selected Marine Research Facilities on US West Coast

Institution	Lab Name	State	Acres
Aquarium of the Pacific	Aquarium of the Pacific	CA	5.0
California State University	Moss Landing Marine Laboratories	CA	9.2
Mendocino College	Coastal Field Station	CA	15.0
Monterey Bay Aquarium Research Institute	Monterey Bay Aquarium Research Institute	CA	3.3
San Francisco State University	Estuary & Ocean Science Center	CA	53.0
Stanford University	Hopkins Marine Station	CA	11.0
University of California, Davis	Bodega Marine Laboratory	CA	362.0
University of California, San Diego	Scripps Institute of Oceanography, UCSD	CA	170.0
University of California, Santa Cruz	Long Marine Lab	CA	100.0
University of Southern California	Wrigley Marine Science Center	CA	14.0
Oregon State University	Hatfield Marine Science Center	OR	40.0
University of Oregon	Oregon Institute of Marine Biology	OR	100.0
Seattle Pacific University	Blakely Island Field Station	WA	900.0
University of Washington	Friday Harbor Laboratories	WA	370.0
Walla Walla University	Rosario Beach Marine Laboratory	WA	40.0
Western Washington University	Shannon Point Marine Center	WA	78.0

Source: National Association of Marine Laboratories and individual institution websites, list is organized by state and name of the institution.

These facilities are utilized for a variety of research purposes:

- They provide access to the environment.
- They provide logistical support for a wide range of activities including individual research projects; networking of research on larger scales; science, technology, engineering, and mathematics (STEM) training; and public outreach.
- Through time they become model ecosystems in which the steady accumulation of site-specific knowledge becomes a powerful platform for future research.

- They foster a community of scholars that promotes the exchange of ideas, collaboration, and the integration of knowledge, and can facilitate the flow of information between the scientific community and decision makers about environmental issues.[91]

Several marine labs have recently completed or are planning improvements. As an example, Oregon State University (OSU) is currently planning additional facilities at the Hatfield Marine Science Center in Newport, Oregon to help implement OSU's Marine Studies Initiative, a 10-year program to foster innovative approaches to addressing key issues involving the coast, the ocean and ocean literacy. The new marine research building (72,000 square feet) will not only enhance marine science education and research capacity but will also serve as a vertical tsunami evacuation site, via the roof of a building (at a height of 47 feet), which is designed to serve as a vertical evacuation site for more than 900 people.[92]

Figure 4-23: Proposed New Research Building at Hatfield Marine Science Center

4.4.2 Opportunities in Humboldt Bay

Opportunities in Humboldt Bay appear to be positive. However, the strategy for future development is still evolving.

4.4.2.1 Existing Facilities at Humboldt State University[93]

Humboldt State University's existing marine science facilities include Telonicher Marine Laboratory in Trinidad Bay, approximately 14 miles north of Arcata. The Telonicher Lab consists of a multi-purpose 16,200 square feet building on a 1.4 acre site overlooking the Pacific Ocean, near Trinidad Bay, Trinidad Beach, and Trinidad Headland. Specialized facilities include a culture room, a wet lab, and a shop for design and fabrication of experimental equipment. The Lab also contains several holding tanks (ranging

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[91] National Association of Marine Laboratories (NAML) and the Organization of Biological Field Stations (OBFS), *Field Stations and Marine Laboratories of the Future: A Strategic Vision*, 2013.

[92] Nealon, Sean, *OSU Marine Studies Building to Be a National Model for Tsunami "Vertical Evacuation",* November 22, 2017. http://today.oregonstate.edu/news/osu-marine-studies-building-be-national-model-tsunami-%E2%80%9Cvertical-evacuation%E2%80%9D (accessed April 2, 2018).

[93] Humboldt State University Marine Sciences website. http://www2.humboldt.edu/marinesciences/facilities.html (accessed April 2, 2018).

in size from 30 gallons to 1400 gallons). Seawater water is pumped in from Trinidad Bay with a capacity of 150,000 gallons. The Lab was originally built in 1965 and expanded in 1975 to its current size.[94]

HSU also has a research vessel, the *R.V. Coral Sea*. This vessel enables the study the biology, chemistry and geology of the coastal Pacific Ocean. Built in 1974 and refit in 2006 with new engines, the *R.V. Coral Sea* is used by all departments with marine science programs to support undergraduate instruction and student and faculty research. In addition, there are several smaller boats available for inshore and near shore coastal research (e.g., waterfowl and eelgrass in Humboldt Bay, to sea birds and marine mammals offshore).

4.4.2.2 National Marine Research and Innovation Park

In 2017, a concept to build a National Marine Research and Innovation Park (NMRIP) was proposed by the Humboldt Bay Harbor Recreation and Conservation District (HBHRCD) in conjunction with Humboldt State University (HSU) and other potential partners, including:

- Humboldt Bay Municipal Water District,
- Educational institutions (PK-20),
- Local, regional and tribal governments,
- Natural resource and planning agencies, and
- Multiple private and nonprofit partners.

The NMRIP concept currently in development envisions the repurposing of the Samoa pulp mill into a multi-use facility housing both research and commercial opportunities in aquaculture, biomass conversion, and renewable energy.

The original concept site drawing and building redevelopment concept are shown in Figure 4-24 and Figure 4-25. Although details of the proposal are in early stages, these figures illustrate the redevelopment of the Redwood Marine Terminal 2, warehouse and uplands that is envisioned.[95]

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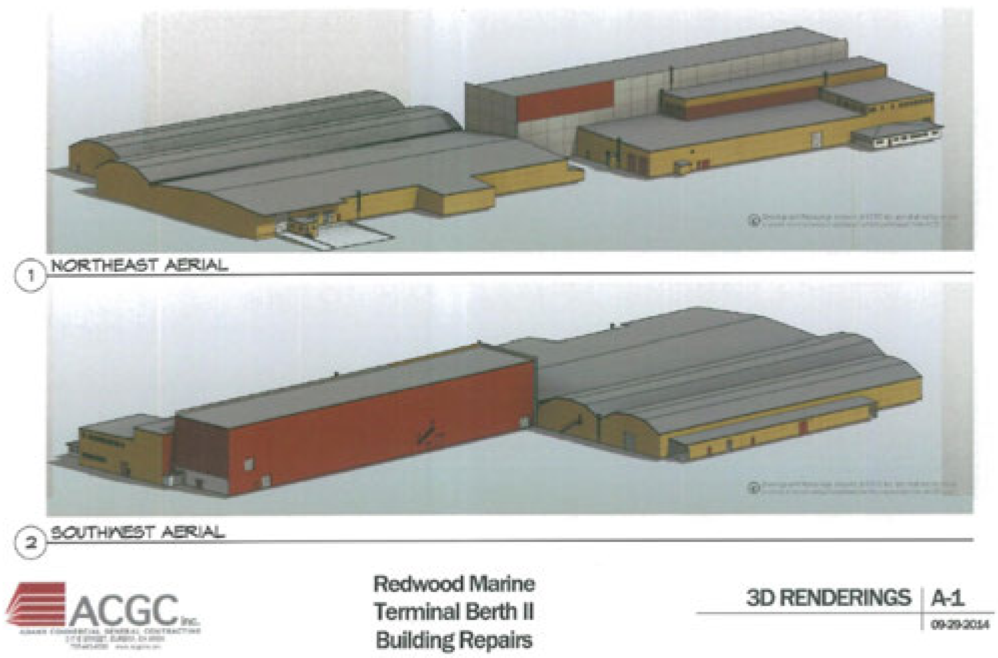
[94] Soden, Tabitha, "Humboldt State's Marine Lab Celebrates 50 Years", *Eureka Times Standard*, November 16, 2015.

[95] Williamson, Rhea L., *Northern California's Marine Research and Innovation Park: from Extraction to Sustainability*. http://conference.ifas.ufl.edu/nwwws/documents/Presentations/4%20Williamson%20B3%20REVISED.pdf, (accessed February 21,2018).

Figure 4-24: NMRIP Site Concept Drawing

Source: Humboldt Bay Harbor, Recreation and Conservation District

Figure 4-25: NMRIP Building Concept Drawings



Source: Humboldt Bay Harbor, Recreation and Conservation District

The current planning at HSU calls for public-private partnerships in which HSU would develop appropriately sized research facilities at sites belonging to public and/or private developer, as required. Research would be focused on aquaculture, energy (wind and wave) and other coastal research opportunities.[96] These efforts would be augmented by existing facilities at HSU.

An existing example of this type of public-private partnerships is research currently being conducted on water quality in Humboldt Bay. California Sea Grant, Humboldt State University researchers, and Hog Island Oyster Company are working together to study the impacts of ocean acidification and the extent

[96] Karp, Steven, interview with the authors, March 29, 2018. Dr. Karp is Interim Dean of Research at Humboldt State University.

to which eelgrass may reduce acidification. The research includes use of a monitoring instrument, located at Hog Island's oyster hatchery, to track Humboldt Bay's chemistry.[97],[98]

4.4.2.3 Space Requirements

Plans for marine research are facilities are currently evolving to and are constrained by budgets. At a minimum there would be no new stand-alone facilities, but development would occur within existing. If development of a stand-alone facility occurred, it could range from 5 to 10 acres, in line with the smaller marine labs along the U.S. West Coast. Future demand for CDI land for marine research ranges from a low of zero acres (i.e. the activity does not occur on Humboldt Bay) to a high of 10 acres. (See Table 4-12).

Table 4-12: Current CDI Use and Future Demand, Marine Research

Land Use	Current Acres	Future Acres		Change in Acres	
		Low	High	Low	High
Marine Research	0	0	10	0	10

Source: BST Associates

[97] California Sea Grant, "*Changing Waters in Humboldt Bay".*

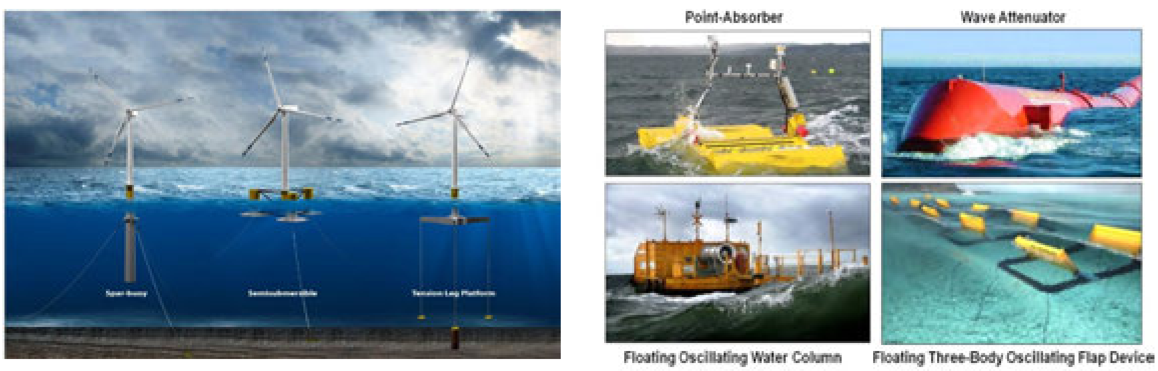
[98] Tyburczy, Joe, interview with the authors, March 29, 2018. Dr. Tyburczy is an Extension Specialist with California Sea Grant.

4.5 Offshore Energy

The offshore energy industry represents a potential future use of CDI lands in Humboldt Bay. Although this use currently does not exist in Humboldt Bay, the offshore areas near Humboldt Bay have been identified as an important energy resource.

Offshore energy devices include offshore floating wind systems (OFW) and wave energy systems, called marine hydrokinetic systems (MHK)[99]; both types of devices represent potential opportunities for Humboldt Bay. Offshore wind energy is widespread in Europe and is beginning to be developed on the U.S. Atlantic Coast. On the U.S. West Coast, a test installation is currently in the planning process for coastal waters near Humboldt Bay. Wave energy, which is still in developmental stages, is being tested near Newport, Oregon. Figure 4-26 presents some of the devices for these two energy options.[100]

Figure 4-26: Offshore Wind System and Wave Energy Devices



Source: National Renewable Energy Laboratory

4.5.1.1 Global Market

The global market for wind energy is strong, driven by the increasing competitiveness of wind power and opportunities to reduce emission of greenhouse gases by renewable energy sources. BP Energy Economics projects that subsidies required to support these systems will be phased out by the mid-2020s and that the gain in market share from renewables will be more rapid than for any other energy source over a similar period, with the closest parallel being the build-up of nuclear power in the 1970s and 1980s.[101]

The International Energy Agency (IEA) estimates the average annual growth in development of wind energy was 24% per year from 1990 to 2015.[102] In 2016, wind turbines accounted for 23.2% of renewable electricity in the Organization for Economic Cooperation and Development (OECD). Most of

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[99] Coast & Harbor Engineering, *Determining the Infrastructure Needs to Support Offshore Floating Wind and Marine Hydrokinetic Facilities on the Pacific West Coast and Hawaii*, March 3, 2016.

[100] National Renewable Energy Laboratory, *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs*, December 2016.

[101] BP Energy Economics, *BP Energy Outlook*, 2018 Edition.

[102] International Energy Agency, *Renewables Information 2017 Overview*, July 20. 2017.

the growth also occurred in OECD Europe. However, the United States is the largest producers of electricity from wind within the OECD producing 229.3 TWh.

A growing portion of this capacity is occurring in offshore wind farms. Europe has installed offshore wind capacity of more than 12,600 megawatts generated by 3,589 grid-connected wind turbines in 10 countries. The leading countries are:

- The U.K. accounts for about 36 percent of installed capacity,
- Germany (29 percent)
- China (11 percent)
- Denmark (8.8 percent),
- The Netherlands (7.8 percent),
- Belgium (5 percent), and
- Sweden (1.4 percent of capacity).

One of the key factors supporting development of offshore wind power is the falling cost of capital development, which is estimated to have decreased from $3.8 million per megawatt of electricity in 2016, to $2.2 million per megawatt at the end of 2017, driven by increased turbine capacity and platform technology.

Estimates of the annual growth in offshore wind power include:

- Research and Markets projects growth of 12.0% per year from 2017 to 2025, growing from 15.0 GW in 2017 to 65.5 GW by 2025.[103]
- Bloomberg New Energy Finance projects growth of 16.0% per year from 2017 to 2030, growing from 17.6 GW in 2017 to 114.9 GW by 2030. Bloomberg expects the U.S. to expand into offshore wind power.[104] (See Figure 4-27).

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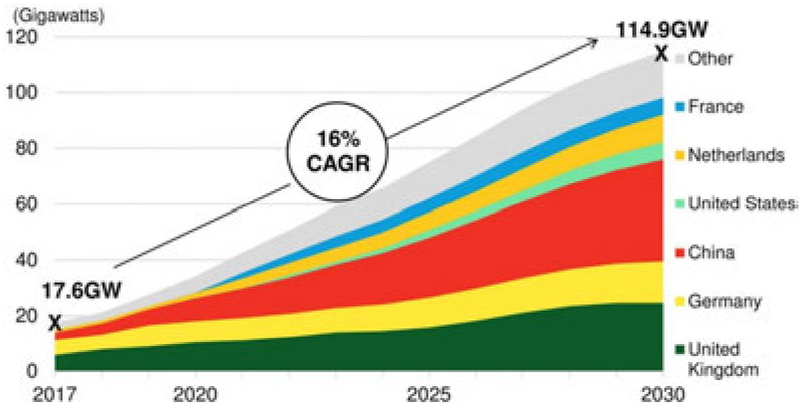
[103] Research and Markets, G*lobal Offshore Wind Energy Market Size, Market Share, Application Analysis, Regional Outlook, Growth Trends, Key Players, Competitive Strategies and Forecasts, 2017 to 2025*, December 12, 2017. As reported in Business Wire.

[104] Bloomberg New Energy Finance Business Wire, *Global Offshore Wind Market Set to Grow Sixfold by 2030*, January 8, 2018.

Figure 4-27: Expected Growth in Offshore Wind Power



The market for wave or tidal energy is less well developed.[105] In 2016, 1,008 GWh of electricity were generated from tide, wave and ocean motion, with France and Korea each producing approximately 500 GWh and Canada produced 13 GWh. Wave energy appears to be in the same place technologically as wind power was 30 years ago. There is no consensus on the best design. In the U.S., much of the research on wave energy has occurred via the Northwest National Marine Renewable Energy Center with facilities in Oregon, Washington and Alaska.

4.5.1.2 United States Market

Analysts expect U.S. offshore wind energy to enjoy significant growth in the coming decade, due primarily to falling capital costs and operating costs. According to the U.S. Energy Information Administration (EIA), generation from renewable sources is projected to grow under all forecast scenarios, led by growth in wind and solar photovoltaic generation.[106]

Although only one offshore project has been developed in the United States to date (in Rhode Island), planning is underway for 25 offshore wind projects with a combined capacity of 24 gigawatts. Most of these projects are located along the U.S. Northeast and mid-Atlantic coasts.

The U.S. Department of Energy's (USDOE) *Wind Vision Roadmap* found that "deployment of wind technology for U.S. electricity generation provides a domestic, sustainable, and essentially zero-carbon, zero-pollution and zero-water use U.S. electricity resource."[107] The report documented a tripling of growth in wind energy capacity (including land-based, offshore, and distributed) between 2008 and 2014. The report projects that U.S. wind power could potentially supply 10% of the nation's electrical demand in 2020, 20% in 2030, and 35% in 2050. (See Figure 4-28).

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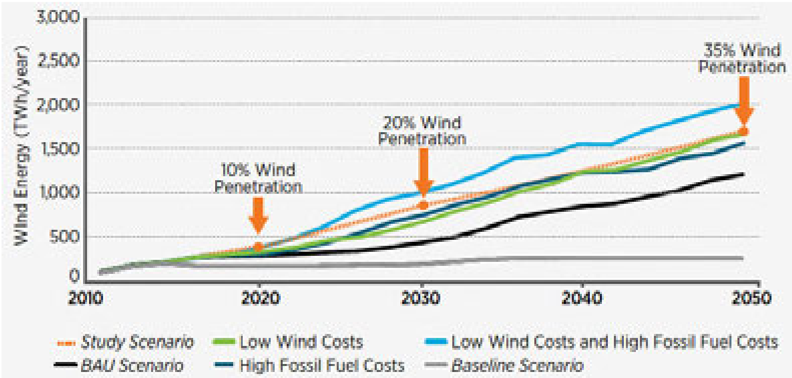
[105] Levitan, Dave, "Why Wave Power Has Lagged Far Behind as Energy Source", Yale Environment 360, April 28, 2014.

[106] Drouin, Roger, "After an Uncertain Start, U.S. Offshore Wind Is Powering Up", Yale Environment 360, January 11, 2018.

[107] U.S. Department of Energy Wind and Water Power Technologies Office, *Wind Vision: A New Era for Wind Power in the United States*, March 2015.

