Can Agricultural Lands and Uses on Humboldt Bay Adapt to Sea Level Rise?

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Humboldt Bay Sea Level Rise Hydrodynamic Modeling and Inundation Vulnerability Mapping: Northern Hydrology and Engineering

Note: This report was prepared by Trinity Associates and does not necessarily reflect the views of the agencies and organizations that participated in the Humboldt Bay Sea Level Rise Adaptation Planning Group.

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"In order to adapt to future change in sea level rise, coastal [agricultural landowners and] *wildlife area managers need to understand vulnerability and risk, because adaptation to sea level rise is a risk management strategy against an uncertain future." (Sullivan 2013)*

This paper analyzes the climate change impact from sea level rise to agricultural land use around Humboldt Bay, California. This paper covers: (1) anticipated effects from sea level rise; (2) where sea level rise will likely occur; (3) when sea level rise is expected to happen; (4) what would be placed at risk; (5) how sensitive and important are prioritized assets at risk; and (6) development of strategies and recommendations for adaptation to anticipated (modeled) sea level rise impacts.

BACKGROUND

Sea level rise is one impact of climate change that will affect low-lying coastal areas around Humboldt Bay, including its agricultural lands. For the purpose of assessing vulnerability of coastal agricultural lands to sea level rise, it is important to segregate these lands based on their origin: (1) diked former tidelands and (2) alluvial bottom lands (Figure 1). Alluvial bottom lands are generally higher in elevation than the current tidal regime. From 1880 to 1910, approximately 8,000 acres of salt marsh and tidal channel habitat (tidelands) on Humboldt Bay were diked off and drained for agricultural use (Figure 2, Laird and Powell 2013). These former salt marsh plains dissected with a maze of tidal channels provided a complex of habitats for multiple species.

Sea level rise will also affect other low-lying coastal areas around Humboldt Bay, such as freshwater wetlands, which are significant for wildlife species that use both tidal and adjacent freshwater wetlands. Major changes in species distribution and species richness are expected to result from tidal inundation under projected sea level rise scenarios and loss of existing remnant freshwater systems (marshes). Humboldt Bay agricultural dikes protect much more than livestock grazing. They also protect seasonal freshwater wetlands and wildlife habitat from being converted to mudflats, to the detriment of sensitive wildlife species.

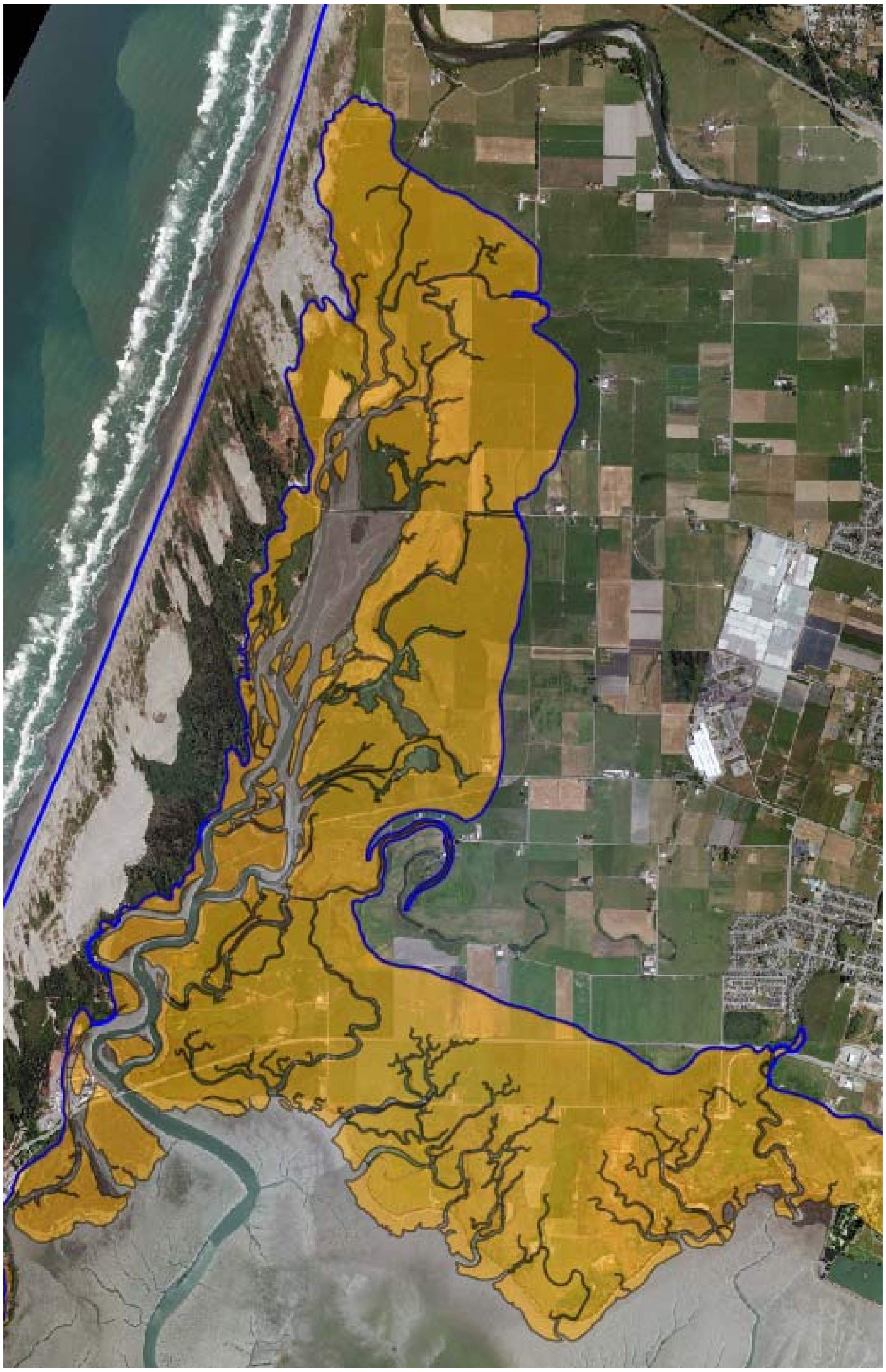


Figure 1. There are two types of agricultural lands on Humboldt Bay: (1) former tidelands (yellow shading) and (2) alluvial bottom lands (outside of blue tidal boundary of 1870).

