PART 3 – Looking Ahead (2015 and Beyond)

Goleta Slough is a coastal estuary in Santa Barbara County that contains more than 300 acres of tidal wetland habitats. These wetlands provide key habitat for several threatened and endangered species including tidewater goby and southern California steelhead.

Goleta Slough has experienced several major flood events over the past century that have forced the closure of Santa Barbara Airport and surrounding areas. As the climate changes and sea levels rise, the risk of flooding and other adverse impacts to both infrastructure and habitats will increase due to the more frequent occurrence of elevated water levels within Goleta Slough.

Part 3 of the Goleta Slough Area Sea Level Rise and Management Plan provides a summary of projected effects of climate change at Goleta Slough and the impacts it may have on the natural ecosystem and the built environment. This section includes an inventory of the infrastructure and habitats that may experience impacts due to rising Slough water levels. For each vulnerable infrastructure element or habitat, this section presents a set of adaptation strategies which could be adopted in order to reduce the risk to that infrastructure or habitat. The final segment of this section describes analysis conducted to compare the expected outcomes of different lagoon inlet management strategies under existing conditions and with increasing amounts of sea level rise.

The purpose of this section is to provide information to decision-makers, planners, managers, and stakeholders to assist them as they identify and prioritize adaptation strategies, including infrastructure improvements, policy changes and management approaches to address existing challenges facing Goleta Slough as well as future sea level rise related impacts. The goals of these adaptation strategies are twofold:

1. To maintain and enhance existing ecosystem functions provided by Goleta Slough in the face of rising sea levels, and to enhance and expand priority habitats where possible; and,
2. To minimize the risk of damage to infrastructure within the Goleta Slough Ecosystem (see Figures 2-1 and 2-4) due to flooding under anticipated future sea level rise conditions.

3.1 Climate Change Projections

During the preparation of this document, Environmental Science Associates (ESA) conducted a review of the current science related to future sea level and climate conditions. The following section presents a summary of the projected effects of climate change for the Goleta Slough area. Detailed climate change projections are provided in Appendix D. A major goal of this document is to identify adaptation measures that address the expected impacts of sea level rise on habitats and infrastructure in and around Goleta Slough. It is also important to recognize that rising sea levels are just one of the many anticipated consequences of changes in the global climate that are projected to occur over the coming century and beyond. Other impacts of climate change that are expected to affect Goleta Slough habitats and functioning include increases in temperature and changes in precipitation.

3.1.1 Proposed Goleta Slough Climate Change Scenarios

The scientific community commonly presents sea level rise projections in terms of the range of predicted future sea levels at a given target year in the future (often 2050, 2100). For example, the National Research Council's (NRC) 2012 report presents a range of scenarios showing 17.4 to 65.5 in of sea level rise by the year 2100. These "year 2100" projections are sometimes mis-interpreted as the "maximum" amount of projected future sea level rise. This interpretation is incorrect. While there continues to be uncertainty with respect to the rate of future sea level rise, the scientific consensus based on current projections for greenhouse gas emissions is that sea levels will continue to increase for the next 1000-2000 years (IPCC, 2013, California Coastal Commission Final SLR Policy Guidance, 2015; http://www.coastal.ca.gov/climate/slrguidance.html).

It is recommended that planners and managers evaluate Slough assets, including habitats, development areas and infrastructure, in terms of the amount of sea level rise that can be accommodated before that asset becomes at risk of impacts from sea level rise. Adaptation strategies should include the ability to accommodate an increasing amount of sea level rise over time, and should anticipate the required lead in time necessary to implement these strategies.

For current planning efforts we recommend the identification of adaptation strategies to accommodate at least 5 feet of sea level rise. Moderate sea level rise scenarios indicate that this is approximately the amount of sea level rise expected to occur by the year 2100. Given an expected project lifespan of 50-100 years, it is reasonable to assume that infrastructure constructed today may still be in use in a world that has experienced more than 5 feet of sea level rise.

In addition to the anticipated increase in mean sea level over time, changes in future wave conditions can affect coastal water levels. Currently, there is no scientific consensus on the expected changes to wave climate (direction, height, period) caused by climate change. The NRC report, reviewing previous global climate modeling and downscaled analysis for California (Cayan et al 2008), discusses a potential northward shift in the storm track affecting waves over the next century (NRC 2012), however current USGS wave modeling efforts utilizing the updated modeling for the next IPCC report (CMIP5) show a shift in wave direction about 15 degrees south (Barnard et al in prep). A shift in 15 degrees to the south can cause significant increases in waves in the Santa Barbara Channel (Adams et al 2007), and has been shown to be a controlling factor of the Goleta Beach widths, which directly affect the functioning of Goleta Slough (Revell and Griggs 2006).

To date there has been no formal evaluation of the expected changes in the hydrology of the Goleta Slough watershed due to climate change. The NRC report indicates a potential decrease in precipitation for the Goleta watershed, showing a decrease of 7.4% for emissions scenario B1 and a decrease of 24.4% for emissions scenario A2 by the year 2100. The report also indicates a potential decrease in runoff (-1.8% for B1, -31.0% for A2) due to precipitation. In general, the predicted trends for these parameters suggest that watershed runoff into Goleta Slough will decrease over the coming century.