The USDOE prepared a follow-up report in 2017, which validated the results of the *Wind Vision Roadmap* but also suggested new actions to further support the sector.[108]

Figure 4-28: Wind Vision Study Scenario



The Wind Energy Technologies Office focused on opportunities for development of the offshore wind systems in another recent report.[109] Key findings included:

- U.S. offshore wind resources are abundant with technical potential of 2,058 gigawatts (GW) of offshore wind resource capacity accessible in U.S. waters using existing technology.
- Offshore wind could be competitively priced with other forms of generation within the next decade.
- Offshore wind could enable benefits for system operators, utilities, and ratepayers due to:
  - Lower marginal costs of production and
  - In certain locations (including offshore of Humboldt bay), it is possible to generate power during periods of peak use.
- Offshore wind provides numerous environmental and economic external benefits, including:
  - Reduced greenhouse gas emissions,
  - Decreased air pollution from other emissions,
  - Reduced water consumption,
  - Greater energy diversity and security, and
  - Increased economic development and employment

4.5.1.3 California Market

The State of California has made a strong commitment to reduce greenhouse gas emissions:

- The Clean Energy and Pollution Reduction Act of 2015 requires that electric utilities increase retail sales of qualified renewable energy to at least 50 percent by 2030, via the.

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[108] U.S. Department of Energy Wind and Water Power Technologies Office, *2016–2017 Status Assessment and Update on the Wind Vision Roadmap*, October 2017.

[109] U.S. Department of Energy Wind and Water Power Technologies Office, *National Offshore Wind Strategy, Facilitating the Development of the Offshore Wind Industry in the United States*, September 2016.

- In 2016, Senate Bill 32 put into law a statewide goal to reduce greenhouse gas (GHG) emissions 40 percent below 1990 levels by 2030.[110]

Development of offshore wind systems could be a prominent part of this transition.

The National Renewable Energy Laboratory, in conjunction with United States Department of the Interior Bureau of Ocean Energy Management (BOEM), produced detailed evaluations of the wind resources available at various locations along the California coastline. As shown in Figure 4-29, there are several areas along the California coast with favorable conditions for offshore wind systems, including the area offshore of Humboldt Bay.

The U.S. Navy reviewed the report and stated its intention to veto offshore wind energy systems in the ocean area off San Luis Obispo and Santa Barbara counties as well as the entire offshore zone stretching from Los Angeles north to Big Sur. Because of this, efforts are now focused farther north, in the Humboldt Bay area. While wind conditions are favorable in the Humboldt Bay region, the area is not close to the large population centers in California.

A recent report by the University of California Berkeley finds that "as California accelerates its transition to a low-carbon future, one of its challenges is to choose "high-road" policies that not only cut emissions but spur broad-based growth, create quality jobs, and benefit communities. The state and federal governments have recently launched a planning process for one emerging clean energy source with significant high-road potential: offshore wind."[111]

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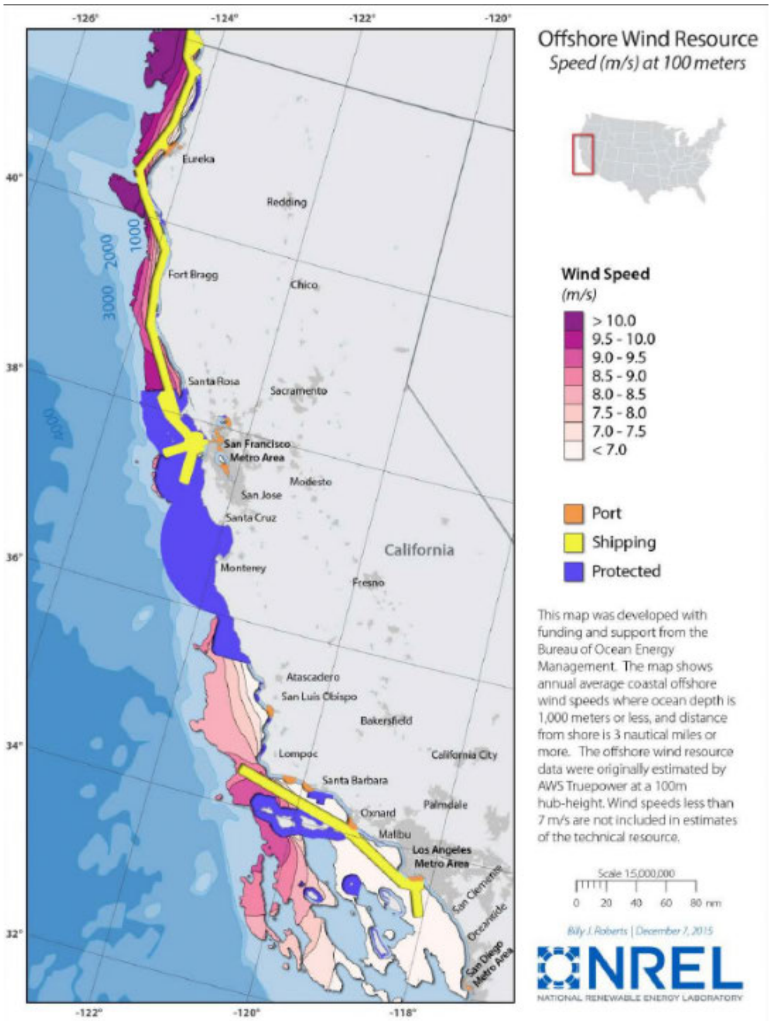
[110] California Energy Commission, *Offshore Renewable Energy - Docket # 17-MISC-01*. http://docketpublic.energy.ca.gov/PublicDocuments/17-MISC-01/TN222736_20180226T113840_Notice_of_Webinar_on_Offshore_Renewable_Energy_3122018.pdf (accessed 4/2/2018).

[111] Green Economy Program, Center for Labor Research and Education, University of California, Berkeley. *High Road for Deep Water Policy Options for a California Offshore Wind Industry*, November 2017.

Figure 4-29: Wind speed map of California offshore technical resource area with competing use and environmental conflicts overlaid[112]



Source: National Renewable Energy Laboratory

4.5.1.4 Humboldt Bay

The Redwood Coast Energy Authority (RCEA) is a local government joint powers agency whose member agencies include: Humboldt County, the Cities of Arcata, Blue Lake, Eureka, Ferndale, Fortuna, Rio Dell, Trinidad, and the Humboldt Bay Municipal Water District. The mission of RCEA is to develop and implement sustainable energy initiatives that reduce energy demand, increase energy efficiency, and advance the use of clean, efficient and renewable energy resources available in the region. In 2012, RCEA adopted the Humboldt County Comprehensive Action Plan for Energy (CAPE), that established specific strategic action items relevant to the development of the region's offshore wind energy resources, including:

- Large-Scale Wind Energy: Work with utilities and private companies to develop off-shore wind energy demonstration projects.

[112] National Renewable Energy Laboratory, *Potential Offshore Wind*.

- Emerging Energy Technologies: Support the development of emerging energy technology from local innovators and inventors, as well as from non-local sources.
- Business Development: Collaborate with local economic development entities to attract technology developers, manufacturers, and energy service providers to locate operations in the County when appropriate.
- Proactive Development Support: Collaborate with local jurisdictions to identify and pre-assess locations and facilities that could appropriately support energy generation projects and/or other energy-related business ventures.
- Local Energy Investment: Work with local economic development entities and financial institutions to develop programs and resources that facilitate local community investment in and/or ownership of energy efficiency and renewable energy projects.

One technical issue that will need to be addressed is transmission capacity. Existing transmission capacity out of Humboldt County is approximately 60 MW, but according to the National Renewable Energy Laboratory (NREL) the maximum technical potential for the Humboldt County coast is 1100 MW with a capacity factor (annual average of maximum output) of 55 percent. Full development of the offshore resource would require a major upgrade to the transmission lines. If Humboldt's capacity were fully developed, it could supply twenty times the total electricity consumption of Humboldt County.

In alignment with its priories of developing local renewable resources as well as supporting energy-related local economic development, RCEA has begun actively exploring the potential to move forward with a local offshore wind energy project.[113] The RCEA issued a request for qualifications from potential bidders in February 2018.[114] Principle Power was the winning bidder, and a Memorandum of Understanding (MOU) was approved in October 2017. This MOU establishes a collaborative effort to work together on the key requirements needed to develop Humboldt's offshore wind energy potential, which will take a number of years to complete.[115]

4.5.2 CDI Land Required

Humboldt's most promising sites for offshore wind development are approximately 15 to 20 miles offshore in deep water, so the turbines would be mounted on floating platforms. The development of offshore wind energy off the coast of Humboldt Bay would likely require the redevelopment of new port facilities.

A report prepared for BOEM by Hatch Mott MacDonald[116:] identified the different types of ports that are involved in wind energy projects:

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[113] Kalt, Jen, "Redwood Coast Energy Authority Proposes Offshore Wind Project", EcoNews Report, Feb 22, 2018.

[114] Redwood Coast Energy Authority, *Request for Qualifications for Humboldt County Offshore Wind Energy Development Partners*, February 2018.

[115] Winkler, Michael, "Renewable Energy Potential in Humboldt Includes Offshore Wind", Northcoast Environmental Center website, December 13, 2017. http://www.yournec.org/node/10819 (accessed 4/2/2018).

[116] Coast & Harbor Engineering, *Determining the Infrastructure Needs*.

- Quick Reaction Port (QRP): QRPs are intended to be the homeport for operations and maintenance vessels. The ports must be close enough to the energy development site to allow vessels to reach the site in less than two hours. QRPs are estimated to require 1 to 2 acres.
- Assembly Port (AP): This type of port will be utilized during final assembly of the entire devices for marine tow out to the installation location. Direct access to a high capacity deep water dock is required. Marine navigation access to the energy development site from the AP should be deep draft, and in the case of OFW not have any air draft restrictions. APs will likely be located as near as possible to the installation site. APs are estimated to require 50 to 100 acres.
- Fabrication and Construction Port (FCP): This type of port will be utilized during the installation or construction phase. FCPs may handle device components or serve as a transport hub for overland or marine transport. They may also provide fabrication of turbine or MHK components, or construction of the floating foundation. FCPs are estimated to require 100 to 200 acres.

The Hatch Mott MacDonald reviewed existing marine terminals in Humboldt Bay facilities and made several observations:

> The port was classified as a potential QRP for OFW and MHK, a potential fabrication and construction port for OFW and MHK, and an assembly port for OFW Semi-Sub and TLP, and MHK. The port's biggest assets related to OFW and MHK development (land, no air draft restriction, and navigation channel geometry, proximity to the ocean), show that assembly and quick reaction facilities appear feasible with some significant facility upgrades. Anchor handling tugs, bulk carriers, and other offshore construction vessels would likely be able to be accommodated, but may require upgrades to upland facilities such as crane capability.
>
> Manufacturing and fabrication at the port is less likely due to the remote location and limited overland transport connections. OFW assembly could potentially be conducted quayside at one of the Redwood terminals but would potentially require purpose-built facilities such as construction of a new concrete wharf, and potential berth dredging. Channel depth may limit tow-out operations to high tide. Schneider dock may require lengthening and other various upgrades prior to use. MHK construction and assembly at these sites is also possible, but would likely require wharf upgrades (bearing capacity, crane)."[18]

As shown in Figure 4-30, Humboldt Bay port facilities meet all the requirements for various offshore wind components with exception of the spar system which requires far greater depth.

Figure 4-30: Humboldt Bay Assessment and Cursory Gap Analysis

Port Classification	Technology	Score	Potential Gap
Quick Reaction	OFW & MHK	3	May require berth rehabilitation. Vessel specific moorage may be required. Helipad may be required
Fabrication & Construction	OFW Turbine	2	Exclusive-use area (10+ acres) with direct quayside access. New berth. Crane/SPMT.
	OFW Foundation	2	New Crane, exclusive upland area development (50+ acres depending on throughput). New berth. Crane/SMPT.
	MHK	2	Fabrication facility (1-5 acres). Likely a new berth. Crane/SPMT.
Assembly	OFW Semi-Sub	2	Berth dredging may be required. New crane. Rehabilitation and strengthening of existing docks or construction of new facility.
	OFW TLP	2	Berth dredging may be required. New crane. Rehabilitation and strengthening of existing docks or construction of new facility.
	OFW Spar	0	Spar draft does not allow for assembly with existing technology within the port.
	MHK	2	10 acre facility with berth. Likely a new crane. Berth may need rehabilitation and strengthening.

Notes on scoring

0 Does not meet primary criteria and is not suitable with existing technology due to not meeting one or more of the primary criteria (e.g. air draft restriction, upland area restrictions)

1 May not meet all primary criteria (such as available upland area), but temporary use of facilities will allow demonstration-scale project (e.g. staging area for 1 device is temporarily cleared at port).

2 Meets primary criteria. Land redevelopment, new purpose built marine terminal or berth required.

3 Meets primary criteria, and some secondary criteria. Moderate level of improvements needed, such as new high capacity (500+ tons) crane, existing berth upgrades, or berth bearing capacity investigation

4 Meets all primary criteria and most if not all secondary criteria. Minimal improvements are needed such as new small cargo crane (<10 tons), warehouses, helipad.

Source: Hatch Mott MacDonald

A report developed by the Green Economy Program at the University of California, also evaluated California's options for wind energy ports:

> California has several options for siting a supply chain, but all are complicated by the fact that under current floating wind technologies, the final assembly must be done in protected waters at a port, then towed directly out to the final operations site. Because offshore turbines by the mid-2020s could be at least 700 feet high, no bridges can stand in the way. One option is for different sites to be used for manufacturing, then final assembly at a separate location.
>
> Ideally, however, one site would be used for integrated manufacturing and assembly, as with major European offshore wind hubs such as Cuxhaven in Germany and Grimsby in northern England. California's only viable site for manufacturing as well as assembly is the Port of Humboldt Bay, which has vast expanses of vacant industrial land but would need upgrading of its dock and transportation infrastructure.[117]

[117] Green Economy Program, *High Road for Deep Water.*

Because offshore wind energy production does not currently occur in the Humboldt Bay region, the scale and timing of development is uncertain at this time. As a result, the potential acreage that may be required in Humboldt Bay varies across a wide range.

According to discussions with Redwood Coast Energy Authority (RCEA) and its contractor Principle Power, a marine terminal designed for final assembly of wind turbines should be approximately 20 acres.[118] For this analysis, the amount of land required in the future is assumed to range from a low of 0 acres (i.e. the activity does not occur in Humboldt Bay) to 20 acres. (See Table 4-13).

A facility for assembling the floating hulls as well as final assembly would be substantially larger, ranging from 50 to 100 acres. It would not be necessary for the entire facility to be located on the water as long as there was adequate access to the water.[119] For this analysis, the amount of land required in the future for hull and turbine assembly is assumed to range from a low of 0 acres (i.e. the activity does not occur in Humboldt Bay) to a high of 100 acres.

If Humboldt Bay were to become the center of West Coast offshore wind energy, long-term demand could be as much as 300 acres, if all activities of the supply chain were to locate in the area. The 300 acres would not necessarily have to be contiguous, and would also not all need to be CDI property. It is also possible that portions of the work (fabrication of components, for example) could be performed at other water-served areas (such as the San Francisco Bay area) and then shipped to Humboldt Bay for assembly. For this analysis, the amount of land required in the future if all component production and assembly were to occur in Humboldt Bay is assumed to range from a low of 0 acres (i.e. the activity does not occur in Humboldt Bay) to a high of 300 acres.

Table 4-13: Current CDI Use and Future Demand, Offshore Energy

Land Use	Current Acres	Future Acres Low	Future Acres High	Change in Acres Low	Change in Acres High
Turbine assembly	0	0	20	0	20
Hull and turbine assembly	0	0	100	0	100
All component production and assembly	0	0	300	0	300

Source: BST Associates

[118] Principle Power and Redwood Coast Energy Authority, interview with the authors, April 25, 2018.

[119] Principle Power and Redwood Coast Energy Authority, interview with the authors, April 25, 2018.

5 Comparison of Supply and Demand

Current demand for CDI land in Humboldt Bay is estimated to be 121 acres. Future demand for CDI is projected to range from 120 to 492 acres. The largest source of uncertainty is the offshore energy sector, for which demand may range from zero acres (i.e. the activity does not occur on Humboldt Bay) to 300 acres. (See Table 5-1).

Total existing supply is 1,100 acres. The current surplus of CDI land is 979 acres, while future surplus may range from a high of 980 acres to a low of 608 acres.

Sea level rise may impact a substantial portion of the supply of CDI land. Under the high estimate of sea level rise, the amount of CDI land lost may grow from 79 acres in 2030 to 400 acres in 2100. Under the high estimates of demand for CDI land and loss of CDI land due to sea level rise, the surplus of CDI land exceeds 200 acres; under lower levels of demand and/or land loss the surplus of CDI land increases.

Table 5-1: Summary of Current CDI Use, Future Demand, and Supply

		Current	Future Acres		Change in Acres		
Use Category/ Land Use		Acres	Low	High	Low	High	Notes
Marine Cargo							
	Logs	11	11	15	0	4	
	Other General	0	0	25	0	25	Single multi-use terminal may accommodate other general cargo, marine highway, and containers
	Vehicles	0	0	0	0	0	
	Containers	0	0	0	0	0	
	Marine Highway	0	0	0	0	0	
	Aggregates	0	8	12	8	12	
	Woodchips	36	20	36	-16	0	Potentially accommodated with one terminal
	Grain & Oilseeds	0	0	0	0	0	
	Other Dry Bulks	0	0	0	0	0	
	Liquid Bulks	4	4	4	0	0	
	Cruise ships	3	3	3	0	0	
	Sub-Total	54	46	95	-8	41	
Fishing & Recreational Boating							
	Moorage	46	46	46	0	0	
	Processing	5	5	5	0	0	
	Cold Storage	0	3	3	3	3	
	Gear Storage	0	1	1	1	1	
	Vessel Repair	9	9	12	0	3	
	Sub-Total	60	64	67	4	7	
Other Uses							
	Mariculture	7	10	20	3	13	
	Marine Research	0	0	10	0	10	
	Offshore Energy	0	0	300	0	300	Large range of uncertainty
	Sub-Total	7	10	330	3	323	
Total		121	120	492	-1	371	
Existing Supply							
Land		1,100	1,100	1,100			
Surplus							
Current		979	980	608			

Source: BST Associates

5.1 MULTI-PURPOSE DOCK

Based on projected demand, a single marine terminal may be able to handle a large share of future cargo volumes on Humboldt Bay. The design characteristics of this terminal depend on whether or not it would be used by the wind energy sector. The primary difference between a general-purpose terminal and one for wind equipment is the loading capacity of the dock and other areas where lift equipment carries heavy loads.

BST Associates estimated the need for additional marine terminal space could be as high as 41 acres. This could likely be accommodated at a general-purpose terminal capable of handling multiple cargo types (e.g. wood chips, aggregates, logs, etc.). One example of an existing general-purpose terminal is the Bellingham Shipping Terminal in Bellingham, Washington. This terminal handles breakbulk and bulk cargos, offers 1,250 feet of dock space, with approximately 85,000 square feet of covered storage and 35 acres of available uplands. Water depth in the shipping channel is 35 feet.

The most likely location for a terminal of 41 acres is the Samoa Peninsula. This conclusion is based on the location of the navigation channel and the size of existing parcels. The navigation channel is authorized to a depth of 38 feet MLLW to the Samoa Peninsula and to the Eureka waterfront. The Samoa Peninsula has a number of CDI properties that are 41 acres or larger, but the largest CDI properties in Eureka are 24 acres or less. Fields Landing has two properties large enough to accommodate such a terminal but the authorized channel depth of 26 feet is not sufficient for most ships.