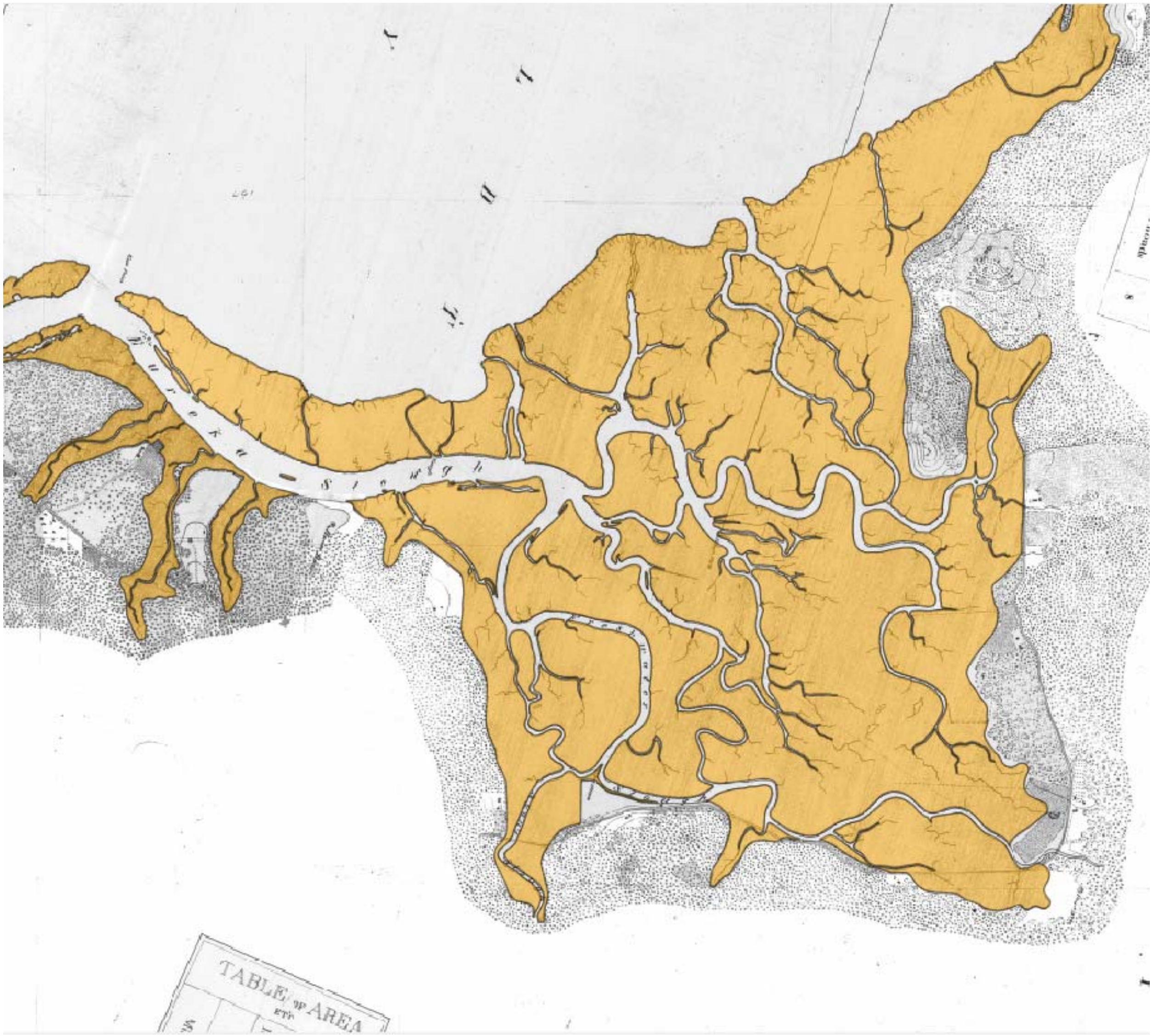


Figure 2. Historical inter-tidal wetlands on Eureka Slough, 1870 U.S. Coast Survey.

In general, former tidelands have compacted by as much as three feet over time as organic material in salt marsh soils oxidized, and because sediment accretion from tides has been blocked by dikes and tide gates. In addition, vertical land movement associated with local tectonic activity is causing land in the Humboldt Bay region to subside (Cascadia Geosciences 2013). Combining subsidence on Humboldt Bay with sea level rise over the last 100 years, tidal elevations have increased approximately 1.5 feet – the most of any area on the West Coast (Russell and Griggs 2012). Humboldt Bay's agricultural lands are primarily protected from salt water inundation during daily high tides by earthen dikes. If these dikes were breached, tidal inundation would cover a substantial area around Humboldt Bay (Figure 3). With time, vulnerability of these agricultural lands is likely to increase; for example with just another 1.5 feet (0.5 meter) of sea level rise, it is projected that today's 100 year tidal event will become tomorrow's new annual king tide (Figure 4, NHE 2013).

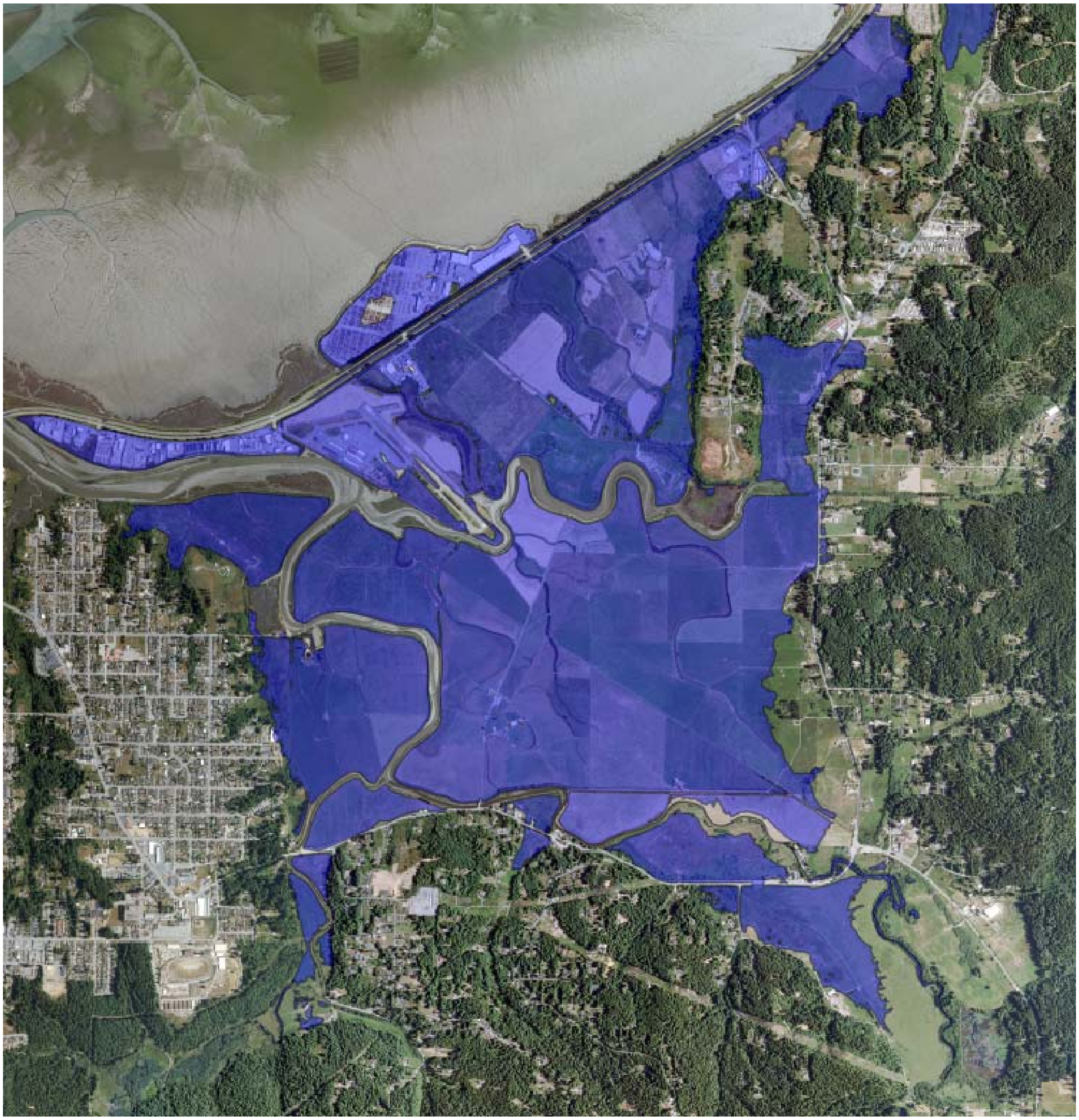


Figure 3. Potential tidal inundation area (blue) by current mean monthly maximum water (MMMW) elevation on Eureka Slough, if existing diked shoreline were not in place (NHE 2014c).