There are many climate change models and scenarios producing different projections of rainfall patterns and the frequency and extent of fires. Some project increasing drought, more intense storms, and increased incidence of fires, which in future studies should be integrated with projections of sea level rise to evaluate effects on sediment transport and deposition and water levels in the Slough. Although mean changes in precipitation or runoff may not be great, most models indicate increases in climate variability (e.g., prolonged droughts, intense storms), which will have significant effects on ecosystems. Because 80% of the erosion occurring in chaparral ecosystems occurs after fires, it will be important to include the impacts of wildfires in future models predicting the effects of climate change on the Slough (sediment loading, marsh and channel accretion, runoff, and water levels).

3.1.2 Sea Level Rise Vulnerability Analysis

ESA has analyzed the vulnerability of natural and manmade assets in the Goleta Slough area to sea level rise related impacts. The goal of the habitat and infrastructure vulnerability analyses is to provide a practical planning-level assessment of the expected extent of future impacts of sea level rise within the Goleta Slough Ecosystem and to suggest and provide a preliminary evaluation of potential adaptation strategies for reducing the vulnerability of both habitats and infrastructure. This analysis is intended to inform regional and local planning efforts and to provide information pertinent to the development of long-term policy and management strategies for the region based on the available data and the current scientific understanding of the physical processes which affect the Slough system.

The following subsections describe the methodology and conceptual framework used to conduct the habitat and infrastructure vulnerability analyses. The results of these analyses are presented in summary sheets in Appendices E and F. Each summary sheet is comprised of a map and a table. The map shows the location of the key habitats or infrastructure within the study area as well as a table describing the exposure and sensitivity to sea level rise flood impacts.

For habitat, potential adaptation strategies are discussed below in section 3.2.1. For infrastructure, a brief discussion of adaptation strategies that might be used to reduce or mitigate for the anticipated flood impacts is presented below in section 3.2.2, with additional strategies presented in the tables in Appendix F.

Vulnerability Methodology

The vulnerability of habitats and infrastructure to impacts from sea level rise is based on the evaluation of three key qualities that are explained further below:

1. The expected **exposure** of that habitat or infrastructure to increased inundation and flooding due to sea level rise;
2. The **sensitivity** of that habitat or infrastructure to increased inundation in order to determine the likely damage due to future flooding; and,
3. The **adaptive capacity** of each habitat or infrastructure, determined by identifying strategies that may be implemented to reduce the risk of damage.

1. Assess Exposure

The exposure of habitat or infrastructure to sea level rise is a function of location and elevation as well as the condition of any existing flood protection. Exposure is first determined by identifying the key habitats and infrastructure that are present within the Slough. ESA has prepared an inventory of these assets within Goleta Slough through an outreach process aimed towards the general public, local government, utilities, and other regulatory agencies.

Public and focus group meetings were held on February 11th and 12th, 2014 in which approximately 40-50 people were involved in discussions of the Slough and surrounding area's vulnerability to sea level rise.

The habitats and infrastructure at Goleta Slough were organized into several general categories. The expected change in inundation frequency was evaluated for each habitat and infrastructure category by comparing the ground surface elevation at the location of that infrastructure of habitat (or the elevation of any existing flood protection berms/levees/tide gate) to the expected future extreme water levels due to sea level rise. Future Slough water levels due to coastal flooding have been estimated based on projected rates of sea level rise and an analysis of the physical processes which shape the Slough.

2. Habitat and Infrastructure Inventory

Existing Habitats

In 2008, URS developed a map of existing vegetation within Goleta Slough as part of the Western Goleta Slough Restoration Project. This mapping effort compiled data from several prior studies and incorporated data from new surveys conducted specifically for that project. This map is shown in Figure 3-1 and comprises the habitat inventory used in this analysis.

Infrastructure Inventory

An inventory of existing infrastructure located in the vicinity of Goleta Slough has been developed based on consultation with local government, utility agencies, planers and other stakeholders. This data inventory was used to identify infrastructure and relevant elevations which may be vulnerable to impacts related to projected sea level rise over the next 100 years. Information was solicited from a variety of local, county and state sources. Table 3-1 lists the key data sources used for this study.