Figure 1: Bellingham Shipping Terminal

5.2 OFFSHORE WIND DOCK

According to discussions with Redwood Coast Energy Authority (RCEA) and its contractor Principle Power, a marine terminal designed for assembling wind power equipment should be a minimum of 20 acres, with a dock length of 250-meters (820 feet) and designed for wheel loadings of 4,000 lb/sq ft. Some additional land behind the terminal for storage is also recommended. A new terminal in Massachusetts, the New Bedford Marine Commerce Terminal, provides a good example. This terminal offers 1,200 linear feet of bulkhead, including 800 feet of deep-draft berthing and 400 feet of barge berthing space, 29-foot controlling depth in the New Bedford Harbor (MLLW), and 26 acres of terminal storage.

Figure 2: New Bedford Marine Commerce Terminal

A facility for assembling the floating hulls would be substantially larger, ranging from 50 to 100 acres. It is not necessary for the entire property to be located on the water as long as there is adequate access to the water.

According to a representative of Principle Power, if Humboldt Bay were to become the center of West Coast offshore wind energy, long-term demand may be as much as 300 acres, if all activities of the supply chain were to locate in the area. The 300 acres would not necessarily have to be contiguous, and would also not all need to be CDI property. It is also possible that portions of the work (fabrication of components, for example) could be performed at other water-served areas, such as the San Francisco Bay area.

An example of a port where all facets of the wind energy supply chain are co-located is Esbjerg, Denmark. Esbjerg is a major center for offshore oil production as well as offshore wind energy, and is home to many manufacturers that serve both industries. The wind energy terminal in Esbjerg is approximately 300 acres, with water depth of 30 feet.

Figure 3: Esbjerg Wind Energy Terminal

6 LIST OF SOURCES

Advisian, *Terminal 6 Business Study*, January 2018.

The Beck Group, *Dead Tree Utilization Assessment*, May 2017. Completed for CALFIRE & California Tree Mortality Task Force.

Bloomberg New Energy Finance Business Wire, *Global Offshore Wind Market Set to Grow Sixfold by 2030*, January 8, 2018.

BP Energy Economics, *BP Energy Outlook*, 2018 Edition.

BST Associates, *Humboldt Bay Alternative Rail Corridor Concept Level Construction Cost and Revenue Analysis Final Report*, August 22, 2013.

BST Associates, *2017 Marine Cargo Forecast and Rail Capacity Analysis*, August 2017.

California Coastal Commission, *Report W22b, Applicant: Coast Seafood Company*, August 14,2017.

California Coastal Commission, *Application No. E-11-029, Applicant: Taylor Mariculture LLC*, 2013

California Coastal Commission, *Application No. 9-13-0500, Applicant: Hog Island Oyster Company*, November 2013.

California Coastal Commission, *Application No. 9-16-0204, Applicant: Humboldt Bay Harbor, Recreation, and Conservation District*, May 2016.

California Department of Boating and Waterways; includes all boat lengths.

California Energy Commission, Offshore Renewable Energy - Docket # 17-MISC-01. http://docketpublic.energy.ca.gov/PublicDocuments/17-MISC-01/TN222736_20180226T113840_Notice_of_Webinar_on_Offshore_Renewable_Energy_3122018.pdf (accessed 4/2/2018).

California Energy Commission, *Transportation Energy Demand Forecast, 2017-2030*, June 20, 2017.

California Geological Survey Department of Conservation, *Aggregate Sustainability in California*, 2012.

California State Board of Equalization, California Timber Harvest Statistics. http://www.boe.ca.gov/proptaxes/pdf/harvyr2.pdf (accessed January 12, 2018).

California Sea Grant, “Changing waters in Humboldt Bay: Extension Specialist Joe Tyburczy awarded funds to track ocean acidification”, California Sea Grant website, December 2016. https://caseagrant.ucsd.edu/news/changing-waters-in-humboldt-bay-extension-specialist-joe-tyburczy-awarded-funds-to-track-ocean (accessed March 2, 2018).

Caltrans, Office of State Planning, Transportation Economics Branch, *California County-Level Economic Forecast 2017-2050*. September 2017.

CalTrans, *Long Term Implementation of the M-580 Marine Highway*, December 2015.

Cardno TEC Inc., *West Coast Marine Highway Market Analysis Project*, April 2014. Prepared for the West Coast Corridor Coalition through a cooperative agreement with United States Department of Transportation – Maritime Administration.

City of Eureka Harbor Division, *Leveraging Waterfront Assets into Revenue and Cost Saving Opportunities*, March 2017.

Coast & Harbor Engineering, *Determining the Infrastructure Needs to Support Offshore Floating Wind and Marine Hydrokinetic Facilities on the Pacific West Coast and Hawaii*, March 3, 2016.

Cruise Lines International Association, *2018 Cruise Industry Outlook*, December 2017.

Driscoll, John, "California Redwood looks to restart chip export facility; ships would move sawmill byproduct to Asian markets". The Times-Standard, October 15, 2010. http://www.times-standard.com/article/zz/20101015/NEWS/101019432 (accessed March 8, 2018).

Drouin, Roger, "After an Uncertain Start, U.S. Offshore Wind Is Powering Up", Yale Environment 360, January 11, 2018.

Green Economy Program, Center for Labor Research and Education, University of California, Berkeley. *High Road for Deep Water Policy Options for a California Offshore Wind Industry*, November 2017.

Greenway Partners, *Regional Cold Storage Facility, Technical Study*, September 15, 2015. Prepared for the City of Eureka.

Hackett, Steven and Richmond, Laurie, interview with the authors, January 22, 2018.

Hog Island Oyster Co. Inc., "About Hog Island Oyster Co. Inc.", https://www.bcorporation.net/community/hog-island-oyster-co-inc (accessed February 23, 2018).

Humboldt Bay Area Harbor Safety Committee., *Harbor Safety Plan of the Humboldt Bay Area*, revised July 2009.

Humboldt Bay Harbor, Recreation and Conservation District, *Final Environmental Impact Report for the Humboldt Bay Mariculture Pre-Permitting Project, Volume 1, SCH #2013062068*. February 8, 2016.

Humboldt County, *Humboldt Bay Area Plan of the Humboldt County Local Coastal Program*. December 2014

Humboldt County, *Humboldt County General Plan for the Areas Outside the Coastal Zone*. Adopted October 23, 2017

Humboldt County, *Prosperity, Comprehensive Economic Development Strategy 2013-2018*. 2012

Humboldt County Association of Governments, *HCAOG 20-Year RTP–2017 Update/Public Draft,* September 2017.

Humboldt County Association of Governments, *Variety in Rural Options of Mobility Semi-Final Draft*, 2017.

Humboldt State University Marine Sciences website. http://www2.humboldt.edu/marinesciences/facilities.html (accessed April 2, 2018).

Humboldt State University Special Collections website, http://library.humboldt.edu/humco/holdings/LPHammondAid.htm#publicinfooffice. Accessed 2-16-2018.

International Energy Agency, *Renewables Information 2017 Overview*, July 20. 2017.

Joyce, Michael, "Does Biomass Still Have A Place In Humboldt County's Energy Future?", *Eureka Times Standard,* May 2, 2016.

JSI, *Coast Seafoods Company Recirculated Draft EIR Appendix J Economic Impacts*, July 2016.

Kalt, Jen, "Redwood Coast Energy Authority Proposes Offshore Wind Project", EcoNews Report, Feb 22, 2018.

Karp, Steven, interview with the authors, March 29, 2018.

Kelly, Erin, interview with the authors, April 4, 2018.

Koren, James Rufus, "Why builders of big L.A. projects are making concrete with gravel and sand shipped from Canada", *Los Angeles Times*, November 4, 2017.

LACO, *Technical Memorandum, Coastal-Dependent Industrial Site Inventory Review, Assessor's Parcel Numbers 401-301-05, 401-301-09, 401-311-01*, March 26, 2015.

Laird, Alderon, *Humboldt Bay Area Plan Sea Level Rise Vulnerability Assessment*, January 2018.

Levitan, Dave, "Why Wave Power Has Lagged Far Behind as Energy Source", Yale Environment 360, April 28, 2014.

Mercator International and Oxford Economics, *Executive Summary for San Pedro Bay Long-term Unconstrained Cargo Forecast*, January 2016.

Mercator International, *Seaport Alliance Strategic Business Plan*, May 16, 2015.

National Association of Marine Laboratories (NAML) and the Organization of Biological Field Stations (OBFS), *Field Stations and Marine Laboratories of the Future: A Strategic Vision*, 2013.

National Marine Fisheries Service Office of Science and Technology, Fisheries Statistics Division, *Fisheries of the United States, Current Fishery Statistics No. 2016*. August 2017.

National Oceanographic and Atmospheric Administration, *Basic Questions about Aquaculture*, https://www.fisheries.noaa.gov/topic/aquaculture (accessed February 15, 2018).

National Oceanographic and Atmospheric Administration, *Fisheries of the U.S.*, 2016.

National Oceanographic and Atmospheric Administration Office of Aquaculture, *U.S. Aquaculture*, https://www.fisheries.noaa.gov/national/aquaculture/us-aquaculture (accessed February 15, 2018).

National Oceanographic and Atmospheric Administration, SeaGrant and the Aquarium of the Pacific, *Offshore Aquaculture in the Southern California Bight*, April 2015.

National Renewable Energy Laboratory, *Potential Offshore Wind Energy Areas in California: An Assessment of Locations, Technology, and Costs*, December 2016.

Nealon, Sean, OSU Marine Studies Building to Be a National Model for Tsunami "Vertical Evacuation", November 22, 2017. http://today.oregonstate.edu/news/osu-marine-studies-building-be-national-model-tsunami-%E2%80%9Cvertical-evacuation%E2%80%9D (accessed April 2, 2018).

New Bedford Marine Commerce Terminal, http://newbedfordwindenergycenter.org/a-full-service-port/new-bedford-marine-commerce-terminal/ (accessed 3-18-2018).

Northern Economics, *The Economic Impact of Shellfish Aquaculture in Washington, Oregon and California*, April 2013.

Oceanspaces, http://oceanspaces.org/, (accessed February 12,2018).

Pacific Affiliates, *Chevron Eureka Terminal MOTEMS Inspection Repairs*, May 15, 2015.

Pacific Seafood, "Pacific Seafood is the First Company in the World to Offer Four-Star BAP Oysters" press release, February 5, 2018.

PB Ports & Marine, *Port of Humboldt Bay Harbor Revitalization Plan Final Report*, February 2003

PB Ports & Marine, *The Long Term Financial and Economic Feasibility of the Northwestern Pacific Railroad*, January 2003.

Petrusha, Tim, interview with the authors, January 25, 2018.

Petrusha, Tim and Howser, Suzie, interview with the authors, January 25, 2018.

Pincomb, Art, “Mineral Appraisals: What is the Value of a Quarry or Mine?”, *The M&TS Journal, Volume 32, Issue 2*, 2nd Quarter 2016.

Port of Redwood City, “Port, Cemex Aggregates Reach New 10-Year Deal” port press release, June 26, 2017.

Principle Power and Redwood Coast Energy Authority, interview with the authors, April 25, 2018.

Raimey, Jeff and Wilkes, Donald, interview with the authors, January 24, 2018.

Redwood Coast Energy Authority, *Request for Qualifications for Humboldt County Offshore Wind Energy Development Partners*, February 2018.

Research and Markets, G*lobal Offshore Wind Energy Market Size, Market Share, Application Analysis, Regional Outlook, Growth Trends, Key Players, Competitive Strategies and Forecasts, 2017 to 2025*, December 12, 2017. As reported in Business Wire.

Robinson, Gilpin R. Jr., and Brown, William M, *Sociocultural Dimensions of Supply and Demand for Natural Aggregate— Examples from the Mid-Atlantic Region, United States*, U.S. Geological Survey Open-File Report 02-350, September 2002.

Schubel, Jerry R. and Thompson, Kimberly, *Marine Finfish Aquaculture in the U.S. and California: A Story of Lost Opportunities for Leadership and Economic Development*, December 2, 2016.

Shanker, Deena, “How We’ll Eat Fish in the Future”, *Bloomberg News*, May 26, 2017.

Sierra Pacific Industries, “Sierra Pacific Industries Announces Permanent Closure of Arcata, CA Sawmill”, press release, January 25, 2016.

Simpson Timber Company, *Five Generations of Family Management, Number 22*, September 1999.

Soden, Tabitha, “Humboldt State’s Marine Lab Celebrates 50 Years”, *Eureka Times Standard*, November 16, 2015.

Tyburczy, Joe, interview with the authors, March 29, 2018.

U.N. Food and Agriculture Organization, *The State of World Fisheries and Aquaculture*, 2016.

U.S. Department of Agriculture, *Americans’ Seafood Consumption Below Recommendations*, October 2016

U.S. Department of Agriculture, *California’s Forest Products Industry: A Descriptive Analysis, for years 2000, 2006 and 2012*, 2012.

U.S. Department of Agriculture, *Census of Agriculture*.

U.S. Department of Agriculture, National Agricultural Statistics Service, *2013 Census of Agriculture Highlights, ACH12-21*, February 2015.

U.S. Department of Energy Wind and Water Power Technologies Office, *2016–2017 Status Assessment and Update on the Wind Vision Roadmap*, October 2017.

U.S. Department of Energy Wind and Water Power Technologies Office, *National Offshore Wind Strategy, Facilitating the Development of the Offshore Wind Industry in the United States*, September 2016.

U.S. Department of Energy Wind and Water Power Technologies Office, *Wind Vision: A New Era for Wind Power in the United States*, March 2015.

U.S. Department of Health and Human Services and U.S. Department of Agriculture, *2015 – 2020 Dietary Guidelines for Americans*, 8th Edition, December 2015.

U.S. Maritime Administration, "America's Marine Highway Program", https://www.marad.dot.gov/ships-and-shipping/dot-maritime-administration-americas-marine-highway-program/ (accessed 3-22-2018).

U.S. Maritime Administration, marine highway corridor descriptions, https://www.marad.dot.gov/wp-content/uploads/pdf/Click-here-for-Route-Descriptions.pdf (accessed 3-22-2018).

White, Cliff, "Aquaculture in California Has Promising Future", seafoodsource.com, September 29, 2016, https://www.seafoodsource.com/news/aquaculture/report-aquaculture-in-california-has-promising-future (accessed February 21, 2018).

Williamson, Rhea L., Northern California's Marine Research and Innovation Park: from Extraction to Sustainability. http://conference.ifas.ufl.edu/nwwws/documents/Presentations/4%20Williamson%20B3%20REVISED.pdf, (accessed February 21,2018).

Winkler, Michael, "Renewable Energy Potential in Humboldt Includes Offshore Wind", Northcoast Environmental Center website, December 13, 2017. http://www.yournec.org/node/10819 (accessed 4/2/2018).

World Bank, Fish Farms to Produce Nearly Two Thirds of Global Food Fish Supply by 2030, Report Shows, press release, February 5, 2014. http://www.worldbank.org/en/news/press-release/2014/02/05/fish-farms-global-food-fish-supply-2030 (accessed February 15, 2018).

4 Economic Development

4.1 INTRODUCTION

This paper describes issues and opportunities for economic growth and diversification in the City of Eureka. Current and projected economic conditions are a primary guiding force behind the City's ongoing General Plan Update process. The items identified here, and in other such policy papers produced during the General Plan Update, will have a lasting influence on the City's policy framework and land use plan through 2040 and beyond. The first section of this paper identifies key issues and opportunities facing the City, and explores their implications for long-term economic growth. The second section outlines a menu of policy alternatives for each major topic identified in the prior section. The final section discusses the recommended alternatives, which are identified with the goal of maximizing economic returns and community benefits, based on an analysis of the City's competitive position within Humboldt County and the greater North Coast region.

4.2 ISSUES AND OPPORTUNITIES

The items described below include those identified in the General Plan update Background Report, as well as those discussed by the General Plan Update Economic Development Focus Group and City's Economic Development Strategic Plan Ad Hoc Committee. Additional information was also collected through conversations with City staff and interviews with key community stakeholders.

Industrial Development

Eureka's industrial land uses include a variety of development types, but were historically focused on a combination of resource-based activities, included timber processing, commercial fishing, and related activities. Access to the Port of Humboldt Bay provided a convenient and cost effective method for transporting commodities from the relatively isolated North Coast, to larger markets throughout the world. In more recent decades, most of the resource-based industries have experienced a period of decline, with significant contractions in both production volume and local employment. The results of this economic readjustment include a significant reduction in the availability of higher wage industrial employment opportunities, as well as the underutilization of industrial land and associated facilities in the City of Eureka and surrounding areas. Despite this, the industrial sector continues to play an important role in the community's identity, and generates a significant amount of income, on a regional basis, through the ongoing export of durable and non-durable goods, such as timber, fish products, and assorted manufactured goods.

Timber Harvesting and Processing

The timber industry has played a defining role in Eureka's industrial history and is clearly visible in the existing land use patterns prevalent throughout Eureka and surrounding areas. However, the industry has undergone a considerable economic contraction in recent decades, resulting in a significant reduction in regional demand for industrial land. For example, in 1977, the Humboldt County timber industry produced an estimated 903 million board-feet (MMBF) of timber. As of 2012, this had fallen to 221 MMBF. In addition to the loss of production volume, the industry has shifted away from the production of milled lumber and pulp, toward the shipment of raw uncut logs. These two influences, combined with more stringent environmental regulation and enforcement, have resulted in the closure, or relocation, of a many of the lumber and pulp mills that once operated in, or near, Eureka.

Most of the industrial activity associated with the timber industry is concentrated along Railroad Avenue and West Waterfront Drive, between Del Norte Street and Washington Street in the City. This area includes mill facilities and storage yards, including Schmidbauer Lumber, among others. Most of the properties in this area have direct access to dock facilities and the deep water channel. Adjacent land uses in the area include assorted industrial and light industrial properties, as well as regional retail establishments and commercial properties. The area features a large amount of underutilized land, much of which was historically used for log storage, or other timber-related activities. In addition to sites located along the Eureka waterfront, the California Redwood Company, a subsidiary of the Green Diamond Resource Company, recently ceased operation of the Brainard remanufacturing plant along Highway 101, just north of the Murray Field Airport. Although the site is technically located outside of the established City limits, its proximity makes it a candidate for possible annexation.

The Samoa Peninsula, located across Humboldt Bay from the City of Eureka, once hosted two large pulp mills. Among the reasons cited for the closure of the Simpson Paper Company and the Louisiana-Pacific pulp mills include a series of lawsuits associated with environmental contamination and the institution of more stringent federal and state forestry policies that reduced the availability of necessary feed stocks (e.g. wood chips). Although both sites have changed ownership, including attempts to restart the facilities, both pulp mills have permanently ceased operations, leaving behind a substantial inventory of vacant and underutilized land. Although burdened with substantial challenges associated with the remediation of existing environmental contamination, the sites offer existing water supply infrastructure, as well as dock facilities and access to the deep water channel, which make the sites strong candidates for long-term industrial redevelopment.

Coastal-Dependent Industrial Activity

As the largest protected body of water between the San Francisco Bay and the Puget Sound, Humboldt Bay represents a natural point of concentration for coastal-dependent industrial activities. Given the intensity and historic significance of timber operations in the North Coast region, the Port of Humboldt Bay has historically specialized in the shipment of timber products, ranging from wood pulp, to cut boards, and uncut logs. The port also functions as the primary depot for petroleum products and general cargo shipments destined for locations throughout the region. It also occasionally functions as a destination for commercial cruise ships. In addition to serving as a center for goods movement, the Port of Humboldt Bay hosts a commercial fishing fleet and aquaculture industry focused on oyster production, as well as seafood processing and distribution facilities.