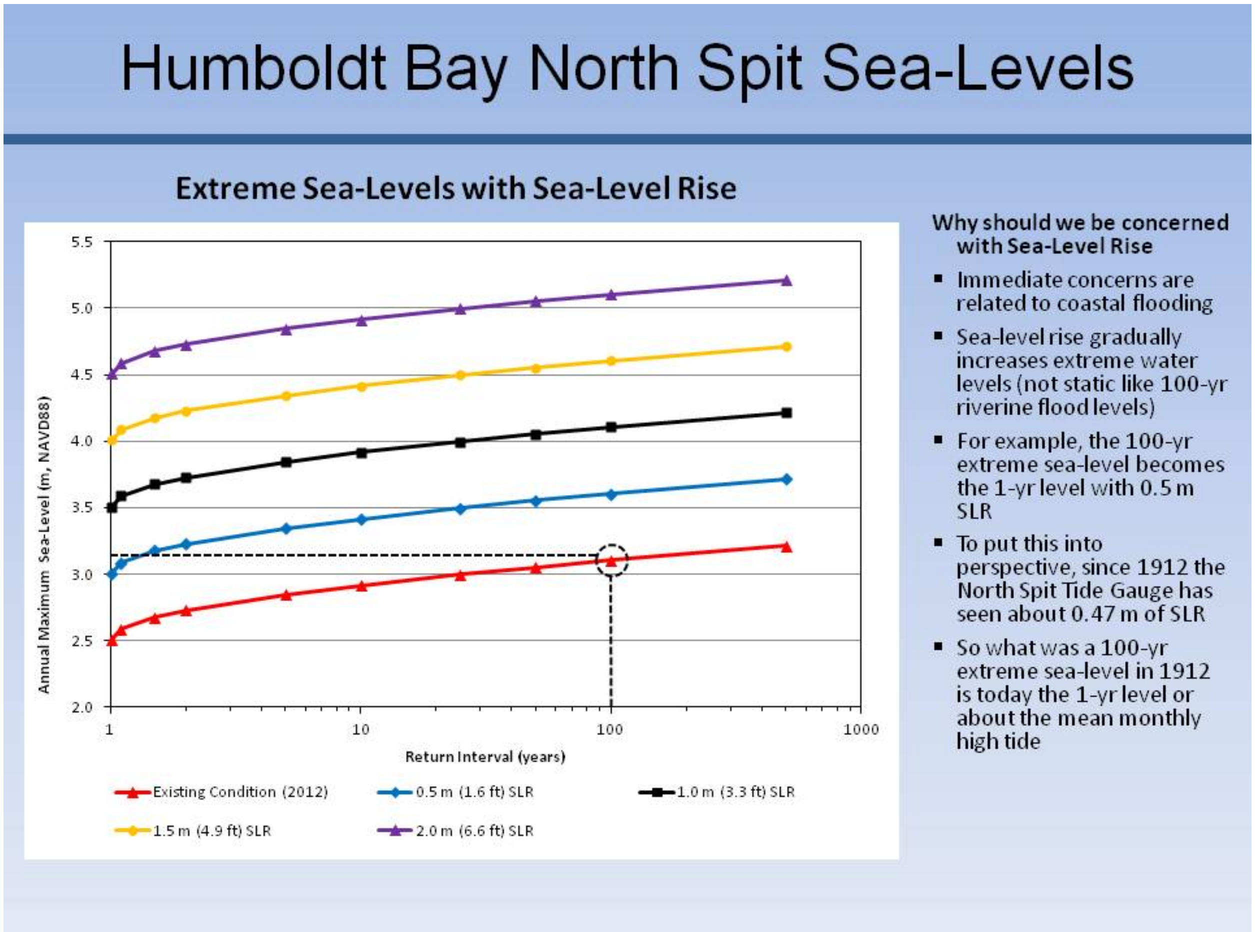


Figure 4. With just 0.5 meters (1.6 feet) of sea level rise, the 100-year event today will become the annual king tide event (NHE 2013).

1. Relative Sea Level Rise Projections and Impacts

California's Ocean Protection Council and Coastal Commission sea level rise guidance documents recommend incorporating sea level rise projections for 2030, 2050, and 2100 into planning and decision making for projects in California (CO-CAT 2013, CCC 2013).

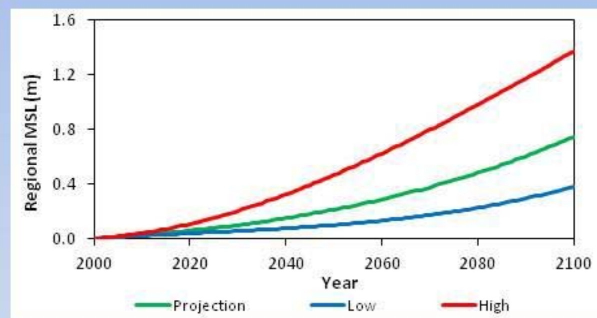
Based on Humboldt Bay's North Spit tide gage, relative sea level rise (i.e., the combination of regional sea level rise rates and local vertical land motion rates) is estimated to be approximately 0.6 feet (7 inches) by 2030, 1.1 feet (13 inches) by 2050, and 3.2 feet (39 inches) by 2100 (Figure 5, NHE 2014b). On Humboldt Bay, sea level rise may affect agricultural land uses by shoreline erosion, tidal inundation, flooding, rising groundwater, and salt water intrusion. As sea level rise affects low-lying agricultural land on Humboldt Bay, it also has the potential to impact valuable freshwater waterfowl and shorebird habitats on these same lands that support most of North America's Aleutian goose population from January through April.

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)

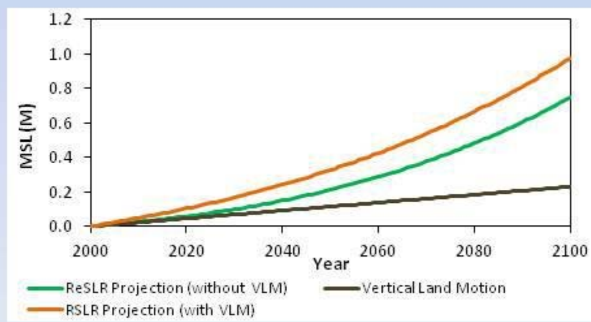


Figure 5. Regional and relative sea level rise projections for Humboldt Bay (NHE 2013).