Table 3-1
Key data sources for infrastructure inventory

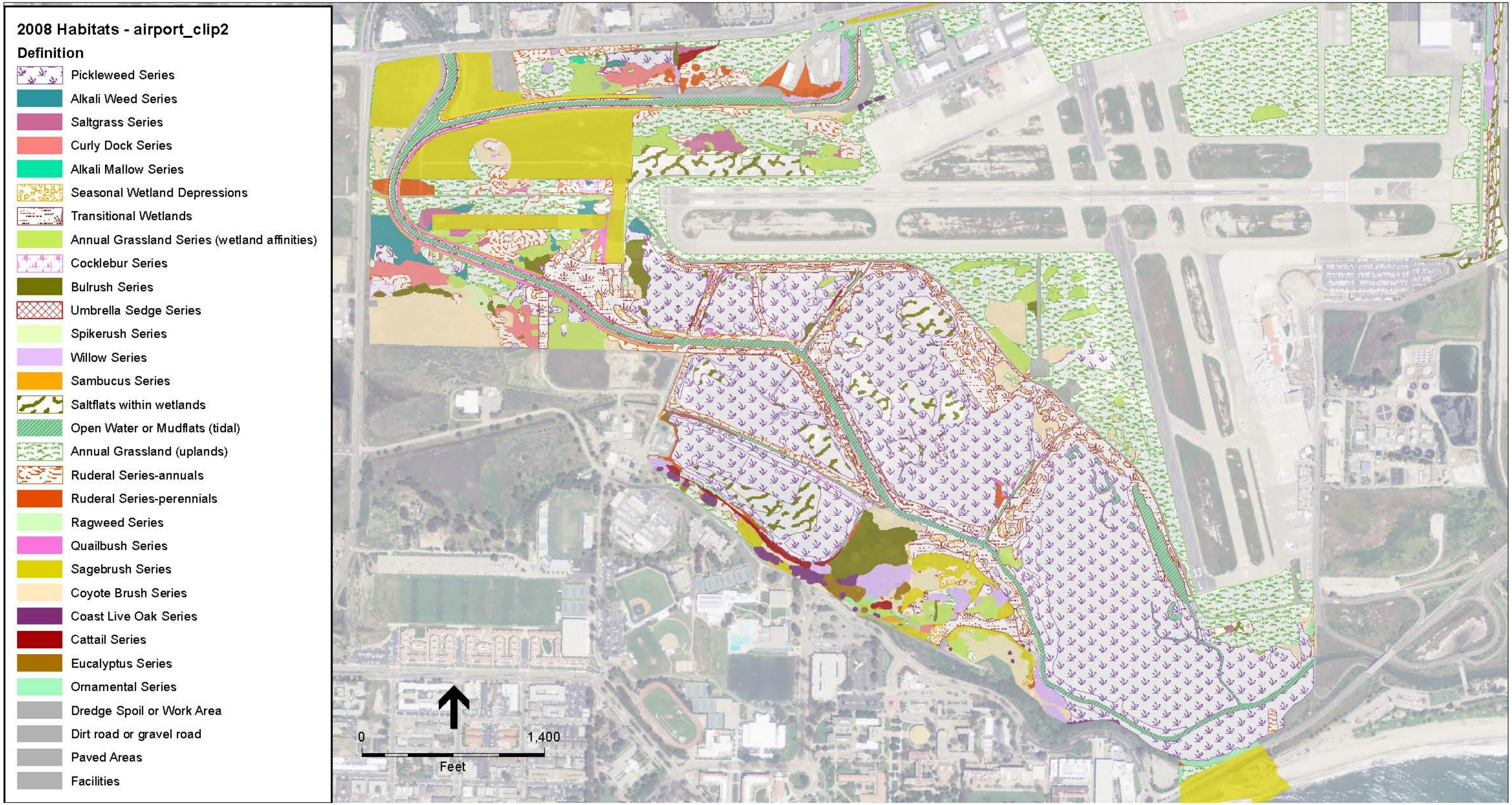
Infrastructure Category:	Source:
Airport Runways and Taxiways	2010 State Coastal LiDAR Penfield and Smith Ground Survey
Roads	Santa Barbara County
Buildings	Santa Barbara County
Storm Sewer and Sanitary Sewer Pipelines	Goleta Sanitary District Goleta West Sanitary District Santa Barbara Airport
Water Treatment Facilities	Goleta Sanitary District Goleta West Sanitary District
Remediation Sites	California State Water Board
Hazardous Materials	Santa Barbara County Fire Department
Natural Gas Pipelines and Storage Wells	Southern California Gas Company (Sempra Energy)
Recycled Water Pipelines	Goleta Water District

Multiple attempts were made to acquire information regarding several additional infrastructure categories; however data for the following infrastructure categories were not made available for use in this study:

- Electrical Distribution Infrastructure
- Utility Service Natural Gas Pipes and Facilities
- Telephone, Cable, and Internet Service Infrastructure

Anecdotal reports suggest that these infrastructure categories are present within the Goleta Slough plan area, however they are not included in the vulnerability assessment due to the lack of available data.

Figure 3-1 Existing vegetation map (URS 2008)



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3.1.3 Estimated Future Slough Water Levels due to Sea Level Rise

The expected increase in future water levels due to sea level rise in Goleta Slough is based on a review of the natural physical processes which shape the Slough system. As described in the *Goleta Slough Existing Conditions and Monitoring Report* (June 30, 2012), coastal estuaries such as Goleta Slough are shaped by both fluvial[1] and coastal processes. Future climate change will have three primary impacts on water levels within the Slough:

1. Increased ocean tide elevations will lead to elevated water levels within the Slough during periods when the Slough inlet is open.