Despite this broad array of maritime activities, decades of decline in the timber and fishing industries have greatly reduced the volume of activity taking place at the Port of Humboldt Bay. With continued declines in port activity, some question whether the traffic will be sufficient in the future to justify the expense of dredging the channel and employing pilots to guide ships into harbor. With the loss of many of its major users (e.g., the pulp mills), the Humboldt Bay Harbor, Recreation, and Conservation District (HBHRCD) is already experiencing financial hardship, making the continued maintenance of port infrastructure and the dredging of the deep water channel topics of utmost concern to many area residents and policy makers.

COMMERCIAL FISHING AND AQUACULTURE

Non-tribal commercial fishing began in the Humboldt Bay area following the establishment of the first commercial harbor in the mid-1800s. By the 1970s, more than half of the seafood consumed in California originated from the greater Humboldt Bay area. However, since that time, concerns over the long-term sustainability of coastal salmon and ground fish populations prompted California legislators, in cooperation with the Pacific Fishery Management Council, to implement increasingly stringent management policies for the commercial and recreational fishing. Average prices, per pound landed, have remained relatively flat over the long-term, but fluctuate considerably among the various fisheries. Meanwhile, the commercial fishing fleet faces rising costs, particularly for fuel and insurance, and increased competition from fishing fleets based in other areas. As a result of these combined influences, the local industry has sustained significant declines, with total landings decreasing from nearly 40 million pounds in the early 1980s, to 35.6 million pounds in 2013. The number of boats with landings in the Eureka area (primarily Eureka and Fields landing) has also decreased dramatically, from a high of 858 in the early 1980s, to a low of 118 as of the mid-2000s.

In addition to declines in overall fishing activity, the industry struggles with aging infrastructure and the closure of important support businesses, such as Eureka Ice and Cold Storage, in 2008. Infrastructure supporting the commercial and recreational fishing industries includes an assortment of unloading facilities (including docks, piers, and boat slips), parking and storage areas, launch ramps, fish cleaning stations, fuel docks, and work docks, among other features. These are primarily located at the Woodley Island Marina, although some additional facilities are also available along the Eureka waterfront and at Fields Landing. The primary berthing facilities include 237 slips at the Woodley Island Marina, which is managed by the HBHRCD. Additional berthing is available at the city-managed Boat Basin, located near the Wharfinger Building. Some limited berthing is available at docks along the Eureka waterfront, as well as at Fields Landing and King Salmon.

Along with contractions in total fish landings, the area has seen a contraction in the number of receivers and processors, as well as other support service providers (e.g. marine supply, boat maintenance and repair facilities, ice plants, cold storage facilities, etc.). While consolidation among support providers suggests increased efficiency, it may also make the industry more vulnerable to future regulatory and economic stress. Despite the loss of a number of important service providers and infrastructure components, important steps have been taken to ensure continued availability of important services and infrastructure. For example, the City of Eureka completed construction of the $3.2 million Fisherman's Terminal in 2011. The facility took 15 years to construct and is designed to accommodate seafood processing, loading docks, a market space, and a café. While the facility is occupied by a number of users, including Coast Seafoods and Wild Planet, the City recently completed the recruitment of an operator for the market and café space. Although only at a preliminary stage, the City of Eureka is currently pursuing a feasibility study to assess the viability of a replacement cold storage facility. According to the Fisherman's Marketing Association, cold storage represents an important infrastructure component, since it facilitates more efficient goods movement by allowing the temporary storage of fresh fish, so that distributors can accumulate sufficient product to arrange for shipments that take a full shipping container at a time.

MERCHANT SHIPPING AND THE CRUISE INDUSTRY

Since its establishment, the Port of Humboldt Bay has been primarily export-oriented, with a clear specialization in the handling of assorted timber products, such as pulp, lumber, and logs. With the decline of the timber industry, and the loss of many of the region's lumber and pulp mills, the volume of cargo flowing through the Port of Humboldt Bay has decreased dramatically. For example, the volume of cargo that passed through the port in 2013 was equal to only five percent of the 1995 volume. Similarly, 2010 was the last year in which the port handled general cargo, 2009 was the last year the port handled containers, and 2007 was the last year that the port handled bulk cargo. Today, the port continues to handle some cut lumber, although much of the activity has transitioned to uncut logs. The port also ships some fish products, and acts as the depot for the region's oil deliveries, which arrive via barge, rather than by truck.

The general trend in port activity across northern California suggests that the Port of Humboldt Bay is experiencing trends that are contrary to the larger region. For example, northern California ports, as a group, increased in their assessable tonnage by roughly 50 percent since 1995. This increase in tonnage is primarily explained by increased trade with a variety of Pacific Rim countries, which is primarily characterized by the import of products for distribution to throughout the broader U.S. marketplace. Due to the relatively small size of the local market area, combined with limited transportation access from Eureka to other west coast markets, the Port of Humboldt Bay struggles to compete with other West Coast locations as a port of entry for imported goods. Given projected that long-term population growth in Eureka and the surrounding region remains relatively modest, local consumer demand will likely generate only modest demand for products imported via the port. As noted earlier, with steep declines in the volume of cargo shipped via the port, there is a mounting concern regarding the ability of the community to continue financing the maintenance of port infrastructure and the dredging of the deep water channel. If, for any reason, the port is unable to continue to provide critical services, such as channel dredging and harbor pilot services, important products, such as gasoline and other petroleum products, will have to be trucked into the area, over the winding roads from the south or from the east, which carries a different set of challenges, such as those associated with cost effectiveness, roadway capacity, and public safety.

In addition to commercial fishing and merchant shipping activities, the Port of Humboldt Bay has also been the occasional host for commercial cruise ships. For example, the last cruise ship to dock in Humboldt Bay was a 644-foot vessel called *The World*, which docked in Humboldt Bay in June 2012. Known as "the largest privately owned yacht on the planet," the vessel consists of 165 private condominium units, and visits more than 800 ports in more than 140 countries on annual around-the-world itineraries. The vessel last visited Humboldt Bay in 2003, both times having to anchor in the bay, due to limitations associated with the existing docking facilities on the Eureka waterfront. Another vessel, the 633-foot *Amadea*, was scheduled to visit the Bay in February 2013, but was impeded by weather

A presentation was given to the Eureka City Council in May 2014 regarding the potential for cruise ship visitations. The presentation advocated for the $5 million refurbishment of a facility known as Dock B, which is located adjacent to the Wharfinger Building, in an industrial area along the Eureka waterfront. Per the presentation, it was estimated that the port could host around 10 cruise ships per year, which would subsequently generate an estimated $11.5 million in spending based on average spending per passenger, including employee spending and docking fees. While the expectation that the Port of Humboldt Bay could attract more than a few cruise ships each year after making dock improvements may appear optimistic, the Port of Astoria, Oregon, five hundred miles north of Eureka, hosted twenty cruise ships during the 2013 season.

Agriculture and Value Added Processing

While commercial agricultural production is not significant within the City of Eureka, the City does host a variety of agricultural support services businesses, as well as components of the local food system value chain. Although the City does not offer agricultural land as a competitive asset, the farm industry is nonetheless an important part of the local economy since a large portion of the area's farm production is exported outside of the region. As a regional commercial hub, Eureka has an opportunity to capture economic activity related to the processing, marketing, and distribution of agricultural products. Examples of area business that already participate in the food system value chain include the Lost Cost Brewery and Bien Padre Foods, among others. Companies such as these not only utilize local produce, but often develop brand identities that are closely tied to the local culture (e.g. Humboldt Bay oysters, Humboldt fog cheese, etc.). As such, they are far less likely to relocate production outside of the area when faced with challenges, such as transportation and land availability.

While it is difficult to quantify the magnitude of the economic impacts stemming from marijuana cultivation on the North Coast (due to its illicit nature), available estimates suggest that the underground industry generated roughly one billion dollars' worth of product in Humboldt County in 2010. If this estimate is accurate, it would represent approximately five times the value of all non-timber crops produced within Humboldt County that same year, as reported by the County Agricultural Department. This illicit agricultural production subsequently supports approximately $415 million in retail sales, which is equivalent to roughly one quarter of the estimated gross product for all of Humboldt County. In addition to retail sales, the marijuana economy also supports other local business through purchases of business and personal services, utilities, and real estate.

With multiple states across the country beginning to liberalize regulations surrounding marijuana and derivative substances, members of the community have raised concerns regarding the impact of legalization on the local economy. Some believe that legalization would lead to growth in the overall market for marijuana-based products, allowing area producers to capitalize on their existing competitive advantage and experience in the industry. On the other hand, legalization may also result in the erosion of Humboldt County's existing competitive advantage, one that exists due to its cool, wet climate, and relative isolation. If legalization occurs, there is some likelihood that producers may shift production to locations that are closer to the state's major population centers, in order to achieve greater efficiencies in transportation. Oregon, Washington State, Washington DC, Alaska, and Colorado have all recently legalized recreational marijuana. Accordingly, the City of Eureka anticipates that voters in the State of California may legalize recreational marijuana in 2016.

Projected Industrial Real Estate Demand

The California Coastal Act requires that local jurisdictions like Eureka, which includes land within the Coastal Zone, prepare a Local Coastal Program (LCP). The Coastal Act and the City's LCP give priority to coastal-dependent uses within the Coastal Zone. Land designated for coastal-dependent industrial uses (CDI) is one of the land use designations that provides for coastal-dependent uses, in this case industrial uses, with the purpose of protecting and reserving parcels on, or adjacent to, Humboldt Bay for coastal-dependent and coastal-related uses. In preparing its General Plan Update, it will be important for the City of Eureka to understand the long-term demand for CDI uses, so that the Land Use Element can provide sufficient land in suitable locations to accommodate demand for these uses.

Although reliable projection data for CDI activities do not exist, an analysis of employment projections associated with the industries typically associated with industrial real estate suggest that Humboldt County could add an estimated 6,000 jobs in the Construction, Manufacturing, Wholesale Trade, and Transportation, Warehousing, and Utilities sectors. Based on an average of 1,000 to 1,250 square feet per employee, this translates into demand sufficient to support the absorption of between six million and 7.5 million square feet of built industrial space. Assuming a relatively conservative floor area ratio of 35 percent, this suggests approximately 230 acres of land would be necessary to accommodate all of the county's industrial growth through 2040. If the City were to maintain its fair share of this growth, based on its existing share of countywide industrial employment (i.e., jobs in the four industry sectors identified above), it would capture an estimated 210 new industrial or warehouse oriented jobs through 2040. This would be sufficient to support absorption of between 210,000 and 262,500 square feet of building space. Using the same floor area ratio, the City would need to provide a sufficient inventory of sites to accommodate between 14 and 17 acres of industrial development over the next 25 years. Given the contractions experienced in the timber and fishing industries in recent decades, it is unlikely that much of this demand will be stem from coastal-dependent uses. As a result, the City is likely to experience a shortage of land with land use and zoning suitable for non-coastal-dependent uses. This is because the majority of the City's industrial land is located within the Coastal Zone.

According to the Harbor Revitalization Plan, prepared for the HBHRCD by PB Ports and Marine in 2003, the countywide inventory of land designated for coastal-dependent industrial use is approximately 1,390 acres. Of this, approximately 975 acres are located on the Samoa Peninsula. The three largest sites on the peninsula are known to be either vacant, or significantly underutilized, each including over 200 acres of land, with a cumulative total of roughly 850 acres. In 2013, the HBHRCD purchased a 72-acre site on the peninsula, on which it proposes to construct a commercial aquaculture facility, which remains in the preliminary planning stages. Elsewhere around the Bay, there is additional land that is set aside for coastal-dependent uses. For example, there is an estimated 210 acres of land designated for CDI use in Fields Landing, south of Eureka, and another 205 acres located along the waterfront within the City of Eureka itself. Based on the demand estimates discussed earlier, the City of Eureka possesses more than ten times as much CDI land as will likely be required to accommodate all of its projected industrial employment growth. Yet, because all of the land suitable for industrial development within the City of Eureka is located within the Coastal Zone, it is almost entirely restricted to CDI uses, which largely precludes non-CDI uses, such as traditional manufacturing and warehousing, which is likely to constitute a significant portion of the projected growth in demand.

Corridor Revitalization and Retail Development

As the largest population center in Humboldt County, the City of Eureka represents a hub for retail commerce on the North Coast. This fact is most clearly evident in the per capita taxable sales data. For example, the City of Eureka reported a total of $806.9 million in taxable sales in 2012, which translates into a per capita sales figure of nearly $29,900. Humboldt County, by comparison, reported total taxable sales of $1.77 billion, which translates to a per capita sales figure of more than $13,100, which is slightly lower than the statewide per capita sales figure of $14,743. Eureka's relatively strong competitive advantage in the retail trade sector is generally explained by the relative lack of alternative retail shopping opportunities in the region, and the ability of the City of Eureka to concentrate regional demand. Among the retail business types reported by the Board of Equalization, the City of Eureka shows unusually high per capita sales in the categories of General Merchandise Stores and Motor Vehicle and Parts Dealers. Businesses offering products in these retail categories tend to be larger regional or national chain retailers, and other destination-oriented establishments. This generally corresponds with the fact that Eureka hosts such retail destinations like the Bayshore Mall, Costco, and Target, as well as a number of auto dealerships.

Corridor Revitalization and Focused Infill Areas

In order to further bolster the City's position as a retail hub for Humboldt County and the North Coast, as well as to provide improved retail shopping opportunities for area residents and visitors, the City of Eureka has expressed interest in exploring opportunities to enhance its existing commercial corridors and optimize the provision of retail and services. To more clearly define opportunities for corridor revitalization and retail growth throughout the City of Eureka, the remainder of this subsection identifies a number of corridors and other focused infill areas where change and enhancement may be appropriate. The analysis provides a concise summary of existing land uses, overall character, circulation and parking, known utilities constraints or limitations, and existing or projected market opportunities. The discussion then concludes with a brief summary of projected retail real estate demand within the City of Eureka and Humboldt County more broadly.

BAYSHORE MALL

The Bayshore Mall is an enclosed, climate controlled, shopping center located in southern Eureka, along Highway 101, near the Fort Humboldt State Historic Park and PALCO Marsh. Unlike many enclosed shopping malls, Bayshore includes a number of outward facing establishments that have limited access from the mall's internal corridors. These include a number of larger retailers, such as PETCO, Pier 1 Imports, Ross Dress for Less, Sports Authority, TJ Maxx, and Ulta Beauty. Other anchor tenants include Kohl's, Sears, and Wal-Mart. Although the introduction of Wal-Mart to the Bayshore Mall was highly controversial, the establishment appears to be one of the primary drivers of retail activity in the mall. A brief visual survey of the property identified a significant amount of vacancy at the southern end of the mall, near the internal Kohl's entrance. The greatest amount of foot traffic was evident between the established food court and the internal Wal-Mart entrance. While the parking lot and main entrance for Wal-Mart is also located at the rear of the complex, this area appeared to be one of the most active parts of the mall, with a significant number of parked cars and a large number of shoppers both entering and exiting the store.

The mall has a substantial supply of surface parking, located primarily in the front, but with additional spaces located around the sides and at the rear of the mall property. Signage is on par with other regional malls in California, with good visibility for the external facing establishments and the primary anchor tenants. Visibility for the internally facing establishments is not as strong, particularly at the southern end of the mall, due to limited foot traffic. The overall condition of the mall structure is quite good, providing a high quality appearance and a relatively robust external image. The high degree of vacancy among smaller in-line tenants generally corresponds with an oversupply of smaller retail spaces throughout the Eureka market. Mall management has acted creatively to generate activity inside the mall, such as dressing the vacant storefronts, providing seating and spaces for laptop use, wi-fi access, kiosk retail spaces, and bringing in Bounce-A-Palooza (a bounce house facility providing children's activities), to help fill space in the mall's struggling southern end. Opportunities to re-tenant the vacant spaces will come from broader growth in the retail market in Eureka, or the installation of a more robust anchor tenant at the south end that can draw a higher degree of foot traffic from the more active central and north parts of the mall. There may also be opportunities to review parking standards and parking utilization at the mall site and turn over some of the existing parking fields to new development that could be complementary to the mall tenants.

EUREKA MALL

The Eureka Mall is located between West Harris Street and West Henderson Street, a short distance from the Bayshore Mall location. The Eureka Mall is primarily outward facing, with a mix of regional and national chain stores, including CVS Pharmacy, Dollar Tree, Michael's, Staples, Tuesday Morning, and WinCo Foods. Visibility for the mall anchor tenants is fairly good, with unambiguous signage and relatively good exposure to passing cars, particularly along the south side, facing Harris Street. The overall condition of the mall is fairly good, with fresh paint, well-kept landscaping, and traditional marquee signage. While there is a fairly large amount of parking available along Harris Street, the lot appeared fairly full upon visual inspection, suggesting that the site is not particularly over-parked. Automotive circulation in the vicinity of the mall is focused on West Harris Street, which provides access from Highway 101, and connects the Eureka Mall to residential neighborhoods to the east. While West Henderson Street does connect to Highway 101, it does so primarily in the west bound direction. Vehicles attempting to access the site from the highway via Henderson Street are diverted north or south on Fairfield Street, and must pass through residential neighborhoods to West Harris Street or West Creighton Street, before turning back towards the mall site. Given the existing tenant mix, and the proximity of adjacent residential neighborhoods, the Eureka Mall primarily functions as a community shopping center, providing for daily retail needs of area residents, rather than as a regional retail destination.

HENDERSON CENTER

The area known as Henderson Center is a neighborhood shopping district situated between Harris Street and Henderson Street, approximately one mile to the east of the Eureka Mall. The shopping district is primarily laid out in an east-west direction, with the majority of store fronts opening onto E Street and F Street.

Circulation through the district is characterized by two lane surface streets that extend into the surrounding residential areas. Parking is primarily on-street, with limited off-street parking available adjacent to Jo-Ann's Fabric and Craft and Rite Aid. Pedestrian infrastructure in the Henderson Center area includes street trees, sidewalks and cross walks, with pedestrian-activated signals at the stop lights on Harris Street and Henderson Street. The two primary arterial streets of Harris and Henderson also offer a single bike lane, with cobra head lights along one side of the street.

Henderson Center generally functions as a neighborhood shopping district, with retail establishments offering a variety of products that serve the daily needs of area residents and convenience shoppers. For example, the retail shops located along E Street include the Cherry Blossom Bakery, the Henderson Center Laundromat, the Juniper Salon, Rite Aid Pharmacy, and Umpqua Bank. One block to the east, shoppers can find Bank of America, Henderson Center Bicycles, the Henderson Center Farmers Market office, Jo-Ann's Fabric and Craft, and the U.S. Post Office. The majority of the structures in the Henderson Center are stand-alone retail buildings, constructed in different styles, at different times in the City's history. The relative appearance of the structures, and store fronts, varies from building to building. Overall the building facades are in relatively good repair, with signage that is somewhat inconsistent, but clearly visible and relatively appealing. While the district features a number of existing vacancies, these do not detract significantly from the overall appeal of the district as a neighborhood shopping center. While re-tenanting the vacant spaces would improve the overall shopping experience, the focus should be on attracting tenants that add value to the neighborhood, since the district already features a number of duplicate, low-rent tenants (i.e., two thrift stores).