Although sea level rise is expected to eventually result in overtopping dikes, it will likely be annual extreme high tides, known as king tides that breach these dikes in multiple locations. The diked shoreline is expected to provide protection for up to 2 feet above mean monthly maximum water (MMMW) ((7.74 feet NAVD88); thus there is a diked shoreline threshold of 2 feet (that could be achieved with 1 foot relative sea level rise plus 1 foot king tide) given the range RSLR estimates this shoreline threshold could be reached by 2050. Average king tides on Humboldt Bay reach 8.78 feet at the North Spit tide gage, so essentially, we experience 1.04 feet of sea level rise each year for several days during the winter months. On Humboldt Bay, with 1 foot of sea level rise and current shoreline conditions, 11 miles of the dikes could be overtopped during king tides. With 2 feet of sea level rise, king tides could overtop 23 miles of the dikes, and with 3 feet of sea level rise, king tides could overtop 38 miles, or 93 percent of the dikes (Figures 6 and 7, Laird and Powell 2013). If the elevation of these dikes is not raised, a significant threshold will be reached when relative sea level rise is greater than 2.0 feet (9.74 feet), which could be reached by 2050 under the high greenhouse gas emissions scenario projection, or between 2050 and 2075 as the projected likely tide elevation, and 57 percent of the dikes could be overtopped during annual king tides. Extreme 10-year or 100-year flood events could have similar effects as king tides.

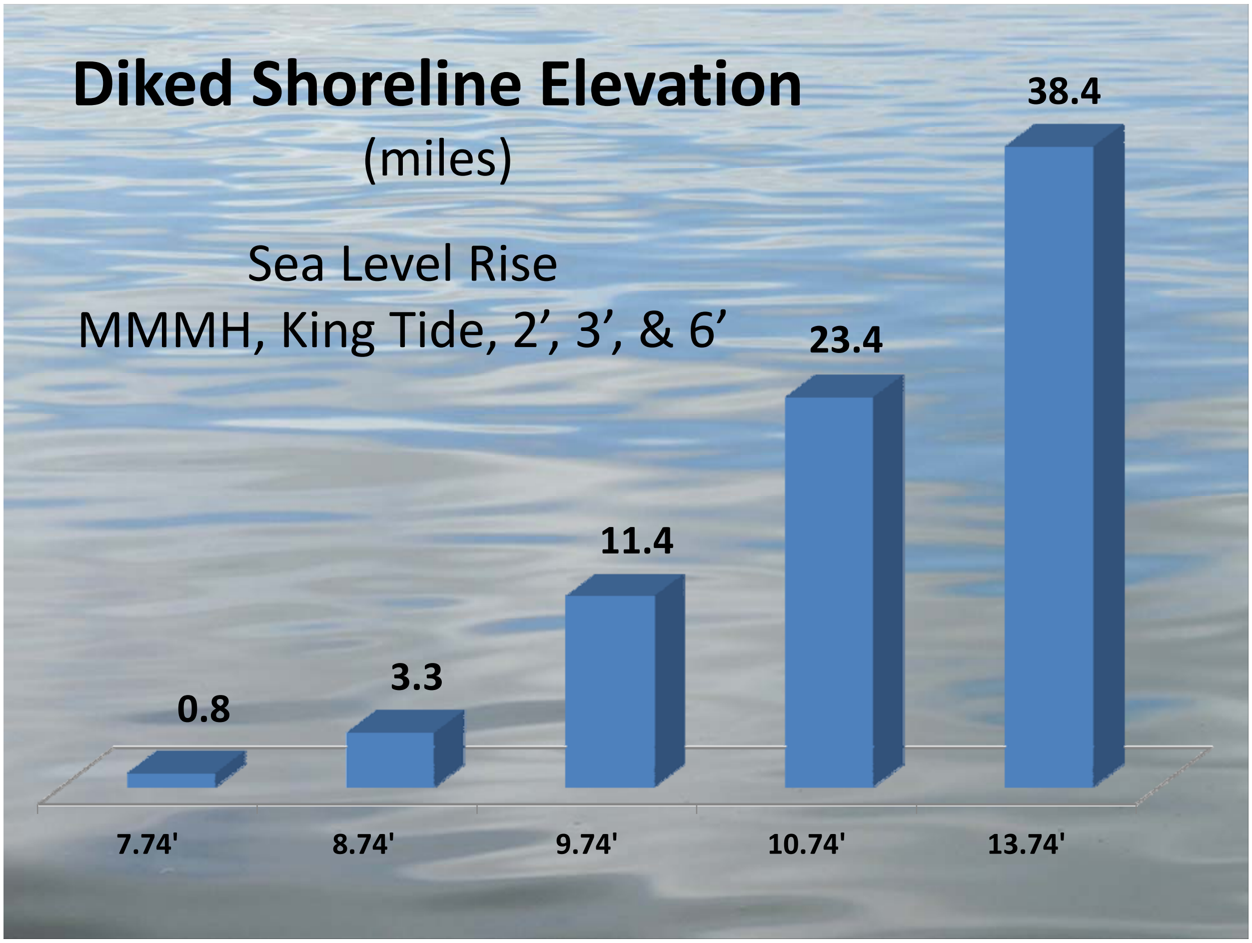


Figure 6. Length, in miles of diked shoreline, overtopped by MMMW (7.74 feet), king tides (8.74 feet), and 2 feet (9.74 feet), 3 feet (10.74 feet), and 6 feet (13.74 feet) of sea level rise. There is a noticeable threshold in the number of miles of overtopped dikes between 2.0 and 3.0 feet of sea level rise (Laird and Powell 2013).

Eureka Slough Diked Shoreline
2.0' SLR/9.74' vs. 3.0' SLR/10.74'

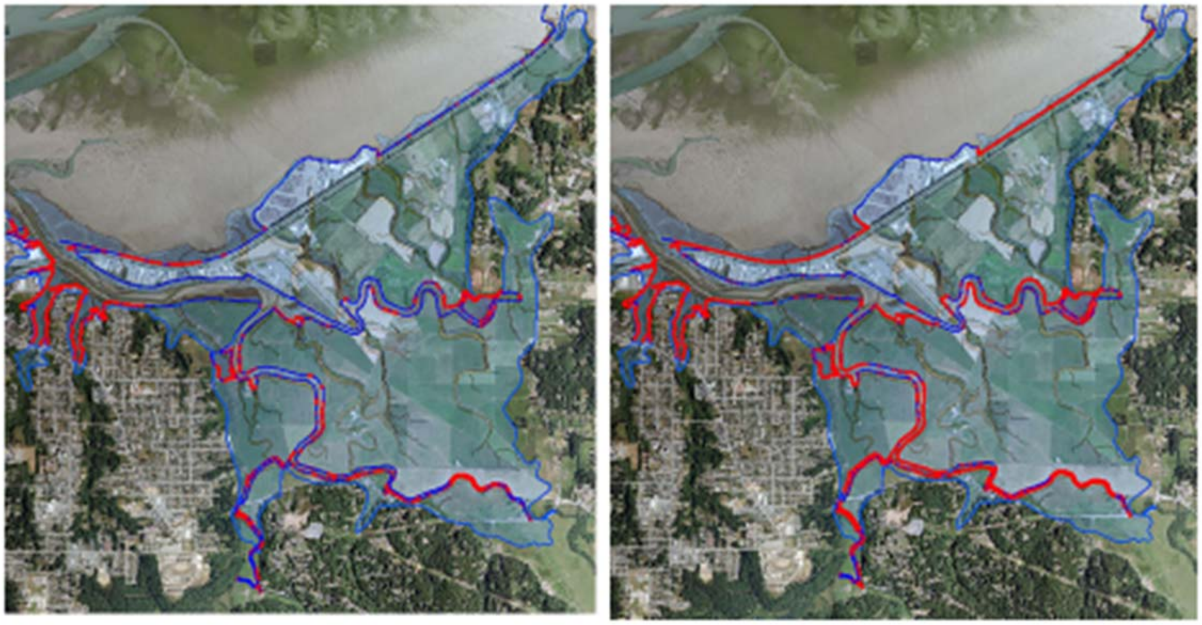


Figure 7. Diked shoreline on Eureka Slough overtopped (red lines) with 2.0 feet (left) of sea level rise versus 3.0 feet (right; Laird and Powell 2013).