2. Increased sea levels will increase the elevation of wave run-up, which will increase the potential size and elevation of the beach berm. Increased elevation of the beach berm may cause higher water levels within the Slough due to ponding when the inlet is closed. Ponded water levels may significantly exceed tidal water levels depending on overtopping of the berm and stream flows into the Slough. The height of the beach berm and therefore the height of ponding will depend on the management of the beach and Slough inlet.

3. Even with 5 feet of sea level rise, fluvial flood events will continue to cause the most extreme water levels in areas of the Slough nearest to the upstream creek confluences. Fluvial flood levels near the Slough may increase as a result of future climate change, however the analysis of fluvial flooding was beyond the scope of this study.

There is only limited water level data available for Goleta Slough. UC Santa Barbara's Cheadle Center for Biodiversity and Ecological Restoration (CCBER) installed a water level gage in the Slough starting in October 2006. This gage has collected intermittent data from 2006 to the present. The City of Santa Barbara installed a second gage in the Slough in May 2013. These two gages provide about 5 years of historic water level data for the period when the slough inlet was managed for open conditions, and 1 year of water level data for when the Slough inlet was left unmanaged. USGS maintains an additional water level gage along the lowest reach of Atascadero Creek, however this gage is located upstream of an artificial weir, and consequently water levels observed at this gage are not representative of water levels within the rest of the Slough.

The historic water level dataset has several gaps and is of insufficient duration to be used for the evaluation of extreme water level events. Historic records show that the two largest flood events of the past 75 years were the floods of 1969 and 1995 with flood elevations greater than 12 and 10 feet NAVD respectively. The FEMA flood map for the Slough shows the 100-year base flood elevation at 14 feet NAVD for the majority of the flatlands adjacent to the creeks in the Slough.

At the time of this study there is considerable uncertainty with respect to the future management of the Slough inlet. The condition of the Slough inlet is one of the primary drivers of elevated water levels within the Slough during winter storm events. Consequently, Slough inlet management is an important adaptation strategy for the management of water levels within Goleta Slough. The City of Santa Barbara has commissioned a study of management options for the Slough inlet with results expected in 2015.

3.1.4 Critical Water Surface Elevations

The short duration of the available historic water level data limits a probabilistic analysis of flood Slough water surface elevations (e.g., to estimate 100-year flood elevations, etc.). Instead, for this

[1] Fluvial – processes related to rivers and streams.

study we have identified a set of critical Slough water surface elevations that are linked to the physical processes that affect water levels within the Slough. We have used these critical water surface elevations to evaluate the expected extent of flood impacts under future conditions. These critical elevations represent our best estimate for the expected elevation of frequently occurring high water levels within Goleta Slough caused by coastal processes. The relevant critical water surface elevation that is expected to occur under future scenarios will depend on the planned lagoon management or adaptation strategies implemented for that scenario, as discussed below.

The critical elevations are not a result of hydraulic or hydrodynamic analysis of the Slough and upland watersheds and are not to be interpreted as "Base Flood Elevations". The results presented in this document do not represent a flood study for purposes of determining flood risk, flood insurance rates, or otherwise. This analysis represents our best estimate of the likely future extent of flood hazards based on available data and is intended to inform future planning and management efforts. The analysis and results presented herein are not intended to evaluate the present or future flood hazard or flood risk for any particular property or location.

Coastal influenced high water elevations within the Slough are controlled by the state of the lagoon inlet. When the inlet is open high water levels within the lagoon closely match the elevation of the high tide. Consequently, our first critical elevation is elevation 5ft NAVD, which represents the mean high tide elevation. This is the elevation water levels within the Slough will reach on a daily basis. As sea levels rise the high tide elevation will increase. Our planning horizon is considering up to +5ft of sea level rise, thus we have identified elevation 10 as the expected future daily high water level within the Slough.

Historic events have shown that the highest water levels within the Slough are most often the result of ponding within the Slough when the inlet is closed and a rain event increases stream flow, rather than high tide levels or wave-overtopping events. During a ponding event water levels within the Slough can rise to match the height of the beach berm before the Slough inlet naturally breaches. The elevation of the beach berm crest increases over time following the closure of the inlet and will approach a characteristic equilibrium elevation that is partially determined by wave run up[2], which varies seasonally. The highest elevation is typically found in the fall and early winter before the first rains of the season. Field surveys and site observations at Goleta Beach suggest that the typical fall beach berm crest elevations is approximately 10 feet (NAVD88). This elevation provides a good indication of the typical expected elevation for flood-related impacts if the lagoon inlet is left unmanaged over the course of a year. Therefore, we have identified elevation 10ft NAVD as the second critical water surface elevation for present day conditions. Because the elevation of the beach berm is controlled by the extent of wave run-up, we expect that the beach berm elevation will rise over time at about the same rate as sea level rise, therefore we identified elevation 15ft NAVD as representative of expected future annual flood elevations if the lagoon mouth is allowed to close.