DOWNTOWN EUREKA

The Eureka Downtown spans an area that, by some accounts, is approximately sixteen blocks long, and four to five blocks wide. It encompasses the commercial and office corridors located south of the westbound portion of Highway 101. Just east of the parcel known as the Balloon Track, Highway 101 turns ninety-degrees and splits into two one-way couplets, running east-west through the Downtown District. These are respectively known as 4th Street and 5th Street, which continue across the Eureka Slough Bridge. The Downtown district also includes 6th and 7th Streets, which parallel Highway 101. Automotive circulation includes alternating one-way streets, facilitating east-west travel. The majority of the streets oriented in a north-south direction are two-way connectors, with the exception of some major arterials, which are multi-lane, one-way streets.

Land uses in the Eureka Downtown are a mix of commercial, office, and mixed use properties, with assorted civic and visitor serving uses dispersed throughout. Major landmarks include the Humboldt County Courthouse and the Eureka City Hall, the Eureka Inn, the Studio of Dance Arts, the Arkley Center for the Performing Arts, the Eureka Theater, and the Morris Graves Museum of Art among others. The Lost Coast Brewery Café and the North Coast Co-op represent two of the more iconic retail establishments in the Downtown area, among a wide variety of other well-known establishments. Both are located on the north side of 4th Street, adjacent to the Eureka Old Town. Land uses at the far eastern and western ends of the corridor include less land intensive uses, such as auto parts stores, grocery stores, service stations, hotels and motels, and auto dealerships. As visitors traverse the Downtown area, the uses transition into higher intensity retail and office uses, with the core between C Street and I Street comprised of a mix of higher intensity retail and multi-story mixed use.

The downtown features a variety of building types and ages throughout the Highway 101 corridor. Overall the streetscape appears relatively attractive, with street trees, on-street parking, and wide sidewalks. Signage, however, is inconsistent, with some businesses standing out more than others, and a lack of clear wayfinding, with the exception of occasional kiosk style signage indicating the way to the Historic Old Town. Vacancy among retail spaces in the Downtown area is somewhat elevated, with a number of the higher rent spaces in larger mixed use buildings standing empty.

EUREKA OLD TOWN

The Eureka Old Town Historic District includes a 350 acre area that is listed with the National Register of Historic Places. The district extends between 1st and 3rd Streets and from C Street to N Street. It contains 154 historical buildings and one related structure. These range in age from the Greek revival structures built in the 1860s, to Italianate Victorian buildings dating to the turn of the century, and a false façade warehouse dating to the 1940s. These historical assets are mixed in amongst newly constructed buildings, such as those present on the waterfront. The district primarily features a mix of specialty retail shops, art galleries, antique shops, restaurants, and visitor serving uses, such as the Clarke Historical Museum, the Humboldt Bay Maritime Museum and historic Madaket Harbor Cruise, and the Old Town Carriage Company, among others. Also dispersed throughout the district are an assortment of non-profit and government uses, including the Redwood Coast Regional Center, the Redwood Coast Energy Authority, the California Department of Fish and Wildlife, and the Humboldt County Department of Health and Human Services, among others.

Traffic circulation in the district is facilities by the proximity to Highway 101, which draws significant traffic past the area. Kiosk style wayfinding signs are installed along the two one-way couplets that make up Highway 101, which direct travelers into the Old Town district. Parking is available on-street, with very limited options for off-street parking. Some areas in the Old Town district have posted time restrictions for on-street parking. Upon visual survey, the district offers multiple vacant units, reflecting the relative oversupply of small retail space within the Eureka market more generally. Also, given the historic nature of the Old Town district, many of the available spaces are non-conventional, in terms of floor plans and available utilities (e.g. with limited electrical and telecommunications access), making it more difficult to find tenants for these spaces.

BROADWAY CORRIDOR

The Broadway Corridor functions as the southern gateway into the City of Eureka. At its most southern end, Highway 101, also known as Broadway, crosses the Swain Slough just before entering the City limits past Herrick Avenue. Beyond commercial billboards and the most basic Caltrans wayfinding, there is little to no gateway signage notifying the visitor of their entrance into the City of Eureka.

Land uses along the southern portion of the Broadway corridor include mixed industrial and highway commercial, including a Big K Mart, the Lithia auto dealership, a Comfort Inn, a Pierson's Building Center, and the Sunset Memorial Park – Ocean View Cemetery. Located just off of Broadway, along Sunset Road, is the new North Coast Brewery. This pattern of scattered, standalone retail and light-industrial uses continue northward Truesdale Street, marking the southern boundary of the Bayshore Mall development. The overall characteristics and land use patterns along the Broadway corridor to the north of the Bayshore Mall are fairly similar to those found in the southern portion. The corridor includes mixed standalone retail, commercial, hotel and motel, and light industrial uses. This section of the corridor also includes a number of larger community and neighborhood type shopping centers, including the Victoria Place shopping center and the area surrounding Eureka Natural Foods.

Streetscape elements along the corridor include minimal sidewalk and landscaping improvements, with unmarked bike lanes in both directions. Street lights are provided on both sides of the street, though they are fairly widely spaced. Wayfinding in this portion of the corridor is virtually non-existent, with business signage that is inconsistent. The City has just recently contracted with a consultant to conduct a "Gateway Feasibility Study" for the south end of Broadway.

TARGET SHOPPING CENTER

The Target shopping center is located in the northeastern corner of the City, where Highway 101 crosses the Eureka Slough. One of Eureka's newest regional shopping facilities, Target, offers grocery items in addition to the traditional general merchandise offerings. Nearby land uses include the Eureka Slough to the east, the Multiple Assistance Center and a light industrial facility to the north, and a mix of residential and commercial uses to the west. No additional retail offerings are available within close proximity to the store. To the south, on the opposite side of Highway 101, are a service station, a Harley-Davidson motorcycle dealership, and an RV park.

The Target store is relatively inaccessible, compared to similar developments throughout Eureka (e.g. Eureka Mall, Costco, etc.). The primary access point is off Highway 101 and provides access to vehicles traveling in the south bound direction only. Vehicles traveling north bound on Highway 101 must first turn left on V Street, then must traveler though three blocks of neighborhood surface streets, prior to entering the parking lot. Otherwise, a northbound vehicle would need to go a considerable distance up Highway 101, before making a U-turn and entering the center from the south-bound direction.

COSTCO SHOPPING CENTER

The Costco shopping center is located on West Wabash Avenue, set back to the west of Highway 101, adjacent to the industrial area located along Railroad Street. Surrounding uses include a mix of commercial, light industrial and heavy industrial activity. The majority of the commercial and retail activity in the area takes place between Short Street at the eastern edge of the site and Highway 101 to the west. Nearby establishments include the newly constructed Holiday Inn Express and Suites, as well as the existing Motel 6, and a variety of retail establishments fronting on Highway 101. Nearby office, industrial and light industrial uses include SHN Consulting Engineers, Honest Engine Car Service, Sudden Link Communications, a FedEx Shipping Center, Bien Padre Foods, and a Renner Petroleum facility, among others. Access to the shopping center is provided along Short Street and Wabash Avenue. As is customary for Costco, the center provides ample parking in the front of the building, with Costco-branded gas pumps at the corner of the two primary access streets.

BURRE CENTER

The largest concentration of retail activity along Myrtle Avenue is located in the vicinity of the Burre Center, at the West Avenue intersection. The largest tenant in the center is the Burre Dental Center, which accompanies other assorted retail establishments. The center is somewhat older with a rather subdued street presence and signage that can be somewhat hard to read from a moving vehicle. A newer shopping center is located on the opposite side of West Avenue, which contains CVS Pharmacy, Dollar Tree, Starbucks, Radio Shack, and Subway, with additional ancillary retail. Signage at this center is of the traditional marquee style, and is much more visible from the street. There is limited landscaping, but a sufficient supply of off-street parking. Both centers feature access points from both West Avenue and Myrtle Avenue.

CUTTEN AND MYRTLETOWN

As adjacent unincorporated communities, the Myrtletown and Cutten neighborhoods are closely tied to Eureka in terms of identity and retail spending patterns. While the only notable retail node within the Cutten neighborhood is at the intersection of Campton Road and Walnut Drive, Myrtletown features a variety of retail offerings along both Myrtle Avenue and Harris Street. Myrtle Avenue extends to the southeast from Burre Center, toward the lowlands surrounding Freshwater Slough. The corridor includes a mix of residential, commercial, and light industrial uses throughout its length. Key commercial nodes include the older Myrtletown Shopping Center, two smaller strip centers located between Glenwood Street and Pennsylvania Avenue, and the area surrounding the intersection with Hubbard Lane, which features the Myrtle Avenue Pet Center and the Myrtle Avenue Market and Deli. The corridor offers little in terms of on-street parking, with most of the existing retail and office developments offering some off-street spaces. The majority of the establishments are located in either small strip centers, or converted residential units. Signage is relatively inconsistent throughout the corridor, with mixed visibility from the roadway. Streetscape elements include a center turn lane and bike lanes in both directions.

Cutten area retail along Harris Street is concentrated at the intersection with Harrison Avenue. The retail node consists of two neighborhood shopping centers. On the south side of Harris Street is the former Safeway supermarket space, which is currently vacant, along with some additional supportive retail, including a Renner service station. A newer Safeway store was constructed across from the old store, on the north side of Harris Street, adjacent to a Walgreens. The shopping centers are primarily surrounded by small medical office buildings, with residential neighborhoods beyond. Signage for the newly built Safeway is up to modern standards, as is the automotive and pedestrian access. While the signage has been removed from the older Safeway structure, newer signage and modest façade improvements could provide a sufficient update. Streetscape improvements include a center turn lane, bike lanes in both directions, and street lighting on the north side of the street.

DISPERSED NEIGHBORHOOD COMMERCIAL

Scattered throughout Eureka's residential neighborhoods are an assortment of small retail and commercial nodes, oriented toward everyday convenience shopping and services. These nodes provide valuable services to area residents and act as natural gathering places for social and civic interactions. One such node, located at the intersection of F Street and Randall Street stands as a prime example. Situated within a primarily residential neighborhood, the one block commercial node includes the Eureka Art and Frame Company, the neighborhood C&V market, the Brick and Fire Bistro, the Daugherty Violin Shop, and the 2 Doors Down wine bar. This mix of uses ensures both day-time and evening activity, as well as eyes on the street, which contribute to improved neighborhood safety and security. The uses also draw in Eureka residents and visitors from outside the area, helping to connect the neighborhood to the surrounding area. Streetscape improvements include basic sidewalks, with juvenile street trees, which add to the street appeal. Signage is modest, but effective, since the residential nature of the two way street forces vehicles to slow down as they pass. The location of the center within a residential neighborhood also supports pedestrian and bicycle access.

Projected Retail Real Estate Demand

Because the City of Eureka functions as a hub for retail sales activity, due in part to the presence of large regional stores such as Target and Costco, it captures a disproportionate share of countywide taxable sales. For example, in 2012, the City of Eureka captured an estimated 45.6 percent of countywide taxable sales, or an estimated $806.9 million. Similarly, countywide per capita retail sales are roughly on par with the statewide average, while per capita sales in the City of Eureka are nearly double the statewide average. An assessment of the retail sales tax data identified that the City features a clear competitive advantage in the more destination oriented retail categories, such as General Merchandise Stores, Clothing and Clothing Accessories, and Motor Vehicles and Parts Dealers. Additional analysis suggests that Humboldt County, as a whole, also receives a net injection of retail sales estimated at $801.5 million, with substantial injections in the categories of Food and Beverage stores, Building Materials stores, and General Merchandise stores.[1]

Based on its current share of countywide taxable sales, the maximum amount of additional retail sales that could be captured within the City of Eureka would equal an estimated $50.5 million.[2] Through a combination of retail leakage capture, as well as capturing a share of projected countywide retail demand due to population growth, the City could see demand sufficient to support between 200,000 to 290,000 square feet of additional retail space through 2040. Due to existing vacancy, a significant portion of this would be captured by existing retail spaces, perhaps in the Old Town and Downtown areas, or perhaps in one of the City's existing mall projects.

[1] Note that that the model used to generate these estimates may not fully compensate for underreported household income associated with the marijuana trade, and thus underestimates local retail purchasing power. For example, Jennifer Budwig estimates that illegal cultivation of marijuana results in the injection of $415 million (2010 dollars) into the Humboldt County economy on an annual basis.

[2] Note that these projections assume that the City is able to capture the maximum possible share of existing retail leakage, which would then be absorbed gradually through 2020.

Health Care, Government, and Professional Office Development

The City of Eureka functions as a hub for office-based industry on the North Coast, including government, healthcare, finance and real estate, and professional services. As the county seat of Humboldt County, the City functions as a dominant government center, hosting the County administrative office, the Superior Court, the County Office of Education, the Department of Health and Human Services, and the Sheriff's department. According to data provided by the Employment Development Department (EDD), six of the ten largest employers in the City of Eureka are government agencies. These include the City and five County agencies. The County agencies include the Office of Education, the Department of Health, the Sheriff's Department, the Social Services Department, and the Public Health Administration.

In addition to being a major government center for the County, the City of Eureka also functions as a central point of access for health care services on the North Coast. For example, the City is served by St. Joseph Hospital, which is the largest acute medical care facility located on the California coast, north of San Francisco Bay. The hospital system employs roughly 1,400 individuals between two campuses, making it one of the largest employers in Humboldt County. As such, the hospital has attracted a cluster of clinics and medical specialists, who provide services to residents of Humboldt County and beyond. For example, the Open Door Community Health Centers operate two clinics in the City of Eureka, including the Burre Dental Center and the Eureka Community Health and Wellness Center. In addition to being a regional medical hub Eureka also functions as a center for private financial and business activity in Humboldt County. For example, with the office of the Humboldt County Recorder located in Eureka, the City is a natural location for real estate and financial services firms like title companies. Umpqua Bank also has a strong presence, with 250 to 499 individuals based out of the bank's 5th Street branch.

Despite the City's strong competitive position in the health care, government, and professional office sector, existing demand for office space is relatively weak and vacancy rates relatively high. The most demand comes from users of smaller office space, with the strongest performing district being Downtown. Over the next fifteen to twenty years, local real estate brokers anticipate that there will be modest growth in office demand that will build slowly over time. According to brokers, opportunities for office development should be focused near other complementary office uses, as well as daytime dining and business services establishments. Medical offices will tend to gravitate towards the locations of other medical facilities, such as the hospital.

Lodging and Tourism Development

With its traditional "export" oriented industries in decline, tourism offers Eureka an opportunity to bring income into the local economy, by attracting visitors from outside the area who spend money on lodging, food, transportation, shopping, entertainment, and services. As of 2012, the industry generated an estimated $339 million in countywide visitor spending. Although there is little available data on visitor spending in Eureka specifically, the available data on transient occupancy tax (TOT) collections suggest that Eureka accounts for 40 percent of the countywide TOT collections, suggesting that it is a major player in the Humboldt County tourism industry.

The majority of Eureka's existing lodging is oriented around the primary automotive corridors of Broadway and Highway 101, with most hotel and motel properties located toward the edge of town. While this provides continence for automotive travelers, it fails to create significant synergy between the City's lodging options and its various amenities, like restaurants, arts and culture venues, and recreational opportunities. Economic Development Focus Group participants identified problems with transients, homeless, and persons suffering from mental illness and/or drug addiction problems congregating in visitor-serving and commercial areas, which act as a deterrent for visitors and can cause safety and security issues. The Focus Group also identified a need for general clean-up and beautification in areas meant to attract tourists, such as the Broadway Corridor and in the Eureka Old Town. Lastly, signage and wayfinding is generally lacking, except along the Downtown section of Highway 101. This absence of wayfinding at the City's gateways, including the Eureka Slough Bridge and near Herrick Avenue means that visitors unfamiliar with the area must rely on often limited knowledge of the area to guide themselves to their destination. By providing improved wayfinding, the City can guide visitors to its many attractions, possibly making them aware of amenities and assets of which they had not previously known.

4.3 ALTERNATIVES

This section of the Policy Paper outlines a variety of alternatives intended to address issues and opportunities identified in the previous section. The purpose of the analysis is to identify an assortment of policy options that are available to the City and to discuss their implications.

Industrial Land Policy Alternatives

Alternative 1: Maintain Existing Inventory of Coastal-Dependent Industrial Land

Retain existing inventory of CDI land to accommodate potential future expansion, or recovery, of existing CDI activities, including timber processing and fishing.

IMPLICATIONS AND DISCUSSION

As discussed in the prior section, the CDI activities prevalent in the North Coast region primarily include timber processing, fishing, and fish processing, as well as some maritime goods movement. Given the historic decline in timber production in the region and the wide spread closure of the region's lumber and pulp mills, and the realities of regulatory constraints and competitive factors, recovery of the industry to previous levels of activity is unlikely. The commercial fishing industry faces a similar dilemma, with total landings that are a fraction of their former volume, which has coincided with the loss of much of the area's fishing boats. The loss of some critical supportive infrastructure (e.g., cold storage) also contributed to the industry's contraction, which subsequently threatens the viability of other important infrastructure components. . These industry contractions mean that the industry requires less CDI land and building space than it did at the peak. Unless the state and federal governments dramatically liberalize the existing regulatory frameworks governing resource extraction in both industries, the timber and fishing sectors are unlikely to require substantial additional land and buildings beyond what they already utilize, with the possibility of limited expansions in certain sub-sectors due to unique circumstances which cannot be foreseen. The maintenance of the existing inventory of CDI land would therefore most likely result in the continued underutilization of land within certain parts of the Coastal Zone.

Alternative 2: Retain Coastal-Dependent Industrial Land Based on Projected Need

Evaluate demand for CDI uses and their relative land requirements, taking into account the relative suitability of different sites. Retain sufficient land to accommodate anticipated demand for CDI and redesignate the remainder to accommodate alternative uses. This alternative would aggressively trim the City's current inventory of CDI land and redesignate CDI land for other non-coastal-dependent uses.

IMPLICATIONS AND DISCUSSION

Under this alternative, the City would evaluate the projected demand for CDI land and pursue the redesignation of land in excess of that amount. This approach would need to allow for the establishment of certain CDI activities in the areas deemed most appropriate for those activities. For example, fishing-related activities and infrastructure traditionally associated with Eureka's waterfront, such as docks and associated on-shore facilities for fishing boats, are part of the charm of the Eureka waterfront and constitute part of its attractiveness as a tourism destination. On the other hand, certain heavy industrial activities, such as bulk cargo storage and handling, may be more appropriate on the Samoa peninsula, due to perceived incompatibility with many residential, commercial, and visitor-serving uses. As a result, the City would need to identify exactly how much land would be required to accommodate CDI uses within the City, versus elsewhere in Humboldt County. The challenge would then be to demonstrate to the California Coastal Commission (CCC) that the future land needs for CDI and other coastal-dependent uses could be adequately met with the remaining inventory. This approach could potentially maximize the amount of land redesignated for non-CDI uses, like manufacturing and commercial activities. This alternative, as well as Alternative 3, may require close coordination between the City of Eureka, Humboldt County, and other stakeholders, such as the HBHRCD and CCC, among others.

Alternative 3: Redesignate Land to Accommodate Non-Coastal-Dependent Uses

Evaluate demand for non-CDI uses, taking into account the relative suitability of different sites for different types of development. Redesignate an amount of existing CDI land, but only an amount that is sufficient to address projected non-CDI uses, and retain a significant amount of CDI land as a buffer to accommodate unforeseen growth in demand for CDI land. As compared to Alternative 2, this alternative would much less aggressively trim the inventory of CDI land, but would create new opportunities to accommodate non-CDI land uses.