2. Vulnerability of Agricultural Lands

There are 41 miles of earthen dikes on Humboldt Bay, protecting approximately 8,000 acres of agricultural land and wildlife habitat (Figure 8, Laird and Powell 2013). Based on current shoreline conditions, extreme high tides and storm surges can overtop low elevation dikes, and wind waves can erode unfortified dikes, causing them to breach. As a result, former tidelands, now agricultural lands, would be flooded with salt water.

Currently, 21 miles of diked shoreline is rated highly vulnerable due to an eroding shoreline and/or dike elevation within 2 feet of the base MMMW elevation of 7.74 feet, as measured at the North Spit tide gage (Figure 9, Laird and Powell 2013). On Humboldt Bay, king tides average 8.78 feet, and storm surges or El Niño events can add another foot in water elevation above MMMW elevation; essentially 2 feet of sea level rise is possible under current conditions for a short duration. These conditions occurred on New Year's Eve 2005, resulting in the highest water elevation, 9.55 feet, at the North Spit tide gage ever recorded. As a result, the Governor declared a "state of disaster" on Humboldt Bay and in response, several miles of diked shoreline were fortified. The 21 miles of highly vulnerable diked shoreline puts thousands of acres of low-lying agricultural lands at immediate risk from shoreline breaching and inundation with saltwater (Figure 10). Agricultural lands, primarily pasture, that are protected by dikes are very sensitive to saltwater flooding.

The majority of the vulnerable agricultural lands on Humboldt Bay are also seasonal freshwater wetlands that are critical waterfowl and shorebird habitat. It is an over-simplification to assess the importance of protecting agricultural lands from salt water inundation without considering critical infrastructure assets such as water transmission pipelines, transportation corridors, natural gas lines, and electrical transmission towers that are located on these agricultural lands, and whose sole defense against inundation is earthen dikes.

Figure 8. Shoreline structure on Eureka Slough is predominately made of dikes (yellow) built in the 1890s to convert fomer tidelands to agricultural uses.

Figure 9. Eroded and low elevation diked shorelines on the Humboldt Bay National Wildlife Refuge in South Bay are vulnerable to breaching during king tides and/or storm surges.

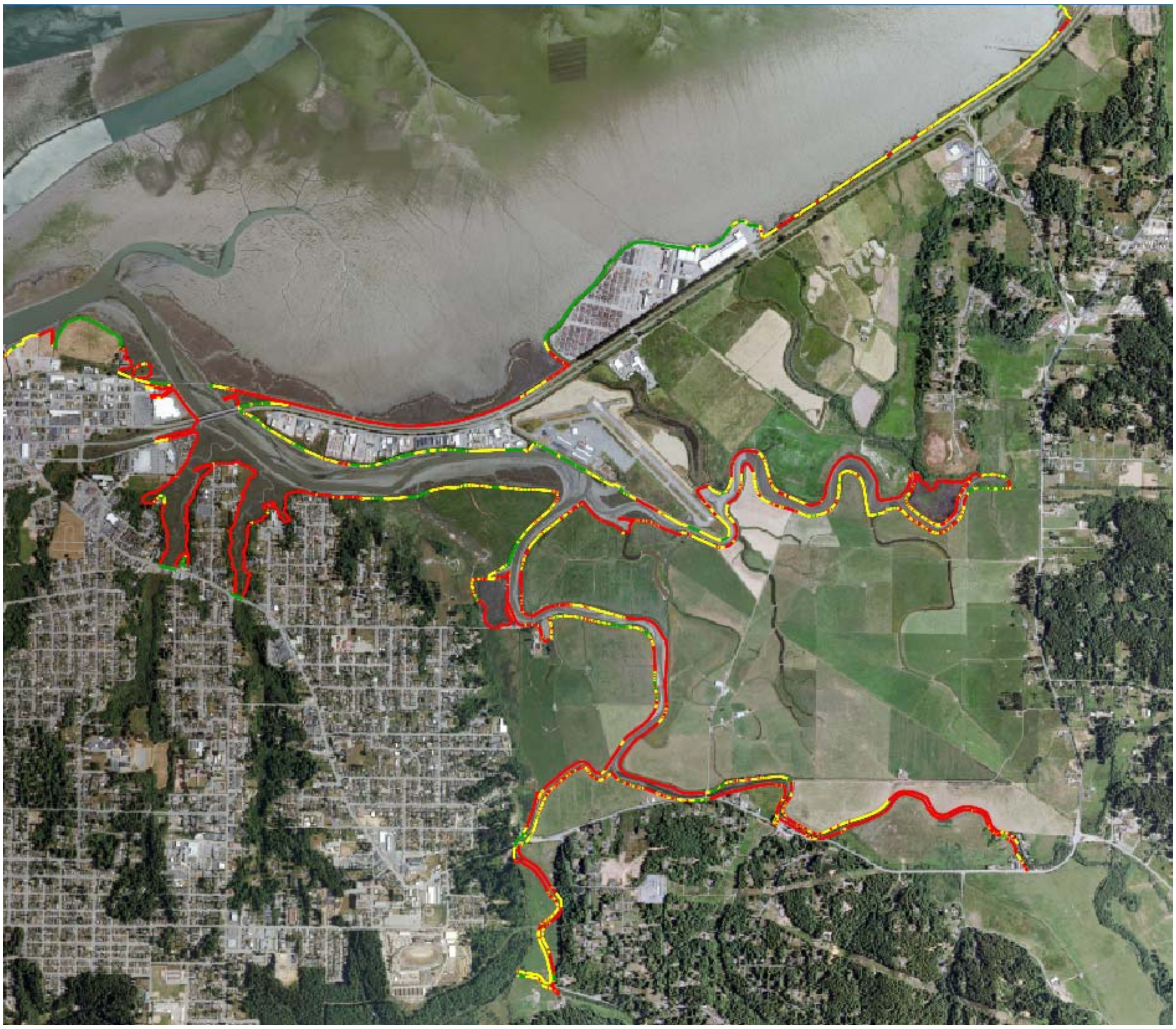


Figure 10. Shoreline vulnerability rating to erosion or overtopping on Eureka Slough: red is highly vulnerable, yellow-moderately, and green low.

With effects of up to 3 feet of compaction and 1.5 feet of relative sea level rise over the last century, these low-lying agricultural lands that are also underlain with former Bay mud drain poorly. Surface elevation on most of these former tidelands is less than the mean high water (MHW) elevation of 5.8 feet. Draining storm water runoff from these diked former tidelands is challenging; there are 97 tide gates on Humboldt Bay (Laird and Powell 2013), and with intense rainfall these lands can become inundated for months at a time. If relative sea level rise rates remain constant, then by 2050 the low water tidal datums could rise to be MLLW 1.33 feet and MLW 1.92 feet. The effectiveness of existing tide gates to drain these lands will be impaired because the percent of time that a tide gate is open and draining the land will be reduced. Rising low tide elevations may eventually result in low-lying areas being converted to wetlands or open water.