Finally, elevation 15ft NAVD represents the 100-year flood elevation at the upper end of the Slough, near the creek mouths (based on the current FEMA flood map). Therefore, elevation 15 is approximately representative of the 1 in 100 year (or 1% annual chance exceedance) flood elevation due to fluvial flooding. The FEMA mapped 1 in 100 year flood elevation varies by location and is generally higher in areas that are farther upstream from the lagoon mouth.

[2] Wave run up: the distance that a wave pushes water up a sloped beach face.

Table 3-2 lists the critical elevations used to evaluate the expected extent of the impacts related to sea level rise within Goleta Slough. We have listed estimated recurrence intervals for these water levels to inform the interpretation of the vulnerability analysis results. Several of these recurrence intervals have been estimated based on extremely limited datasets and include a high degree of uncertainty.

Table 3-2
Critical elevations used to evaluate sea level rise impacts

Elevation	Physical Interpretation	Estimated Recurrence Interval 2015	Estimated Recurrence Interval with 5ft of SLR
5' NAVD	Approx. Mean High Water Level (2014)	**Daily**	**Almost Always**
10' NAVD	Approx. Elevation of beach berm crest (2014); or Approx. Mean Sea Level +5ft SLR	**1-5 Years*** (without inlet management) **5-100 Years*** (with inlet management)	**Daily**
15' NAVD	Approx. Elevation of beach berm crest + 5ft SLR	**~100 years***	**1-5 Years*** (without inlet management) **5-50 Years*** (with inlet management)

* High Level of Uncertainty

If an extreme fluvial[3] flood event occurred concurrently with a king tide, storm surge, or a large wave event, then water levels could significantly exceed the critical water levels listed in Table 3-2. Existing FEMA flood maps show the expected extent of flooding caused by a current 100 year fluvial event (1 in 100-year). FEMA's floodplain mapping did not consider the potential for elevated water levels caused by a closed Slough inlet or by future sea level rise.

This study has not evaluated the expected extent of flooding due to extreme fluvial flood events. The flood hazard due to an extreme fluvial event may exceed the flood hazard due to coastal flooding even with 5 feet of sea level rise. The fluvial flood elevation increases upstream along the creek channels. Sea level rise is expected to increase future fluvial flood elevations and extents due to the backing up of water in the lower parts of the Slough during high tides.

3.1.5 Evaluating Sensitivity to Sea Level Rise

Different habitats and infrastructure may have different levels of sensitivity to elevated water levels within the Slough. Some wetland habitats may be able to keep pace with sea level rise through natural accretion processes while others may convert to different habitat types with different rages of species and vegetation compositions that are more tolerant of increased inundation frequency.

Some infrastructure, such as the airport tarmac, are highly sensitive to inundation and may become inaccessible or unusable if ponded water is present while other infrastructure, such as sewer pipelines, can tolerate complete inundation as long as key pump facilities and electrical infrastructure are not damaged.

[3] Fluvial: related to rivers and creeks. A fluvial flood event occurs when the amount of flowing water exceeds a river or creek channel's capacity.

The sensitivity of the various habitat categories to sea level rise were evaluated using the Sea Level Affecting Marshes Model (SLAMM) modeling tool[4]. The results of this analysis are discussed in Section 3.1.6. The SLAMM results have been compared with a simplified Inundation Frequency (IF) habitat model to provide a validation dataset for the SLAMM model that is discussed in Section 3.1.7. An additional focus group was conducted with representatives from several resource agencies, ecologists and other scientists to discuss issues concerning the habits and ecological systems in the Slough. This focus group provided valuable local knowledge that aided with the interpretation of the SLAMM and IF model results.

A series of focus groups with the operators and managers of the key infrastructure in the Goleta Slough study area was engaged to understand the sensitivity of local infrastructure to flood related damage. The goal of these focus groups was to understand the conditions and mechanisms and crucial components by which existing infrastructure may become damaged, inaccessible, or inoperable as a result of high water levels in the Slough. In some cases, such as for hazardous materials and remediation sites, the sensitivity to sea level rise impacts is not well understood. Infrastructure sensitivity is discussed in Section 3.1.8.

3.1.6 Assessing Habitat Exposure and Sensitivity Using Habitat Evolution Modeling (SLAMM)

Habitat exposure and sensitivity to SLR related impacts were assessed using SLAMM. SLAMM can simulate the evolution of tidal wetland habitats over time by comparing the ground surface elevation, water table and habitat location with rising tide elevations and rates of erosion and accretion. SLAMM uses data from existing habitat surveys in order to develop correlations between habitat types and elevations relative to tidal water levels. SLAMM also tracks the rate of marsh accretion and erosion based on estimates for the local sediment supply and wave energy. The model tracks how marsh elevations evolve over time, and then predicts the extents of future marsh habitats based on the elevation correlations and projected rates of sea level rise. It was initially developed in the mid-1980s with EPA funding to evaluate changes to east coast habitats and wetlands and has evolved over time with support from many other funding sources, including The Nature Conservancy (TNC). The software is open source and freely available. This project used SLAMM version 6.2 beta. It should be noted that SLAMM only projects changes in a tidally influenced system. If the Slough inlet is allowed to remain closed, then the SLAMM results should not be used to support decision-making.