IMPLICATIONS AND DISCUSSION

Under this alternative, the City would evaluate the projected demand for non-CDI land and pursue redesignation of a sufficient amount of land to accommodate that demand, leaving the remainder to accommodate potential long-term demand for coastal-dependent uses. Available projection data, discussed in greater detail in the Eureka General Plan Update Community Background Report, suggest that long-term demand for CDI uses may be reasonably accommodated by the large supply of existing CDI land located throughout the greater Humboldt Bay Area and that the reasonably foreseeable demand for non-CDI uses is relatively limited. In all likelihood, redesignating an inventory of land sufficient to accommodate anticipated demand for non-CDI industrial uses would preserve an inventory of CDI land well in excess of projected long-term demand for CDI uses. This approach would allow for the establishment of certain CDI activities in the areas deemed most appropriate for those activities, as described under Alternative 2. Use of this approach would make it easier to demonstrate to the CCC that the land needs of CDI uses will be adequately met on appropriate sites that are available in Eureka and elsewhere in the region. If successful, this would still allow the redesignation of CDI sites within the City of Eureka that may be identified as excess for non-CDI uses. This alternative, as well as Alternative 2, may require close coordination between the City of Eureka, Humboldt County, and other stakeholders, such as the HBHRCD and the CCC, among others.

Alternative 4: Interim or Temporary Uses on Coastal-Dependent Industrial Land

Short of redesignating CDI land for other uses, the City may also consider seeking CCC approval to allow "interim" or "temporary" uses on CDI land.

IMPLICATIONS AND DISCUSSION

The City may also pursue the possibility of establishing certain "interim" or "temporary" uses. These would include land uses that do not permanently preclude the reuse of sites for CDI activities. For example, the City recently entertained a proposal to establish an RV park on a parcel located in the Coastal Zone, adjacent to Dock B. Such an activity could help to generate value, abate blight, and utilize an existing underutilized site, while leaving open the prospect of developing the site with a higher and better use, without extensive demolition or remediation costs. Challenges associated with this approach include the need to identify uses that do not require substantial capital improvements, as well as the need to enter into binding agreements with potential users with regard to the term of use for the site. For example, the establishment of an RV park requires some up front expenditures, and the user would need to have certain assurances that they would be able to use the site for a term sufficient to recoup those costs. This challenge of identifying appropriate uses and coming to agreement on the terms of use may limit the number of parties interested in pursuing interim or temporary uses. Such uses may also require CCC approval.

Alternative 5: Identify Opportunity Sites for Industrial Activity Outside Coastal Zone

Because nearly all of the City's industrial land is located within the Coastal Zone, it limits the opportunity sites available for the establishment of non-CDI uses. This alternative would require the City to evaluate alternative sites for by-right industrial development that are located outside of the Coastal Zone.

IMPLICATIONS AND DISCUSSION

There is very little land located inside the city limits, but outside of the Coastal Zone, that is suitable for industrial development. This is due primarily to topography, to which the largest expanses of relatively flat, vacant land are located near the City's waterfront. There are also issues associated with land use compatibility that would need to be resolved, due to the prevalence of residential uses throughout the City in areas outside the Coastal Zone. In addition, the ability to extend urban level infrastructure and services to support such uses could be challenging. This alternative could, perhaps, be coupled with the annexation of additional land that is currently located outside the City, although much of the adjacent areas face similar constraints due to topography, existing land uses and infrastructure. If coupled with one of the prior alternatives, the City may be able to identify a smaller number of sites that can be used as part of a portfolio of industrial opportunity sites, which would include industrial land both inside and outside of the Coastal Zone.

Alternative 6: Ensure Accessibility to Industrial Sites by Heavy Trucks

This alternative includes the coordination of land use and transportation infrastructure to ensure that industrial sites, both inside and outside of the Coastal Zone, are accessible by heavy trucks via area roadways.

IMPLICATIONS AND DISCUSSION

In order to retain the viability of existing industrial sites, both coastal-dependent and non-coastal-dependent, the City would coordinate transportation investments and requirements to facilitate continued access for heavy trucks, such as delivery vehicles. For example, due to the location of the City's existing industrial area to the west of Highway 101, deliveries going to and from this area must turn off of Highway 101 onto side streets. If this ability was significantly impeded in any way, it could threaten the long-term viability of industrial or even light industrial activities on these sites. In order to ensure the usability of areas designated for industrial development, the City would proactively pursue infrastructure and roadway improvements that improve the access to industrial opportunity sites by heavy trucks. Note that this will likely require close coordination with Caltrans, particularly with regard to the Broadway/Highway 101 corridor.

Commercial Fishing Policy Alternatives

Alternative 7: Maintain Infrastructure and Support Services for the Fishing Fleet

Under this alternative, the City would adopt policies prioritizing the maintenance of infrastructure and the retention of support services for the commercial fishing industry. This could include the maintenance of existing dock facilities and the Fisherman's Terminal, among other facilities. It may also include the retention of zoning and land use designations allowing the establishment of critical support services, such as fish processing and packing, equipment storage, transportation (e.g. loading and unloading, vehicle turn around space, etc.) facilities, docking and refueling facilities, and boat repair facilities.

IMPLICATIONS AND DISCUSSION

As an historic industry, the Humboldt Bay fishing fleet provides important economic benefits, ranging from fresh caught local seafood, to an authentic North Coast cultural experience that is part of the City's identity as a tourist destination. If the City of Eureka desires to retain the fishing fleet in the face of rising costs, static pricing, and decreasing catch volumes, the City will need to help ensure that the fleet has ready access to the infrastructure and support services necessary for efficient and cost effective operation. With the loss of the cold storage facility in 2008, the City and the fleet lost a crucial piece of infrastructure that allowed the industry to more efficiently handle their goods on the way to market. As a result, the fleet has suffered economically. To ensure the fleet's long-term presence on the Eureka waterfront, along with the economic benefits and employment opportunities it provides, the City would need to make a clear priority of ensuring the maintenance and enhancement of existing facilities, and the retention of important support service providers.

Alternative 8: Encourage Priority Use of Docking Facilities by the Fishing Fleet

To support retention of the remaining commercial fishing fleet, adopt policies expressing support for the priority use of existing and planned docking facilities by the fishing fleet.

IMPLICATIONS AND DISCUSSION

Similar to Alternative 7, this alternative would include the creation of policies that encourage the priority use of docking facilities by the fishing fleet. Although the Woodley Island facilities are operated by the HBHRCD, they are located within the City and are subject to the LCP. The waterfront dock facilities and the Boat Basin are operated by the City. This kind of policy would help to ensure that the fishing fleet has sufficient access to docking facilities, and is not marginalized by other types of commercial and recreational boats that are willing to pay higher rates to rent docking facilities. At the worst, such a policy could result in a reduction in revenues collected from slip rentals. More likely, however, is that the City and other dock operators would simply experience slower growth in slip rental revenues, compared to what would occur in the absence of such a policy.

Alternative 9: Support the Establishment of a Cold Storage Facility

Identify sites suitable for the construction of a cold storage facility. Work with the Fisherman's Marketing Association, the HBHRCD, and other important stakeholders to identify potential funding sources for construction and operation of the facility.

IMPLICATIONS AND DISCUSSION

The establishment of a cold storage facility to replace the one that was closed in 2008 would improve the economics of the fishing fleet, therefore aiding in retention of the industry, by allowing the industry to store its catch more efficiently. This is accomplished by allowing the temporary storage of fresh fish, which allows distributors to accumulate a sufficient amount of product so that they can ship full container loads at one time. Without cold storage, the distributor would need to ship partial loads more frequently, in order to maintain freshness. The facility would need to be sited in an area with sufficient access to the Fisherman's Terminal and other fishing infrastructure. It would also need to be sited in an area that would not overly conflict with other nearby land uses, as well as in an area that can provide access by large trucks. Some financial assistance may be necessary in order to ensure that such a facility is sited and constructed in a timely manner.

Transportation Policy Alternatives

Alternative 10: Support the Development of Alternative Transportation Options

Support the development of alternative transportation options, such as east-west rail connectivity, highway improvements, and/or Marine Highway, which may help to mitigate the risks associated with decreased port activity and the high costs of dredging.

IMPLICATIONS AND DISCUSSION

The purpose of this alternative is to mitigate the potential risks associated with decreased port activity, which could eventually result in the silting up of the port. If there is insufficient activity at the port to finance ongoing dredging of the shipping channel and assorted port facilities, it may limit the ability for certain types of ships to enter and exit the harbor. This could, as a result, impact the ability to ship certain types of goods, such as petroleum, into the region via the port. While some of this goods movement could be shifted to trucks traveling on the inter-regional roadways, such as Highway 101, this may pose certain safety risks and will place additional strain on the roadways.

Under this alternative, the City would evaluate other options for goods movement, including the establishment of an East-West rail connection. Additional research is required to determine the feasibility of an East-West rail connection. There is also the question of route, which has not yet been determined. If a route is selected that passes through the City of Eureka, it could have significant impacts on land use, transportation, and quality of life. If the selected route passes farther to the north, and down the Samoa Peninsula, the railroad would have fewer impacts on the City, but might also generate fewer benefits in terms of the co-location of businesses that rely heavily on rail transportation. In addition to east-west rail, the City may also consider reestablishment of the historic north-south rail line, as well as highway improvements, or a Marine Highway option. Highway improvements could represent an important near-term component of the City's longer-term transportation strategy, which could help the mitigate risk associated with the potential loss of harbor activities. The Marine Highway option would represent a longer-term option that would involve working with the U.S. Department of Transportation Maritime Administration to enroll the City in the Marine Highway Program to expand the use of our nation's navigable waterways in order to relieve landside congestion, reduce air emissions, and generate other public benefits by increasing the efficiency of the surface transportation system. Participation in such a program could generate much needed activity at the port

Alternative 11: Reestablishing Eastbound Connectivity on West Henderson Street

Under this alternative, the City would re-establish two-way travel on West Henderson Street in the vicinity of the Eureka Mall.

IMPLICATIONS AND DISCUSSION

By establishing one-way only travel on West Henderson Street in the vicinity of the Eureka Mall, the City has significantly reduced the amount of vehicle travel passing by the northern side of the Eureka Mall complex, therefore reducing visibility for the establishments located there. In order to generate a smoother flow of traffic in and around the mall, the City could re-establish two-way travel in the vicinity, perhaps only from Spring Street to Highway 101. This would allow automobiles to travel from Highway 101 to the mall, via West Henderson Street, without the need to traverse south to West Harris Street, or north to West Creighton Street, therefore reducing the number of vehicles driving through these residential areas. Re-establishing two-way travel would, however, disrupt the one-way traffic flow on West Henderson Street.

Commercial Development and Revitalization Policy Alternatives

Alternative 12: Focus Regional and Specialty Retail and Key Nodes

To ensure a critical mass of retail activities necessary to maintain a vibrant industry, the City should seek to concentrate both regional and specialty retail activities within key nodes throughout the City.

IMPLICATIONS AND DISCUSSION

Under this alternative, the City would seek to focus new regional and specialty retail development at key nodes throughout the City. For example, regional retail might reasonably be concentrated in and around the Bayshore Mall, which would leverage and strengthen that existing concentration. Specialty retail could, similarly, be concentrated at Henderson Center or in the Eureka Old Town (see Alternative 15). The opposite of this would be to locate large regional retailers, such as big box stores, in relatively isolated locations that are not near any existing concentrations of retail activity. Such a strategy encourages shoppers to make trips to individual stores, meaning that the City loses out on the synergy created by co-locating retail establishments, which can result in longer trips and more traffic impacts. The challenge with regard to encouraging this type of retail concentration is the availability of land in a City that faces significant constraints with regard to available sites.

Alternative 13: Encourage Destination and Complementary Retail Near Costco and/or Target

Under this alternative the City would seek to redesignate land adjacent to the existing Costco and/or Target stores for the purpose of establishing complementary uses, such as additional destination retail.

IMPLICATIONS AND DISCUSSION

Costco and Target are both major regional shopping destinations for the North Coast, which attract high volumes of shoppers every day. These stores each have the capability to serve as anchor tenants that can attract other smaller, complementary businesses which benefit from exposure to the drive-by traffic created by the large anchor stores. In the case of the Eureka Costco and Target stores, they exist as stand-alone retail facilities and there are limited other retail shopping offerings in close proximity. Given appropriate zoning, it is likely that a number of parcels surrounding these anchor tenants would be redeveloped with additional complementary retail uses, resulting in new investment and new economic activity. However, the City of Eureka is likely aware of the fact that there is a finite pool of retail demand, and to the extent that new retail development is captured near the Costco or Target, this is retail demand that would not be available to support backfill of vacant retail spaces (e.g., Bayshore Mall) or development of new retail buildings in other important commercial areas within the City. The City may wish to identify a limited number of tenant types that would be best suited to co-locate next to the Costco or Target and identify those as conditionally permitted uses near those sites.

Alternative 14: Encourage the Retention of Dispersed Neighborhood Commercial

Establish policies that encourage the retention of neighborhood commercial buildings located throughout the community, with a focus on those that directly serve the residents in the surrounding area.

IMPLICATIONS AND DISCUSSION

Eureka contains a number of small retail nodes that are located within primarily residential neighborhoods. In many cases, these individual or small groups of retail buildings provide important services to area residents, including convenient access to grocery items. Due to the vibrancy that these uses provide within these areas, this alternative would include the establishment of policies intended to retain these small retail nodes and ensure that they continue to serve the needs of area residents. Such a policy should be geared toward the retention of existing nodes, rather than the establishment of new retail centers, with provisions for the redevelopment and improvement of existing neighborhood commercial centers. As with Henderson Center, the City should consider emphasizing pedestrian and bicycle access to these nodes, to limit the impact of auto traffic on adjacent residential areas.

Alternative 15: Position Henderson Center as a Unique Neighborhood Shopping District

Given the existing nature of Henderson Center, this alternative would include actions intended to help reinforce the center as a unique neighborhood shopping district that serves as a centerpiece for the surrounding residential neighborhoods.

IMPLICATIONS AND DISCUSSION

Due to its compact grid layout, existing mix of uses, and excellent connectivity to surrounding neighborhoods, the Henderson Center area is well-positioned to help provide a strong identity for the part of the City that immediately surrounds it. Policies for this area should emphasize maintaining and enhancing the existing pedestrian-friendly characteristics of the commercial area. Street lighting, street furniture, and policies that encourage outdoor merchandise displays and outdoor seating for food service establishments should be emphasized. Roadway and traffic calming improvements that encourage residents of surrounding neighborhoods to walk or bicycle to the commercial area should be provided. Signage for individual businesses should primarily be designed with pedestrians and bicyclists in mind (i.e., at ground level), while auto-oriented signage (i.e., large signs) should be more limited, and should promote the Henderson Center destination as a whole, rather than individual businesses. The development of the area should remain consistent with the relatively small scale lots and street-oriented buildings that predominate, rather than development of large parcels with extensive parking fields separating the buildings from the streets. All of these elements could also position the Henderson Center as a specialty retail and dining district; however, that would tend to detract from the potential of Old Town to serve that function. Given its proximity to other visitor attractions, including the waterfront, existing visitor-oriented retail and restaurants, and more immediate access via Highway 101, the City should continue to promote Old Town as a specialty retail and dining district.

Alternative 16: Encourage Reuse of Existing Smaller Retail Spaces Over New Development

Provide incentives to encourage the re-tenanting of existing small retail spaces in lieu of new construction.

IMPLICATIONS AND DISCUSSION

This may include offering various incentives, such as financial assistance that could be used to adapt historic structures to more modern uses, waiver or reduction of permit fees, marketing assistance, and/or provision of technical assistance to prospective tenants. This type of a policy would help to discourage the construction of new small scale retail spaces at a time when local real estate conditions suggest that the market is oversupplied in this category. While policies should not exclude or prohibit the construction of new retail space, it should encourage the reuse of existing properties, particularly those located in the Old Town and Downtown areas.

Alternative 17: Gateway Improvements and Wayfinding on Broadway and Hwy. 101

Establish gateway signage and improved wayfinding on Broadway and the Highway 101 corridor to better direct visitors to Eureka's key destinations and attractions, such as Old Town, Downtown, the waterfront, Bayshore Mall, Woodley Island, etc.

IMPLICATIONS AND DISCUSSION

The intent of this alternative is to establish clear gateways for the City of Eureka that welcome visitors and provides clear direction on where to they can find Eureka's various points of interest, including shopping, recreation, historic sites, and civic offices. At present, the wayfinding along the Broadway corridor does not clearly signal the presence of points of interest, let alone indicate how to reach them. A well-designed wayfinding strategy can not only make travelers aware of the presence of various points of interest, it can easily and clearly point them in the right direction, in addition to guiding them toward parking and other amenities, while helping to reinforce Eureka's "brand" or unique identity through design elements. With a lack of clear signage, the travelers are left to rely on their own knowledge alone. The establishment of clear and appealing gateways can also be an important component of the wayfinding strategy that signals to visitors that Eureka is a welcoming place that prides itself on its history and culture. The challenges associated with wayfinding and gateway improvements include building community consensus on design and funding, as well as identifying which destinations are called out on signage.

Alternative 18: Streetscape Enhancements and Design Standards Along Broadway

In order to create a more unified and appealing commercial environment, this alternative would include the establishment of design standards for retail establishments located along the Broadway corridor, which would also be coupled with strategic streetscape improvements intended to improve visual appeal.

IMPLICATIONS AND DISCUSSION

In the interest of developing a more cohesive southern gateway, and to improve the visual appeal of the retail environment along the Broadway corridor, this alternative would include the establishment of design standards for retail and commercial establishments in the corridor. These may include façade designs, parking requirements, and signage standards, among other items. This should also be coupled with streetscape improvements, such as a City entry feature, sidewalk repairs, landscaping, lighting, and signage. These improvements, coupled with design standards for new development, could help to build a more cohesive shopping experience. While the imposition of design standards may increase the costs associated with establishing a business along the corridor and could discourage some businesses from locating there, the creation of a more cohesive and appealing retail environment may provide benefits to retail businesses, therefore offsetting any initial expense incurred by the businesses.

Alternative 19: Encourage Cleanup and Beatification in Visitor Serving Areas

This alternative would include the establishment of policies and programs intended to encourage cleanup and beautification in the City's visitor serving areas.

IMPLICATIONS AND DISCUSSION

The intent of this alternative is to develop a program that assists in the removal of blight conditions from the City's existing and planned visitor-serving areas, to encourage continued visitation by area residents and visitors alike. Activities associated with this alternative could include trash removal, upgraded landscaping, graffiti abatement, abatement of illegal campsites, and discouraging unauthorized access/use of open spaces, among many other options. The specifics of these activities that would be required are likely to vary significantly place-by-place. Challenges associated with implementation of this alternative include building community consensus on program priorities and funding, as well as coordination with homeless service providers and County Health and Human Services.

Alternative 20: Create a Business Friendly Environment

Under this alternative the City would strive to create a business friendly reputation through the development of streamlined permitting processes and efficient services.