Rising groundwater and salt water intrusion are two additional impacts of sea level rise that may also affect these low-lying agricultural lands and uses. Unfortunately, at this time there is insufficient data to develop a spatial or temporal correlation between either of these impacts and relative sea level rise rates. It will be difficult to adapt to these impacts, which could make existing agricultural land use impacted by sea level rise unsustainable. Rising low tide elevations, reduced drainage capacity, and rising groundwater all could have an adverse impact on underground utilities (municipal water transmission lines, and gas lines) that traverse these former tidelands. Potential impacts include corrosion, increased buoyancy, and reduced access for maintenance and emergency repairs.

ADAPTATION STRATEGIES

Sea level rise adaptation strategies for agricultural lands include no action, protect/defend, accommodate/adapt, and relocate/retreat.

1. Education

The results of sea level rise vulnerability and risk assessments of agricultural lands must be shared with property owners, utility right-of-way holders, transportation agencies, agricultural and wildlife stakeholders, the public, and government decision-makers and staff. Education is an adaptation strategy that is common to all strategies and should be the first 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 areas predicted to be vulnerable to extreme flood events and future sea level rise. The property, infrastructures, and services at risk in these areas are important information to identify and share.

2. No Action

Maintaining the status quo will likely occur by default unless property owners, utility and transportation agencies with right-of-way and infrastructure at risk, local governments, or other entities organize a collaborative planning effort to pursue other adaptation strategies. Not initiating any new actions towards the enhancement of diked shoreline or water control structures protecting former tidelands is not a sustainable strategy in the long-term. There is a high probability that dike segments will fail during king tide and extreme events, leading to tidal inundation of these lands. Even if shoreline structures remain intact, rising low tide elevations, reduction in drainage capacity of water control structures, and rising groundwater could lead to reduced agricultural production and vegetative conversions to wetlands. Relying on agricultural property owners to initiate or lead adaptation planning for diked former tidelands is likely not administratively feasible unless a local umbrella organization like the Humboldt County Resource Conservation District or the Farm Bureau were to assume leadership. Ultimately, the solution to successful adaptation planning for these at-risk agricultural lands may be for agricultural property owners to partner with the owners of utilities and transportation agencies that would be affected if the diked shoreline structures were to fail.

3. Protect/Defend

Protecting agricultural lands from relative sea level rise is a viable adaptation strategy, at least in the short to mid-term time frames (2030 and 2050). Protecting agricultural lands from flooding as a result of shoreline failure is physically possible; dike elevations can be increased and eroding shorelines protected with fortifications or by constructing salt and/or freshwater marsh plains, "living shorelines," but these measures may not be feasible in all areas given economic considerations based on land values versus the cost of protection, as well as current regulations. However, it is important to also consider the value (or criticality) of protecting non-agricultural assets that may be located on agricultural lands or assets on adjacent lands that are afforded protection from sea level rise by the shoreline protection on agricultural lands. For example, the City of Eureka's water transmission lines traverse agricultural lands to the east of Arcata Bay and in Eureka Slough that are protected by dikes, as does PG&E's high pressure gas line, and the diked shoreline on the right bank of Fay Slough protects Highway 101 from being flooded from the east. Diked former tidelands along the Mad River, Eureka, and Elk River Slough systems on Humboldt Bay all drain ultimately through a single slough channel as they join Humboldt Bay. Further, all of these slough channels have a bridge spanning their lower reaches. The bridge abutments and railroad grades could form the framework for installing a "tidal barrier or dam" that would span the width of the slough channel to prevent tidal inflow upstream into the slough systems. Such large scale tidal structures have been employed in other countries to protect large areas from tidal inundation. However, this would be a considerable cost and may not address other issues like rising groundwater elevation, reduced drainage time, or salt water intrusion.

4. Accommodate/Adapt

Shoreline segments designated highly vulnerable (Figure 10), particularly those segments that are already eroding, could be relocated/setback as a form of accommodation by creating living shorelines in front of shoreline dikes. Reducing the length of the shoreline when relocating eroding dikes by cutting off meander segments would help reduce the cost of rebuilding shoreline structures. Flooding caused by stormwater runoff and reduced drainage capacity or rising groundwater can be addressed by raising surface elevations of agricultural lands or pumping, although it is likely not feasible to import sufficient fill to raise the elevation of the thousands of acres of diked former tidelands to address flooding. Inadequate drainage capacity can be expanded, particularly if grant assistance is available to help defray the cost of enhancing or adding additional drainage structures.

Lastly, as rising groundwater and reduced drainage capacity degrade agricultural uses on these diked former tidelands, they could be enhanced as riparian habitat, which would increase the wildlife and wetland values of these lands. Increased freshwater flooding as a result of sea level rise can be accommodated for a time by establishing riparian habitat on these lands. Allowing these dikes to degrade and breach and the former tidelands to become tidally inundated would not restore salt marsh habitat, as the land has lowered in elevation; they would be converted to mud flats.

5. Relocate/Retreat

Relocation of agricultural uses from vulnerable areas as an adaptation strategy is not an option, as nearly all arable land in Humboldt County, particularly in the coastal areas, is already in agricultural production. Relocation of critical assets located on or under agricultural lands is possible. Alternatively, these assets could be elevated. Ultimately, with relative sea level rise, vulnerable agricultural lands will become inter-tidal wetlands. Updating Local Coastal Programs (LCPs) to address relative sea level rise should guide future land use decisions that would avoid placing infrastructure, land uses, property, or services at risk from coastal hazards on diked former tidelands.

6. Regulation

The goal of the Humboldt Bay Sea Level Rise Adaptation Planning Project is to encourage a unified, consistent regional adaptation strategy to address the hazards associated with sea level rise in the Humboldt Bay region. Although there is no single entity responsible for the maintenance of dikes, there are three land use authorities whose LCP jurisdictions cover these agricultural lands and their diked shorelines: (1) Humboldt County, (2) City of Eureka, and (3) City of Arcata. Development of sea level rise adaptation strategies and measures that are applicable to agricultural lands around Humboldt Bay will encourage regional compatibility when updating LCPs. Several state and federal agencies actively manage thousands of acres of diked former tidelands by employing livestock grazing to maintain waterfowl and shorebird habitat: (1) California Department of Fish and Wildlife, (2) Humboldt Bay National Wildlife Refuge, (3) U.S. Fish and Wildlife Service (USFWS), and (4) the National Resources Conservation Service (NRCS). In addition, there are three regulatory agencies with jurisdiction over development activities affecting the tidal shoreline: (1) at the local level, the Humboldt Bay Harbor, Recreation and Conservation District; (2) at the state level, the California Coastal Commission; and (3) at the federal level, the Army Corps of Engineers (ACE).

It is important to highlight that diked former tidelands cannot be protected on a parcel by parcel basis; where landowners who share a common dike need to hold back the tides, they must join together to protect their lands from flooding (Figure 11). The same holds true for land use and regulatory agencies; they must authorize adaptation projects that treat entire hydrologically connected areas, not individual parcels. Humboldt Bay has six major hydrologic units: Arcata, Eureka, and South Bay, and Mad River, Eureka, and Elk River Sloughs. Further stratification of these areas for adaptation planning yields approximately 27 sub-units, the Eureka Slough hydrologic unit for example has eight sub-units (Figure 12). Land use, land management, and regulatory authorities should adopt the basic sea level rise adaptation strategy of treating hydrologically connected areas as a unit, irrespective of jurisdiction, for planning and implementing adaptation measures.