SLAMM simulates the dominant processes involved in wetland conversions during long-term sea level rise: inundation, erosion, overwash, saturation, and accretion. A complex decision tree incorporates both geometric and qualitative relationships to model habitat conversions in coastal habitats through spatial relationships (e.g. adjacency and elevation). It is important to note that while the dominant processes are represented, this is not a hydrodynamic or sediment transport model[5]. The following model processes are applied at each time step:

- *Inundation*: As sea level rises, the ground surface elevation decreases relative to mean sea level. This causes habitats to convert to habitats found lower in the tide frame. Inundation is calculated based on the minimum elevation and slope of the local topographic grid cell.

[4] SLAMM is an Open Source model that is maintained and distributed by Warren Pinnacle Consulting, Inc.

[5] SLAMM simulates processes related to the evolution of different habitats over time. A hydrodynamic model simulates the flow of water due to natural and mechanical forces. A sediment transport model simulates the movement of sediment, often caused by wind or flowing water.

- *Erosion*: Horizontal erosion representing wave action along shorelines is triggered given a minimum fetch threshold and proximity of the marsh to estuarine water or open ocean.
- *Saturation*: Migration of coastal swamps and fresh marshes onto adjacent uplands as driven by a rising water table.
- *Accretion*: Vertical rise of marsh due to buildup of organic and inorganic matter on the marsh surface.
- *Overwash*: Overwash occurs at a specified interval (i.e. every 20 years) causing barrier islands to migrate inland over time. The overwash module has been disabled for this project since barrier islands and the associated overwash by major U.S. East Coast storms (i.e. hurricanes) are not applicable to the Goleta Slough study area.

The primary inputs to SLAMM include a high-resolution digital elevation model, a map of current wetland habitats, future sea level rise projections, marsh accretion rates, tide ranges, and erosion rates. The resulting SLAMM projections of future extents of individual habitats with sea level rise are shown in the habitat summary sheets (Appendix E). Figures 3-2 through 3-4 show the projected habitat extents under current and future conditions assuming open inlet management. The results of the SLAMM analysis are tabulated in Table 3-3 Predicted Habitat Areas and Table 3-4 Predicted Change in Habitat Areas.

Figure 3-2 Habitat bands by inundation frequency under existing conditions using SLAMM model

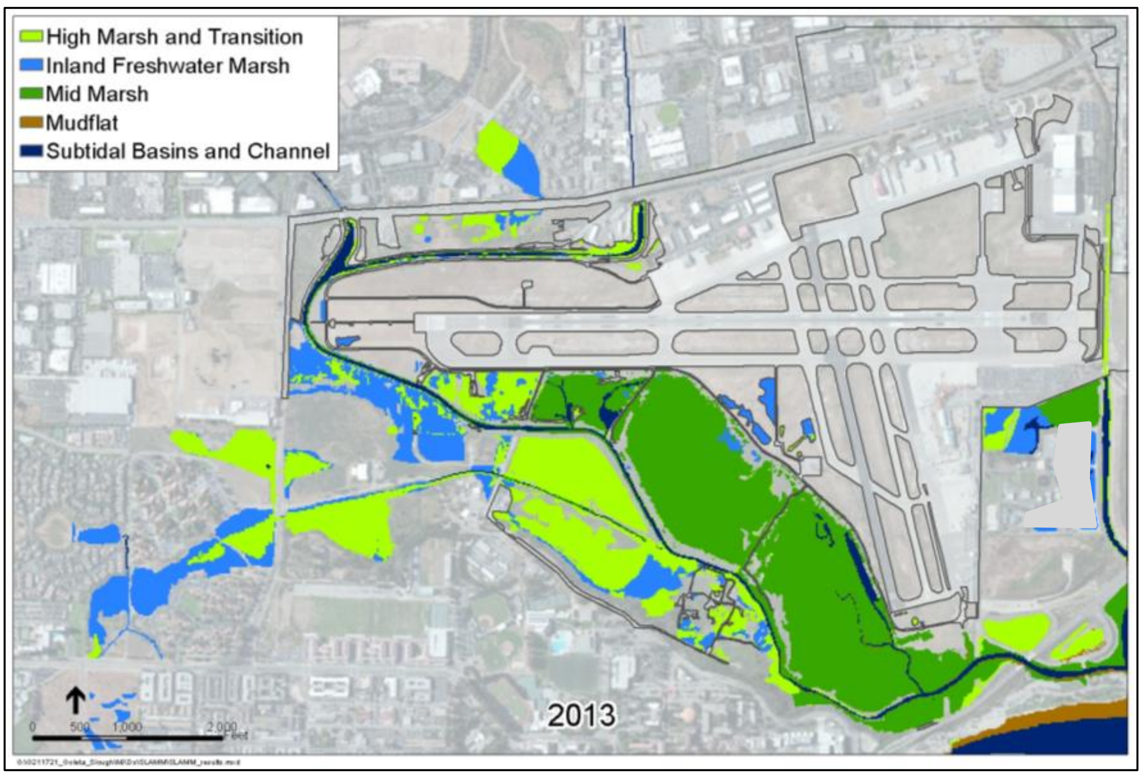

Figure 3-3 Habitat bands by inundation frequency in 2100 with 1mm/year accretion rate using SLAMM model