IMPLICATIONS AND DISCUSSION

The intent of this alternative is to help Eureka build a business friendly reputation. The first step in this process should be to develop an inventory of business needs, both in terms of the items, forms, and permits that businesses will be required to prepare, prior to initiating the planning process, as well as in terms of the things that businesses are looking for in order to locate in, or remain in, the City of Eureka. The former may include a list of required forms and permits, as well as other requirements that the business owner will have to comply with. The latter may include a list of business needs, such as low cost utilities, reasonably priced rental space, a clear and efficient regulatory structure, access to transportation, etc. Another option could be to include a business incubator program that would provide resources, both intellectual and material, to help businesses establish themselves in Eureka. This could include new businesses, as well as businesses that are attempting to set up a new location within the City. Implementation of this alternative will require close coordination between the City and the business community, as well as flexibility and understanding on both their parts. A business incubator program may also require the identification of potential funding sources.

Office Land Use Policy Options

Alternative 21: Accommodate Potential Growth in Health Care Sector

Because the Health Care sector is one of the few industries projected to experience growth through 2040, this alternative would include actions intended to better accommodate expansion in the medical office sector.

IMPLICATIONS AND DISCUSSION

Although the general office sector has experienced considerable fluctuation in demand over the past decade, it has remained relatively stable and, with the expansion of the St. Joseph Hospital complex and the Open Door Clinic facilities, has grown considerably. Although medical office uses may be accommodated in some of the City's existing office space, the majority is likely to cluster near the established and planned medical facilities, such as near the intersection of Harris Street and Harrison Avenue or Myrtle Avenue and Toddy Street. In order to ensure that the City can capture this growth, it should establish zoning and site requirements appropriate for medical office uses, in the areas where the greatest growth is anticipated. This will help to limit negative interaction between medical office uses and surrounding uses, which are typically residential. It will also ensure that the City can attract and retain the critical mass of medical office activity to ensure the long-term health of the industry. This approach may result in the some existing residential areas transitioning to medical office uses; however, the negative impacts of that transition are likely to be relatively small.

Alternative 22: Promote the Flexible Use of Downtown Office Space

Establish use regulations that allow greater flexibility in the use of Downtown office space.

IMPLICATIONS AND DISCUSSION

This alternative seeks to change the City zoning code to allow more flexible use of Downtown office space. For example, the City has already permitted the use of some spaces in live-work arrangements, to some success. Expanding these provisions to allow a greater array of uses, including residential, boutique hotel, artist lofts, etc., could help to absorb some of the existing vacancy through adaptive reuse, particularly among the older professional office buildings. In addition, bringing other daytime and nighttime users into the Downtown area will help to create more demand for existing retail and services businesses and enliven the Downtown area, particularly outside of traditional office business hours.

Alternative 23: Encourage Establishment of Office Space Near Amenities

In the event that new office space is developed within the City of Eureka, this alternative would direct it towards areas with complementary office uses, as well as daytime dining and business services establishments

IMPLICATIONS AND DISCUSSION

In order to maximize the market viability of new professional and medical office space, it should be directed toward areas that provide complementary office uses, as well as daytime dining and business services. This would help to create a critical mass of professional office activities that can provide efficiencies for office users, as well as their clients. It will also help to ensure a sufficient suite of amenities for office tenants, who prefer to locate near other complementary uses, such as day-time restaurants and copy shops, among others. This type of clustering of offices with other synergistic uses create an identifiable location that will have a stronger presence in the competitive marketplace than an equal quantity of office floor area that is scattered across a number of separate locations.

Tourism and Accommodations Policy Options

Alternative 24: Work Proactively on Homelessness and Drug Abuse Issues

In order to work proactively to improve the quality of life for residents of the City of Eureka, and to create a safe and inviting experience for visitors, the City should work proactively with stakeholders to address issues associated with homelessness, drug abuse, and vagrancy throughout the City and the surrounding area.

IMPLICATIONS AND DISCUSSION

Conversations among the General Plan Economic Development Focus Group and the City's Economic Development Strategic Plan Ad Hoc Committee identified issues of homelessness, drug abuse, and visual blight as the number one priority under the topics of improving the local quality of life, with critical implications for business retention, expansion, and attraction, and tourism development. The manifestation of these issues on sidewalks, parks, and other public spaces and near businesses and residential areas is a deterrent to visitors in particular. While the consultant team, the Economic Development Focus Group, and the Economic Development Strategic Plan Ad Hoc Committee appreciate the need for adequate and effective services to address these important social issues, it is also recognized that these issues present a barrier to development of the tourism sector, and prevent the community from capitalizing on the full benefits of Eureka's unique history, culture, and charm. In recognition of the complex nature of these issues, implementation of this alternative will require a concerted long-term effort involving close coordination between the City, social service providers, area businesses, and the community at large.

Alternative 25: Concentrate Hotel Development in Proximity to Attractions

Under this alternative, the City would enact policies to direct the development of lodging establishments into areas that are in close proximity to visitor attractions, including the waterfront and other points of interest, dining, and shopping.

IMPLICATIONS AND DISCUSSION

Existing hotel and motel development in Eureka is primarily concentrated along the auto corridors of Broadway and Highway 101. Focusing future hotel and motel development in the central part of the City, near the waterfront, in proximity to a variety of visitor serving destinations and attractions as well as a wide range of dining and shopping options would encourage synergy between these complementary uses and encourage overnight visitors to explore, and spend money, within the City's commercial core. Given the limited supply of opportunity sites within the Downtown and Old Town areas, the City may work to identify one or two key sites that would be opportune for a range of hotel types, which may include larger destination hotel projects as well as smaller boutique hotels.

Alternative 26: Pursue the Establishment of a Cruise Ship Terminal

Under this alternative, the City would investigate the viability of establishing Dock B, or an alternative site, as the location for a commercial cruise ship terminal.

IMPLICATIONS AND DISCUSSION

Although past efforts to establish a cruise ship terminal in Eureka were unsuccessful, there is some evidence to suggest that the City might be able to draw in a number of smaller cruise ships each year, especially if the City had facilities available to accommodate those vessels. In the near term, the City could pursue plans to utilize an alternative facility, such as the Schneider Dock, as a temporary terminal. In the longer term, development of a permanent cruise ship terminal, at Dock B for example, could be coupled with complementary development, possibly of the kind previously proposed for the Balloon Track site. However, there is, as of yet, no guarantee that the City would attract a stream of vessels sufficient to offset the cost of developing a permanent terminal. Therefore, at this time, the prospect remains relatively speculative. However, in the event that a market opportunity can be substantiated through further analysis, and tracking of visitation to the temporary terminal, the City could potentially demonstrate that the economic impacts of the increased visitation would justify City participation in the project. Such a project could provide a valuable asset that would bolster the City's reputation as a tourist destination and a hub for tourism on the North Coast.

4.3 RECOMMENDATIONS

This third and final section of the Economic Development Policy Paper discusses preliminary recommendations that would support the goal of maximizing economic returns and community benefits, based on an analysis of the City's competitive position within Humboldt County and the greater North Coast region. The discussion is broken down by general topic area, including policy alternatives for Industrial Land, Commercial Fishing, Transportation, Commercial Development and Revitalization, Office Land Use, and Tourism and Accommodations. The policy recommendations discussed here generally correspond with those developed in coordination with the General Plan Update Economic Development Focus Group and the City's Economic Development Strategic Plan Ad Hoc Committee. Note that these recommendations are preliminary based on the research conducted thus far and will require additional community input for refinement and validation.

Industrial Land Policy Recommendations

In order to ensure that there is a sufficient amount of land made available to accommodate potential growth in the industrial sector, the consultant team recommends taking a mixed approach that combines elements of Alternatives 3, 4, and 5.

Policies associated with the provision of industrial land within the City of Eureka are an important topic for the General Plan Update due to the limited availability of industrial land outside of the Coastal Zone. Under this recommendation, the City would evaluate its need for non-CDI land to accommodate realistic projections of growth in non-CDI sectors, and coordinate with other important stakeholders within the Humboldt Bay region to ensure that adequate land will remain to accommodate current and future CDI needs. In particular, the City may need to pursue close coordination with Humboldt County and the HBHRCD in order to make a credible case for redesignation of excess CDI land to the CCC. This approach would balance the City's desire to provide more non-CDI development opportunities with the CCC's priority to preserve CDI land to address long-term needs. The recommended approach is to seek only to convert an amount of CDI land that is sufficient to accommodate reasonably foreseeable demand for non-CDI uses, with the idea that if this approach proves to be too conservative in the future, the City will always have the option to seek redesignation of additional CDI land. From the CCC's perspective, this approach would be much less risky to the overall well-being of CDI activities than an approach that would attempt to convert all CDI land that is currently viewed as "excess".

In conjunction with this approach to CDI land redesignation, the City can also begin the process of identifying a limited number of sites outside the Coastal Zone that could potentially accommodate industrial development by right. These sites would represent an important component of the City's industrial land portfolio and could provide an important strategic fallback position in the event that efforts to redesignate land within the Coastal Zone are unsuccessful. In the short term, the City could also pursue CCC approval for interim or temporary uses on CDI land within the Coastal Zone to begin extracting value from existing vacant and underutilized sites. These uses should not preclude the establishment of permanent uses and could be pursued even while the City pursues redesignation of CDI land.

Commercial Fishing Policy Recommendations

In order to better ensure the long-term viability of the Humboldt Bay commercial fishing fleet, the consultant team recommends the pursuit of Alternatives 7 through 9, to secure berthing facilities for the fleet and ensure the provision of support facilities and services that are necessary to maintain the viability of commercial fishing operations.

The actions described under Alternative 7 would be the minimum required to retain the fishing fleet as it currently exists. This would include the ongoing maintenance of existing facilities that provide critical services to the fishing fleet, such as docking and refueling facilities, the ice plant, equipment storage, etc. Without access to these basic amenities and services, the fishing fleet will not be able to continue commercial operations, and the City will lose an important cultural and economic asset. Similarly, Alternative 8 would help to ensure that the fishing fleet is able to retain access to docking facilities necessary to continue their commercial operations. As regulations and smaller catch volumes place economic strain on the industry, fishermen are less able to absorb increased prices for dock space. As a result, private and recreational vessels that are able to pay higher prices for docking privileges are able to out-price the fishing vessels and threaten their ability to secure necessary dock space. By affirming the fishing fleet's priority position with regard to dock leasing, the City can help to ensure the continuance of commercial fishing activities. Alternative 9 would help to enhance the existing commercial fishing infrastructure and replace the old cold storage facility that closed in 2008. The establishment of a new cold storage facility would aid in retention of the industry, by allowing the fisherman to store and transport their catch more efficiently. This is accomplished by allowing the temporary storage of fresh fish, which allows distributors to accumulate a sufficient amount of product so that they can ship full, rather than partial, loads.

Transportation Policy Recommendations

The consultant team recommends the pursuit of Alternative 10, which would support the establishment of alternative transportation modes, while maintaining and improving existing transportation options. The team supports Alternative 11, since the re-establishment of two-way connectivity on West Henderson Street would improve access to the Eureka Mall. However, this alternative must be evaluated within the context of the City's broader transportation network.

The two alternatives proposed with regard to transportation address two very different issues. Alternative 10 addresses Eureka's relative isolation, and the threat posed by reduced cargo traffic through the Port of Humboldt Bay. The alternative proposed the investigation of alternative transportation options, such as highway improvements, east-west rail, and/or participation in the Marine Highway system, among others. At this point, it is not clear which alternative transportation options would be viable and cost effective. Also, most of these options would require considerable coordination with other jurisdictions and agencies, including the state and federal governments. However, it will be important for the City to understand its options, since the City currently relies on highway and marine transportation only. With reduced traffic through the Port of Humboldt Bay, some question the ability of the Harbor District to sustain dredging activities, which could threaten the viability of the port as a transportation mode. Therefore, the consultant team recommends the adoption of policies that would support the establishment of alternative transportation modes, while also maintaining and improving the viability of existing transportation options.

Alternative 11 would involve the re-establishment of eastbound connectivity on West Henderson Street, near the Eureka Mall. This would allow better visibility for the retail establishments located on the north side of the mall, and would provide improved connectivity with Highway 101 that would limit the need to route eastbound traffic through residential neighborhoods. However, the pursuit of this alternative would require coordination with other transportation policy options discussed in the Transportation Policy Paper and may, or may not, conflict with those recommendations. As a result, the consultant team neither recommends, nor discourages, adoption of Alternative 11 pending further analysis and input, with the understanding that adoption could improve opportunities for retail activity on the north side of the Eureka Mall.

Commercial Development and Revitalization Policy Recommendations

The consultant team recommends the pursuit of Alternative 12, and Alternatives 14 through 20. Each of these alternative policy options could be adopted independently, but would benefit most from coordinated implementation. Alternative 13 warrants greater consideration, as it could be implemented to varying degrees, which would have varying impacts on existing retail concentrations.

The policy alternatives presented in support of commercial development and retail corridor revitalization can generally be divided into two complementary groups. The first focuses on the physical clustering of retail development, and positioning of retail development to appeal to different segments of the market. As an overarching policy, Alternative 12 would have the City use its regulatory powers to focus retail activity at a number of key nodes, helping to ensure the necessary concentration of retail activity that can promote retail vibrancy. These could include the Bayshore Mall, the Eureka Mall, Henderson Center, Downtown, and the Eureka Old Town, although, the City may elect to include additional retail nodes, such as is proposed under Alternative 13. While there is a certain logic associated with the concentration of destination and other complementary retail establishments near major regional anchor stores, such as Costco and Target, this would involve the expansion of two retail nodes, which could detract from efforts to revitalize other existing retail nodes, like Bayshore and Old Town. As a result, the consultant team recommends that the City pursue this approach only when there is evidence of sufficient growth in retail demand to support full utilization of existing retail centers, plus sufficient excess demand to support new development at these two new retail nodes.

Separately, per Alternative 14 the City would use its regulatory powers to try and support the retention of dispersed neighborhood commercial. Since this type of retail node is focused on serving the needs of neighborhood residents, it does not conflict to any great extent with the other alternatives intended to revitalize areas like Downtown and Old Town. As a result, the alternative offers significantly greater benefits than it does costs. Through Alternative 15 the City would work to position the Henderson Center shopping district as a neighborhood commercial area, similar to how it functions currently. While the district could potentially be positioned as a specialty shopping district, that function is better served in the Old Town. Positioning Henderson Center as a neighborhood commercial node would tie together the dispersed neighborhood commercial options and provide a more centralized location for the provision of neighborhood services uses that do not reasonably fit within the dispersed centers. This could include uses such as banks and drug stores that require a larger service area. Lastly, Alternative 16 encourages the City to incentivize the reuse of existing smaller retail spaces, rather than encouraging new development. This alternative is in response to the relatively high vacancy rates that exist throughout the City among smaller retail spaces. This may include offering various incentives, such as financial assistance that could be used to adapt historic structures to more modern uses, waiver or reduction of permit fees, marketing assistance, and/or provision of technical assistance to prospective tenants. While policies should not exclude or prohibit the construction of new retail space, this policy alternative would encourage the reuse of existing properties.

The second grouping of commercial revitalization policy alternatives focuses on gateway improvements, signage and wayfinding, beautification, and cleanup of the City's existing commercial corridors. The consultant team recommends the adoption of Alternatives 17 through 20, with the understanding that these are relatively inexpensive methods by which to improve upon the City's existing assets. Alternative 17, in particular, would help to establish gateways that would inform visitors that they have entered the City of Eureka, as well as wayfinding improvements that will inform visitors and direct them to area attractions. Complementing the gateway and wayfinding improvements, the implementation of Alternative 18 would improve the overall visual appeal and cohesiveness of the Broadway corridor, which currently offers a relatively fragmented and chaotic retail character. Alternative 19 would apply to all of the City's existing commercial and visitor-serving areas and would involve activities intended simply to make the City more appealing to visitors and to improve the relative sense of safety and security. Alternative 20 is primarily focused on attracting and retaining commercial and retail businesses. It would help the City position itself to provide a clear list of items necessary for businesses to establish themselves within the City. It would also involve the City working with businesses to remove barriers to business establishment and retention.

Office Land Use Policy Recommendations

The consultant team recommends the pursuit of Alternatives 21 through 23.

Alternative 21 is intended to help ensure that the City can accommodate growth in the Health Care sector. With the recent expansion of the St. Joseph Hospital complex, the City is positioned to experience growth in the medical office sector, which will primarily be concentrated in proximity to existing nodes of medical office activity. However, in order to ensure that the City is able to capture this growth, without losing out to other nearby communities, it should ensure that there is a clear and efficient process for the establishment of medical office facilities in proximity to other health care uses, like the hospital. Alternative 22 is geared toward the adaptive reuse of existing office space in the Downtown. This would involve changes to the City zoning code that would allow a greater array of uses, including residential, boutique hotel, artist lofts, etc. While such uses may reduce the total supply of land available to accommodate office uses, further diversification of downtown land uses will help to create an environment that will be more attractive to office tenants for existing under-utilized buildings and parcels. Alternative 23 addresses the siting of future office developments, encouraging the concentration of such uses in areas that have access to important daytime amenities, such as restaurants and copy shops, among others. This is intended to ensure that new office developments are able to successfully market their properties, as both functional and appealing locations for commercial office uses.

Tourism and Accommodations Policy Recommendations

The consultant team recommends the pursuit of Alternatives 24 and 25. At this time, the consultant team neither recommends nor discourages the City from Alternative 26.

The implementation of Alternative 24 will be crucial to Eureka's success as a tourism destination. During conversations with the General Plan Economic Development Focus Group and the City's Economic Development Strategic Plan Ad Hoc Committee, multiple individuals commented that issues of homelessness, drug abuse, and visual blight function as deterrents to visitors who perceive potential issues associated with safety and security for themselves and their property. Resolution of these issues will require a concerted long-term effort, along with close coordination between the City, social service providers, area businesses, and the community at large. Alternative 25 focuses on the siting of future hotel and motel developments. Existing lodging in the City of Eureka is primarily concentrated along the automotive corridors, which corresponds with historic market demand; however, contemporary lodging trends suggest that new hotel and motel developments should be concentrated closer to attractions and amenities, providing a unified and appealing walkable experience. As a result, the consultant team recommends that the City seek to accommodate future hotel and motel development in proximity to the Downtown and Eureka Old Town districts.

Alternative 26 proposes the establishment of a cruise ship terminal within the City of Eureka, possibly at the existing Dock B site. At this time, the consultant team neither recommends nor discourages the City from pursuing this alternative. While the cruise ship industry might offer the City a much needed source of employment and revenue, it is not clear whether the economic impact estimates previously presented could, in fact, be realized. With an estimated up-front investment of at least $5 million for full development of the Dock B site, the City would need to attract a substantial stream of cruise ship visitation that is not guaranteed. Once the cruise ship terminal is built, it may take a number of years to build up a schedule of vessels sufficient to begin offsetting the initial investment. Therefore, the City would need to closely evaluate its ability to absorb any portion of such costs that would not be covered by private investment or possible grant funding. Similarly, once established, the cruise ship terminal would require significant resources for promotion and advertising, in order to build relationships with cruise lines, independent cruise vessels, and the cruise industry more broadly. However, in the event that a terminal was successfully constructed, in conjunction with nearby complementary uses, and the City receives visitation sufficient to offset the cost of development, it could provide a valuable asset that would bolster the City's reputation as a tourist destination and a hub for tourism on the North Coast. It would also provide increased traffic to the Port of Humboldt Bay, which could help to offset the costs of port maintenance, making the cruise industry an important strategic asset to the City and the region. In the interim, the City could pursue the use of an alternative facility, like the Schneider Dock, as a temporary terminal. This would allow the City to begin marketing and recruitment efforts, to begin building the more robust cruise ship visitation schedule that would ultimately be necessary to support development of a more permanent facility.