Figure 11. Diked former tidelands cannot be protected on a parcel by parcel basis as illustrated here on Mad River Slough; where landowners who share a common dike need to hold back the tides, they must all join together to protect their lands from flooding.

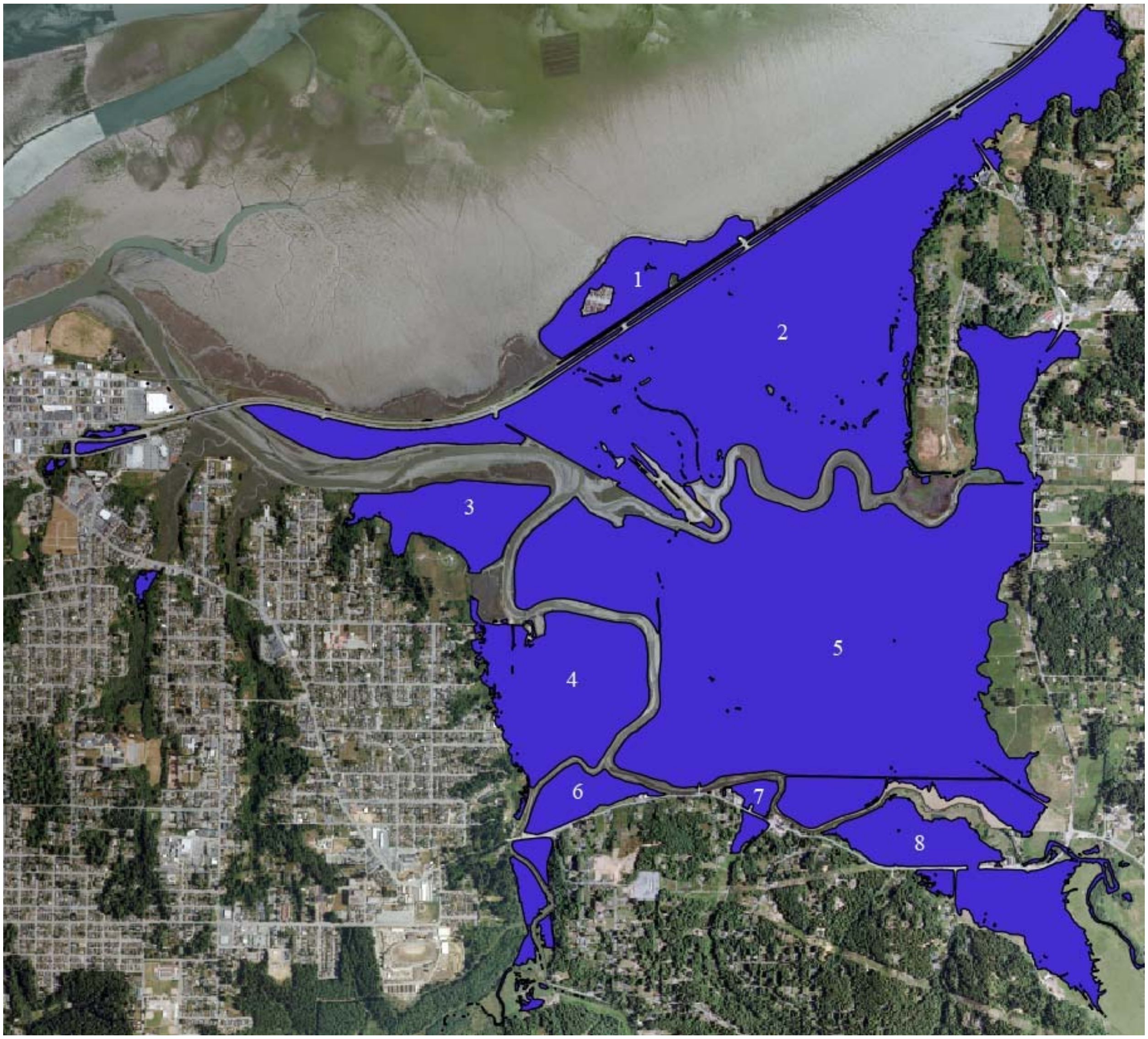


Figure 12. Blue shaded areas depict eight discrete hydrological sub-units within the larger Eureka Slough hydrologic complex that are vulnerable to inundation, if the diked shoreline were to be breached or overtopped (NHE 2014b).

ADAPTATION MEASURES

Sustaining agricultural, wildlife, and other natural resource uses of low-lying agricultural lands will require development and implementation of adaptation measures. There are several adaptation measures that could increase the resiliency of these diked agricultural lands to sea level rise:

1. Dikes could be raised 2 or 3 more feet; however, this may require expanding the footprint of the dike onto the agricultural lands, which are also seasonal freshwater wetlands, unless the dike faces can be steepened with fortification.

2. Where diked shoreline reaches are exposed to wind-generated waves, the dike could be relocated/setback inland and salt or freshwater marsh plains could be created in front; the living shoreline would provide protection for the dike.
3. Retrofitting top-hinged tide gates with side-hinged tide gates and enlarging the diameter of the inlet culvert can increase the efficiency of the water control structure to drain flooded agricultural lands through a greater range of tidal elevations. Adding more tide gates can also increase the amount of drainage during a tide cycle.
4. Importing clean fill material to raise the surface elevation of compacted and subsided agricultural lands on a limited scale due to the lack of sufficient volume of suitable fill would make some lands much more resilient to rising groundwater and rising MLW and MLLW elevations which will impede stormwater runoff and convert pasture forage to more salt tolerant vegetation.
5. Constructing a large multiple tide gate or tidal dam/barrier structure at the mouth of tidal sloughs (Mad River, Eureka, and Elk River Sloughs) may be a feasible means to offer protection from tidal inundation for thousands of acres of diked former tidelands.
6. Diked former tidelands that do not have underground utilities or transportation systems to boost their intrinsic value can be enhanced as riparian wildlife habitat until the dikes are breached or overtopped rather than simply allowing these lands to become mud flats via dike breaching.
7. Because multiple landowners need to be involved in these sub-units, these landowners need to become organized and form a collaborative adaptation planning stakeholder group to successfully develop and implement adaptation measures. Perhaps the Humboldt County Resource Conservation District or Farm Bureau could assist in this planning effort.
8. Ultimately, regulatory integration will also be necessary. The NRCS and USFWS have programs that assist local agricultural landowners to sustain agricultural practices and protect wildlife habitat. These federal agencies could develop a Memorandum of Agreement with the ACE to authorize activities sanctioned by the Services to increase the resiliency of agricultural lands facing the impacts of sea level rise. The agricultural areas that are vulnerable to relative sea level rise on Humboldt Bay are subject to both the California Coastal Act and Federal Coastal Zone Management Act. Therefore, these federal Services could also prepare a general consistency determination (CD) for the Coastal Commission's concurrence to authorize placement of fill on diked former tidelands as an adaptation measure for sustaining agricultural practices and wildlife habitat in response to relative sea level rise. The proposed CD and these physical adaptation measures would enable property owners to increase the adaptive capacity of their agricultural lands, possibly sustaining agricultural uses and wildlife habitat.