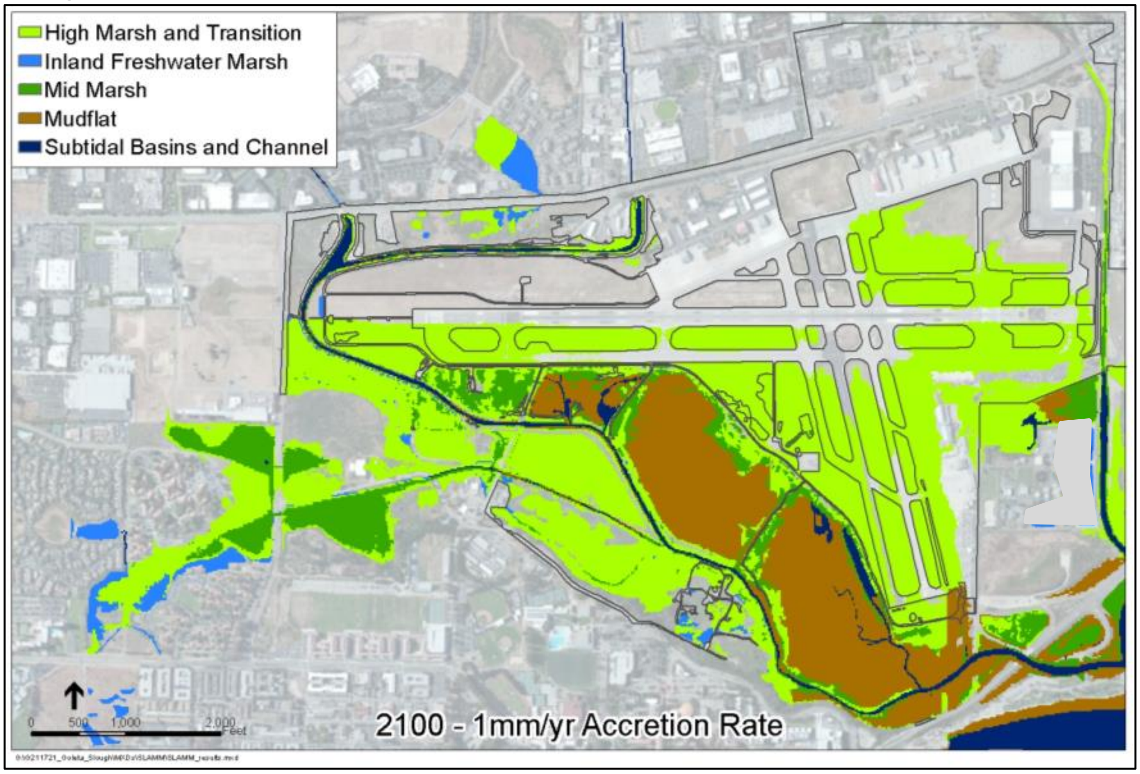

Figure 3-4 Habitat bands by inundation frequency in 2100 with 5mm/year accretion rate using SLAMM model