4.4 REFERENCES

Articles and Reports

Benjamin Fordham. (2014). Harbor leaders want to attract cruise ships. *Mad River Union*.

Caroline Pomeroy, C. J. (2010). *California's North Coast Fishing Communities, Historical Perspective and Recent Trends, Eureka Fishing Community Profile*. La Jolla, CA: California Sea Grant College Program.

Dean Runyon Associates. (2014). *California Travel Impacts by County, 1992-2012*. Sacramento: California Tourism and Travel Commission.

City of Eureka General Plan Update, Draft Community Background Report, October 2014.

Greenson, T. (2011, December 4). Humboldt's $400 million question: bankers thesis quantifies impact of pot on local economy. *The Times Standard*.

Jessica Cejnar. (2012). Eureka welcomes The World; luxury ship arrives at Fairhaven. *The Times-Standard*.

Lorna Rodriguez. (2013). Cruise ship cancels North Coast stop. *The Times-Standard*.

Lorna Rodriguez. (2013). Eureka City Council hears presentation about Humboldt's possible cruise ship industry. *The Times-Standard*.

PB Ports & Marine. (2003). *Harbor District Revitalization Plan*. Eureka, CA: Humboldt Bay Harbor Recreation and Conservation District.

Other Data Sources

California Department of Fish and Game, commercial fish landings, 2000-2012
California Department of Forestry, *State Forest Notes, No. 74*. 1979.
California Employment Development Department, Labor Market Information, 2014
California State Board of Equalization, Taxable Sales, 2014
California State Board of Equalization, Timber Yield Tax data, 2014
Claritas, Inc., retail gap analysis, 2014
Pacific Maritime Association, assessable cargo reports, 2014

APN	zoning	situsaddre	owner_name	acres	zip	Shape_Area	tideland_acres	percent_tideland
405051008	WC		EUREKA CITY OF	508.87	95501	22166485.26	508.87	100.00%
405051007	WC		EUREKA CITY OF	237.40	95501	10341186.87	237.40	100.00%
501241033				17.06	95501	2657.738475	0.06	0.36%
501241020				83.61	95501	3597448	82.59	98.78%
405071003	WC		EUREKA CITY OF	180.66	95501	7869422.714	180.66	100.00%
501241018				8.30	95501	359788.7206	8.26	99.52%
501241030				3.61	95501	114577.2381	2.63	72.86%
501241021	WC		CALIFORNIA STATE OF	10.24	95501	445840.568	10.24	100.00%
501241019	WC		CALIFORNIA STATE OF	8.42	95501	364636.8547	8.37	99.44%
501241004	WC		MANGUS SUZANNE S & ALLEN GLENN L III & SMIT	77.92	95501	3392864.028	77.89	99.96%
501241005				5.31	95501	196885.0411	4.52	85.07%
405031009			HUMBOLDT BAY HARBOR REC & CONS DIST	39.50	95501	1280906.908	29.41	74.44%
402271001	AC		CALIFORNIA STATE OF	170.36	95501	241801.5051	5.55	3.26%
405021010	NR		STANILAND MARK	0.85	95501	546.5984007	0.01	1.48%
501251011			GABRYCH EUGENE & MARION	133.87	95501	5831435.739	133.87	100.00%
405021008	NR		SMITH DAVID L	0.98	95501	263.066474	0.01	0.62%
405021007	NR		MITCHELL JOHN W	1.91	95501	9631.509668	0.22	11.55%
405021006	NR		UNITED STATES OF AMERICA	0.61	95501	3933.798515	0.09	14.81%
405021005	NR		UNITED STATES OF AMERICA	0.59	95501	4327.277844	0.10	16.72%
405021004	NR		DUCEY DENNIS L	0.63	95501	4388.622345	0.10	16.06%
405021003	NR		UNITED STATES OF AMERICA	0.95	95501	5355.689618	0.12	12.98%
405021002	NR		SMITH CARMEN T	0.85	95501	4126.063118	0.09	11.18%
002231011	WC		EUREKA CITY OF	1.17	95501	38599.63525	0.89	75.49%
002231012	WC		EUREKA CITY OF	10.29	95501	264284.6591	6.07	58.98%
405021013	NR		RETZLOFF JACK L	1.12	95501	6410.241234	0.15	13.11%
405021012	NR		JOHNSON CHRIS T & KAY	1.44	95501	8175.780697	0.19	13.01%
002231009	CW		SNGC LLC	7.22	95501	214.0047789	0.00	0.07%
002231010	WC		EUREKA CITY OF	0.83	95501	23833.85797	0.55	66.02%
002241006	WC		EUREKA CITY OF	3.68	95501	87060.46804	2.00	54.37%
014011001				5.06	95501	136267.7298	3.13	61.81%
014011002				7.25	95501	125146.161	2.87	39.60%
014021001				1.69	95501	41673.35464	0.96	56.72%
014041001				6.43	95501	119194.5836	2.74	42.56%
002231008	CW		SNGC LLC	2.62	95501	1040.278333	0.02	0.91%
002231004	NR		DINSMORE ROSE M	3.27	95501	5868.658555	0.13	4.12%
002231002	P		NORTHWESTERN PACIFIC RAILROAD CO SB	4.56	95501	8837.369955	0.20	4.45%

APN	zoning	situsaddre	owner_name	acres	zip	Shape_Area	tideland_ acres	percent_ti deland
014051001				9.46	95501	146125.7632	3.35	35.47%
014031001				8.50	95501	152465.0631	3.50	41.16%
014121001				10.22	95501	85112.00768	1.95	19.12%
014061003				7.27	95501	134453.7554	3.09	42.48%
017102006	AC		CALIFORNIA STATE OF HWY	22.86	95501	201646.9605	4.63	20.25%
002231020	CS	2433 2ND ST	BOTTLING GROUP LLC	1.38	95501	5.9785415	0.00	0.01%
001162010	WD		EUREKA CITY OF	0.61	95501	26443.26354	0.61	100.00%
001161016			EUREKA CITY OF	0.56	95501	24536.12865	0.56	100.00%
002201008	CS	2525 4TH ST	TARGET CORPORATION	12.35	95501	11091.85344	0.25	2.06%
001121022	CW		NORTHWESTERN PACIFIC RAILROAD CO	3.07	95501	34189.99925	0.78	25.57%
001121029	CW		CITY OF EUREKA	0.40	95501	11196.37735	0.26	64.77%
001121004	CW		EUREKA CITY OF	0.06	95501	2282.766653	0.05	89.93%
001054037	CW		EUREKA CITY OF	0.18	95501	5723.01919	0.13	72.92%
001161017			EUREKA CITY OF	0.94	95501	1333.982496	0.03	3.24%
014031004				2.04	95501	50154.99545	1.15	56.31%
014041002				0.66	95501	8328.790079	0.19	28.93%
014071005				1.79	95501	5163.507897	0.12	6.61%
001054044	CW		EUREKA CITY OF	0.22	95501	6574.523954	0.15	68.44%
001162009	CW		HUNTER GILBERT A	0.61	95501	5953.700198	0.14	22.46%
001054035	CW		PEONY PIER LLC	0.19	95501	737.960043	0.02	8.71%
001054045	CW	1 E ST	EUREKA REDEVELOPMENT AGENCY	1.34	95501	359.1165714	0.01	0.61%
014051003				1.84	95501	26405.9427	0.61	33.03%
001011013	CW		EUREKA CITY OF	0.31	95501	7701.463568	0.18	56.78%
001012006	CW	34 W WATERFRONT DR	DAVENPORT HARRY E & JOYCE A	0.55	95501	902.654038	0.02	3.78%
002182004	RS-600(	1238 BAY ST	JANKE FRED & BETTY	0.96	95501	1054.403896	0.02	2.52%
017102011	AC		HUMBOLDT COUNTY OF	105.11	95501	254732.4592	5.85	5.56%
001161015			EUREKA CITY OF	3.11	95501	53290.7175	1.22	39.38%
014031002				0.89	95501	11295.95316	0.26	29.07%
014101001				9.58	95501	31119.27434	0.71	7.45%
014121002				1.30	95501	6367.054193	0.15	11.23%
014111001				1.10	95501	4853.864163	0.11	10.09%
001011015	CW		EUREKA CITY OF	0.09	95501	988.6825674	0.02	26.36%
001012005	CW		EUREKA CITY OF	0.21	95501	9258.543434	0.21	99.21%
001012009	CW	12 W WATERFRONT DR	FAR WESTERN PROPERTIES LLC	1.43	95501	94.38233184	0.00	0.15%
001012002	CW		EUREKA CITY OF	1.45	95501	15714.02257	0.36	24.84%
014111002				1.22	95501	4557.165926	0.10	8.58%

APN	zoning	situsaddre	owner_name	acres	zip	Shape_Area	tideland_acres	percent_tideland
003021007	MC		EUREKA CITY OF	1.54	95501	1606.896388	0.04	2.40%
001011008	CW		EUREKA CITY OF	0.35	95501	15225.75309	0.35	99.53%
001011026	CW	4 C ST	EUREKA REDEVELOPMENT AGENCY	1.96	95501	37.58239192	0.00	0.04%
001012008	CW		EUREKA CITY OF	0.57	95501	22280.21748	0.51	89.93%
001011009	CW	25 WATERFRONT DR	COAST OSTREA COMPANY	1.17	95501	7790.689148	0.18	15.27%
014061002				1.61	95501	8141.84893	0.19	11.63%
003011001	MC		EUREKA CITY OF	10.54	95501	393070.8491	9.02	85.60%
017102003				5.22	95501	17829.01786	0.41	7.84%
002182003	RS-600(	1226 BAY ST	PRICE BENJAMIN M	1.00	95501	1301.566592	0.03	2.99%
002182008	NR	1275 SEARLES ST	LL DOT INC	3.47	95501	16714.8892	0.38	11.05%
003062026	CW	1 MARINA WAY	EUREKA CITY OF	26.26	95501	900382.6567	20.67	78.71%
003062028	MC	990 WATERFRONT DR	SCHNEIDER DAVID L	10.61	95501	1966.796473	0.05	0.43%
002162004	RS-600(	1000 BAY ST	LINDQUIST GARTH D	0.37	95501	35.09952565	0.00	0.22%
002152005	NR	1032 BAY ST	FOURSQUARE GOSPEL CHURCH	4.77	95501	8814.040849	0.20	4.24%
003062021	MC		EUREKA REDEVELOPMENT AGENCY	5.05	95501	124.2120794	0.00	0.06%
002152002	RS-600(	1138 BAY ST	MAJOR BERNICE M	1.04	95501	250.6736259	0.01	0.56%
002182009	RS-600(		DIXIE ED M JR & GARRETT JANICE M	0.36	95501	113.1098825	0.00	0.73%
002182002	RS-600(	1214 BAY ST	MILLSAP ARNOLD L & DONNA M	0.50	95501	125.8055936	0.00	0.58%
002182005	RS-600(	1254 BAY ST	CONDON WILLIAM & ANN E S	0.48	95501	1.614802245	0.00	0.01%
003082015	MC		EUREKA FOREST PRODUCTS INC	3.89	95501	163156.6846	3.75	96.35%
003082016	MC		PRESTON PROPERTIES	15.64	95501	245071.6642	5.63	35.96%
002182006	RS-600(	1264 BAY ST	WADE GERALDINE P	0.86	95501	258.0657596	0.01	0.69%
006171020		1355 MYRTLE AVE	PRIOR ROBERT D EX	3.25	95501	3532.583696	0.08	2.49%
002182007	NR	1314 BAY ST	TOMLINSON GELLIA L	0.89	95501	1555.218432	0.04	4.00%
006231014	NR		WILKINS DAVID R & MARILYN J	0.87	95501	2261.815126	0.05	5.96%
003062024	MC	1090 W WATERFRONT D	SCHNEIDER DAVID L	5.73	95501	666.3318242	0.02	0.27%
006171011	NR		EUREKA CITY OF	0.14	95501	86.7002819	0.00	1.41%
003072005	MC		EUREKA CITY OF	2.93	95501	121131.0986	2.78	94.78%
003082001	MC		EUREKA CITY OF	5.29	95501	154914.0831	3.56	67.23%
003082002	MC		EUREKA FOREST PRODUCTS INC	14.23	95501	19703.72839	0.45	3.18%
007031004	MC		EUREKA CITY OF	20.31	95501	642759.9943	14.76	72.65%
014161013			CALIFORNIA OREGON BROADCASTING INVESTME	4.29	95501	2995.032576	0.07	1.60%
007051006	MC		EUREKA CITY OF	14.70	95501	572364.9041	13.14	89.41%
001054048	CW			0.60	95501	2584.987111	0.06	9.81%
007061005	MC		EUREKA CITY OF	9.34	95501	307511.0231	7.06	75.58%
007061006	MC		EUREKA CITY OF	5.17	95501	66801.50231	1.53	29.66%

APN	zoning	situsaddre	owner_name	acres	zip	Shape_Area	tideland_ acres	percent_ti deland
007071014	MC		EUREKA CITY OF	12.65	95501	77743.80523	1.78	14.10%
007071013	MC		EUREKA CITY OF	5.68	95501	247300.1661	5.68	100.00%
007081014			EUREKA CITY OF	0.13	95501	5481.554609	0.13	100.00%
007081015	MC		EUREKA CITY OF	0.24	95501	9186.224138	0.21	89.64%
007091001	MC			1.05	95501	45630.77822	1.05	100.00%
405061004	WC		EUREKA CITY OF	71.44	95501	3065980.868	70.39	98.53%
002162001			CA OR BROADCASTING INVESTMENTS	2.53	95501	17677.27561	0.41	16.01%
002161001			CA OR BROADCASTING INVESTMENTS	1.88	95501	7188.392005	0.17	8.79%
002231021			EUREKA CITY OF	0.05	95501	279.9191298	0.01	13.45%
007081003	MC		MILLER RICHARD K	0.13	95501	4457.246244	0.10	78.14%
019321014	WD		EUREKA CITY OF	5.37	95501	109812.3316	2.52	46.95%
007091005	MC		EUREKA CITY OF	0.10	95501	722.366024	0.02	16.22%
007071008	MC		CHEVRON USA INC	4.70	95501	56017.57554	1.29	27.36%
405011010	NR		EUREKA CITY OF	45.18	95501	402736.8698	9.25	20.46%
007081002	MC	3420 CHRISTIE ST	MILLER RICHARD K	0.09	95501	2539.847397	0.06	64.77%
017102008				1.30	95501	13112.70981	0.30	23.14%
302181040			EUREKA CITY OF	37.85	95501	1001.29048	0.02	0.06%
305181005			EUREKA CITY OF	61.51	95501	118524.6957	2.72	4.42%
405011007			EUREKA CITY OF	33.41	95501	1277366.554	29.32	87.77%
405011005			EUREKA CITY OF	0.89	95501	15194.40869	0.35	39.32%
405011006			EUREKA CITY OF	2.28	95501	67781.91993	1.56	68.26%
405031007	NR		HUMBOLDT BAY HARBOR REC & CONS DIST	11.60	95501	69761.1072	1.60	13.80%
007081004	MC		GIEREK SHERYLE L N	0.08	95501	3470.55342	0.08	96.27%
007081001	MC		CALIFORNIA STATE OF	1.27	95501	55247.69616	1.27	100.00%
019321005	MC	2400 HILFIKER LN	EUREKA CITY OF	6.21	95501	52089.09943	1.20	19.26%
007081013	MC		EUREKA CITY OF	0.26	95501	11481.06897	0.26	100.00%
007081016	MC	1925 TRUESDALE ST	EUREKA CITY OF	1.21	95501	8261.364891	0.19	15.72%
002162003	NR	990 BAY ST	ASHE DANIEL G & ELISA C	0.32	95501	1.374480079	0.00	0.01%
007091006	MC		EUREKA CITY OF	0.10	95501	148.632251	0.00	3.35%
002252028				4.95	95501	151.1029168	0.00	0.07%
007091011	MC		EUREKA CITY OF	1.94	95501	52590.70642	1.21	62.22%
019321012	MC		EUREKA CITY OF	6.63	95501	52000.161	1.19	17.99%
405011004			EUREKA CITY OF	10.75	95501	340892.0588	7.83	72.78%
405011011	NR		EUREKA CITY OF	209.98	95501	1589090.721	36.48	17.37%
405011003			EUREKA CITY OF	1.02	95501	1343.404543	0.03	3.02%
405011008			EUREKA CITY OF	1.30	95501	56716.2001	1.30	100.00%

APN	zoning	situsaddre	owner_name	acres	zip	Shape_Area	tideland_acres	percent_tideland
405021011			EUREKA CITY OF	0.76	95501	30875.7642	0.71	93.82%
405032008			EUREKA CITY OF	32.30	95501	1171782.439	26.90	83.27%
405032007	NR		EUREKA CITY OF	18.54	95501	318479.7269	7.31	39.44%
405032006			EUREKA CITY OF	6.16	95501	268426.0396	6.16	100.00%
405041006			EUREKA CITY OF	103.90	95501	4525096.615	103.88	99.98%
501251009			CALIFORNIA STATE OF	6.41	95501	279043.0675	6.41	100.00%
501241026				23.57	95501	1007113.215	23.12	98.11%
501251003			MANGUS SUZANNE S & ALLEN GLENN L III & SMIT	44.91	95501	1956291.041	44.91	100.00%
501251013			GABRYCH EUGENE	194.07	95501	8453641.003	194.07	100.00%
019321009	MC		EUREKA CITY OF	1.59	95501	31197.91072	0.72	45.08%
019321006	NR		SHWAIKA WILLIAM T & NANCY L	1.21	95501	23486.65719	0.54	44.45%
019331008	WD		EUREKA CITY OF	13.54	95501	245056.8698	5.63	41.55%
302171001	WD		EUREKA CITY OF	46.36	95501	491624.8029	11.29	24.35%
302181002			EUREKA CITY OF	18.16	95501	580.6024329	0.01	0.07%
302181039			HOFF JAMES N & CLAIRE G	1.26	95501	23083.4884	0.53	41.97%
017102004			JOHNSON RANCHES INC	1.95	95501	21718.26054	0.50	25.58%
007091002	MC		EUREKA CITY OF	1.44	95501	35066.24697	0.81	56.01%
405061006	WC		EUREKA CITY OF	346.31	95501	15019184.94	344.79	99.56%
405041007	WC		EUREKA CITY OF	282.73	95501	12310980.56	282.62	99.96%
002252029				13.55	95501	92059.80175	2.11	15.60%
405011002			TABLE BLUFF RESERVATION-WIYOT TRIBE	1.46	95501	19322.1032	0.44	30.35%
017081001				60.49	95501	37719.34666	0.87	1.43%
404141004				15.22	95501	2160.164294	0.05	0.33%
404141003				6.34	95501	19986.57403	0.46	7.24%
014021002				18.62	95501	380724.61	8.74	46.94%
405031010	NR			40.90	95501	211883.295	4.86	11.89%
404141005				0.58	95501	5204.487831	0.12	20.52%
404141002				3.77	95501	129602.22	2.98	78.93%
007091003			EUREKA CITY OF	1.75	95501	36875.58948	0.85	48.46%
019331001	NR		EUREKA CITY OF	0.80	95501	32499.11074	0.75	93.66%
019331009	NR		EUREKA CITY OF	2.21	95501	1959.721181	0.04	2.04%