1. Regulatory Constraints to Adaptation Measures

The Coastal Act of 1976 (Act) (Public Resource Code (PRC) § 30000 et seq.), and thereby also the Federal Coastal Zone Management Act pursuant to its consistency provision, contains several policies that would constrain the implementation of some of these feasible adaptation measures:

1. While dikes could be raised, that would require increasing the footprint of the dike. Diked former tidelands are seasonal freshwater wetlands and placing fill in a coastal wetland is limited; increasing a dike's footprint is not an allowable reason to place fill in a wetland (PRC § 30233). Increasing the height of a dike could be achieved without expanding its footprint if the shoreline is hardened with sheet piling or rock rip rap, but armoring a shoreline is not an allowable fill of a wetland if none existed previously (PRC § 30610).
2. Where diked shoreline reaches are exposed to wind generated waves, they could be relocated inland and living shorelines could be created in front to provide protection. Relocating a dike would employ current engineering standards in rebuilding a dike to appropriate and stable slopes, which would likely result in expanding the footprint of the relocated dike. This would trigger the same regulatory constraints described above.
3. Retrofitting top-hinged tide gates with side-hinged tide gates and enlarging the diameter of the inlet culvert can increase the efficiency of the water control structure to drain flooded agricultural lands through a greater range of tidal elevations. Adding more tide gates can also increase the amount of drainage during a tide cycle or from stormwater runoff. Few regulatory constraints are anticipated with this adaptation measure.
4. Importing clean fill material to raise the surface elevation of compacted and subsided agricultural lands would make these lands much more resilient to rising groundwater and rising MLW and MLLW elevations, which could flood low lying areas, and thus able to support continued grazing activities. Unfortunately, enhancing agricultural activities by placing fill to elevate the surface above groundwater or rising low tides is not an allowable fill in a coastal wetland pursuant to PRC § 30233. This adaptation measure is also counter to achieving the policy in PRC § 30230 of restoring marine resources whenever feasible. There is an inherent conflict within the Coastal Act between restoring former tidelands, a marine resource, and perpetuating agricultural uses pursuant to PRC § 30241 and 30242, which seek to protect and maintain agricultural lands from being converted to other uses. The Coastal Act anticipated the need to balance policies that are brought into conflict under unique circumstances to protect coastal resources, such as agriculture, wetlands, wildlife habitat, and coastal infrastructure, and allows the Commission to weigh the net benefit derived to coastal resources from a proposed action (PRC § 30007.5).
5. Converting diked former tidelands from seasonal or perennial freshwater wetlands to riparian habitat would increase wildlife and wetland values. But PRC § 30230, the Marine Resource policy, would require that these former tidelands be restored to the inter-tidal habitat that they once were. Unfortunately, the surface elevation of these diked former tidelands has lowered by as much as

three feet. Restoring tidal inundation would not restore salt marsh habitat that existed before diking; rather, the lower surface elevation would be tidally inundated for a greater period of time, resulting in mud flats, not salt marsh.

2. Justifying Adaptation Measures to Regulatory Constraints

Fortunately, the Act's basic goals are to "protect, maintain, and, where feasible, enhance and restore the overall quality of the coastal zone environment and its natural and artificial resources" (PRC § 30001.5 (a)). The Act can resolve conflicting policies by seeking a balance that is the most protective of significant coastal resources (PRC § 30007.5); agricultural, wildlife lands, and critical infrastructure are significant coastal resources worthy of protection.

Increasing an agricultural dike's footprint is not an allowable reason to place fill in a wetland (PRC § 30233). But agricultural lands are not single purpose use areas. These lands support important regional seasonal freshwater wetlands and wildlife populations, as well as protect critical regional infrastructure. On Humboldt Bay, agricultural dikes protect much more than livestock grazing. They protect seasonal freshwater wetlands and wildlife habitat from being converted to inter-tidal wetlands to the detriment of sensitive wildlife species. Pursuant to PRC § 30233, enhancing and protecting wildlife habitat is an allowable reason to place fill in a coastal wetland. If these land surfaces are not raised, they will not be able to support seasonal freshwater wetland vegetation in the face of rising groundwater and low tides thus rendering any dike enhancement moot. These dikes also protect other critical regional assets from being inundated by saltwater, such as municipal water lines, transportation corridors, pressurized gas lines, and electrical transmission towers. These critical regional assets will be very expensive to protect with other means and more expensive to relocate or elevate; it is desirable that the agricultural dikes protect these regional assets as long as possible.

Enhancing agricultural activities by placing fill to elevate the surface of the pastures above groundwater or rising low tides is also not an allowable fill in a coastal wetland pursuant to PRC § 30233. But, as discussed above, agricultural lands are not single purpose use areas. These lands support important regional seasonal freshwater wetlands and wildlife populations, as well as protect critical regional infrastructure. Restoring former salt marsh habitat will not be achieved simply by opening an area to tidal action, because these lands have compacted and subsided. Their surfaces must be raised; otherwise, these lands will become mudflats, not salt marsh.

Protecting valuable agricultural lands is also counter to achieving the policy in PRC § 30230 of restoring marine resources whenever feasible. Restoring marine resources is the goal if there are no physical, economic, or political impediments. However, these impediments do exist at many sites where agricultural lands can be sustained with the placement of fill, or where dikes offer protection for critical infrastructure and existing seasonal freshwater wetlands.

CONCLUSIONS

The diked former tidelands on Humboldt Bay are currently predominately used for agricultural uses like livestock grazing, as wildlife habitat, for utility lines, and coastal open space for recreation. These lands are vulnerable to tidal inundation from shoreline breaching or overtopping, and flooding from rising low tide elevations and rising groundwater. The present land uses are likely sustainable for decades with adaptation measures, but eventually sea level rise will flood these former tidelands. As sea level rise progresses, utilities and transportation systems located on these former tidelands will need to adapt to tidal inundation if they are to remain in their present right-of-ways, or relocate.

Adaptation planning for an asset at risk, such as the agricultural lands on Humboldt Bay, should be undertaken by a collaborative stakeholder group consisting of property owners, affected property and asset owners, people who derive benefits from this asset, LCP and regulatory authorities, and if possible, funding agencies. Successful implementation of adaptation options for these agricultural lands will likely require partnerships amongst affected stakeholders. Building on the work products produced for this Project and the deliberations of the Adaptation Planning Working Group, it is most realistic that the stakeholders of these agricultural lands at risk select adaptation strategies that are feasible for their asset at risk, and determine when adaptation options should be initiated, and how to secure funding to implement the adaptation options.

Implementing adaptation measures will require permits. The agricultural areas that are vulnerable to sea level rise on Humboldt Bay are subject to both the California Coastal Act and Federal Coastal Zone Management Act. The NRCS and USFWS have programs that can assist local agricultural landowners to sustain agricultural practices and protect wildlife habitat. The Services could prepare a general CD for the Coastal Commission's concurrence to authorize placement of fill on diked former tidelands in the context of implementing adaptation measures for sustaining agricultural practices, wildlife habitat, and protecting critical infrastructure in response to relative sea level rise. The proposed CD and these physical adaptation measures would enable property owners to increase the resiliency of their agricultural lands, possibly sustaining agricultural uses and seasonal freshwater wetland habitats for several decades, and put these lands in a much better position to be reclaimed as salt marsh by the Bay in the future.

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