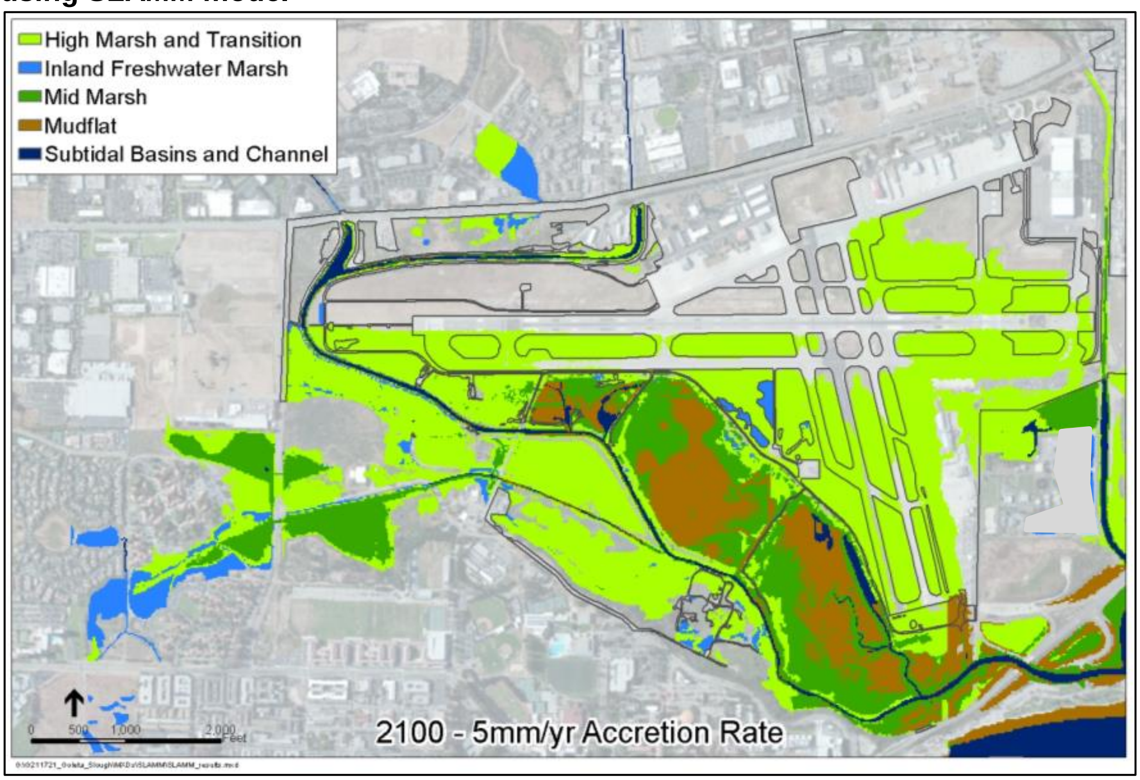

Table 3-3 Predicted Habitat Areas (from SLAMM analysis)

	Acres								
	Year 2013	Year 2050				Year 2100			
	With Tide Gate	With Tide Gate		Without Tide Gate		With Tide Gate		Without Tide Gate	
Habitat Type	(no accretion)	1 mm/yr accretion	5 mm/yr accretion	1 mm/yr accretion	5 mm/yr accretion	1 mm/yr accretion	5 mm/yr accretion	1 mm/yr accretion	5 mm/yr accretion
Uplands	597	595	595	594	594	553	553	548	549
Freshwater Non-Tidal Marsh	26	24	26	21	22	19	20	13	16
Open Water	38	40	40	40	40	43	42	46	44
Mudflat	8	7	7	10	9	26	18	27	20
Saltmarsh	24	24	24	25	25	11	17	12	18
High Marsh/Transitional	11	14	13	15	14	53	54	58	58
Total	728	729	729	729	728	728	729	726	729

Table 3-4 Predicted Change in Habitat Area, Relative to 2013 (from SLAMM analysis)

	Acres	Change in Acreage							
	Year 2013	Year 2050				Year 2100			
	With Tide Gate	With Tide Gate		Without Tide Gate		With Tide Gate		Without Tide Gate	
Habitat Type	(no accretion)	1 mm/yr accretion	5 mm/yr accretion	1 mm/yr accretion	5 mm/yr accretion	1 mm/yr accretion	5 mm/yr accretion	1 mm/yr accretion	5 mm/yr accretion
Uplands	597	(2)	-	(1)	-	(41)	-	(5)	1
Freshwater Non-Tidal Marsh	26	(2)	2	(5)	1	(3)	1	(7)	3
Open Water	38	2	-	-	-	3	(1)	4	(2)
Mudflat	8	(1)	-	3	(1)	17	(8)	9	(7)
Saltmarsh	24	-	-	1	-	(14)	6	(5)	6
High Marsh/Transitional	11	3	(1)	2	(1)	39	1	4	-

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3.1.7 Inundation Frequency Model

In order to validate the SLAMM results, a simplified Inundation Frequency habitat model has been applied to the Goleta Slough system. Like SLAMM, the Inundation Frequency model predicts future habitats based on the elevation of the landscape relative to the tides. However the Inundation Frequency uses a simplified method for determining habitat type based on the range of inundation frequencies characteristic of different habitat types.

Clusters of wetland species have been observed to occupy regions of tidal marsh based on the frequency of inundation. Relationships between habitat occurrence and the amount of time submerged (inundation frequency) were developed based on observations of habitat occurrence at several coastal lagoons along the Santa Barbara County coast (Hubbard, pers. comm., 2013). Table 3-5 lists the several key wetland habitat categories and their associated inundation frequencies.

Table 3-5. Wetland Habitat Inundation Frequency

Habitat Category	Inundation Frequency
Subtidal	100%
Mudflat	45%-100%
Low Marsh	20%-45%
Mid Marsh	5%-20%
High Marsh	0%-5%
Uplands	0%

In a tidal estuary like Goleta Slough, the frequency of inundation at a given location is determined by the elevation relative to the local tides. A frequency analysis of water levels in Goleta Slough was undertaken using water level data provide by CCBER and the City of Santa Barbara in order to identify the inundation frequency at different elevations. The results of this analysis were used to identify the elevations associated with six representative habitat categories. These relationships between elevation and habitat were then applied to the 2010 Coastal LiDAR topography (Figure 3-5) in order to map the expected habitats across the site.

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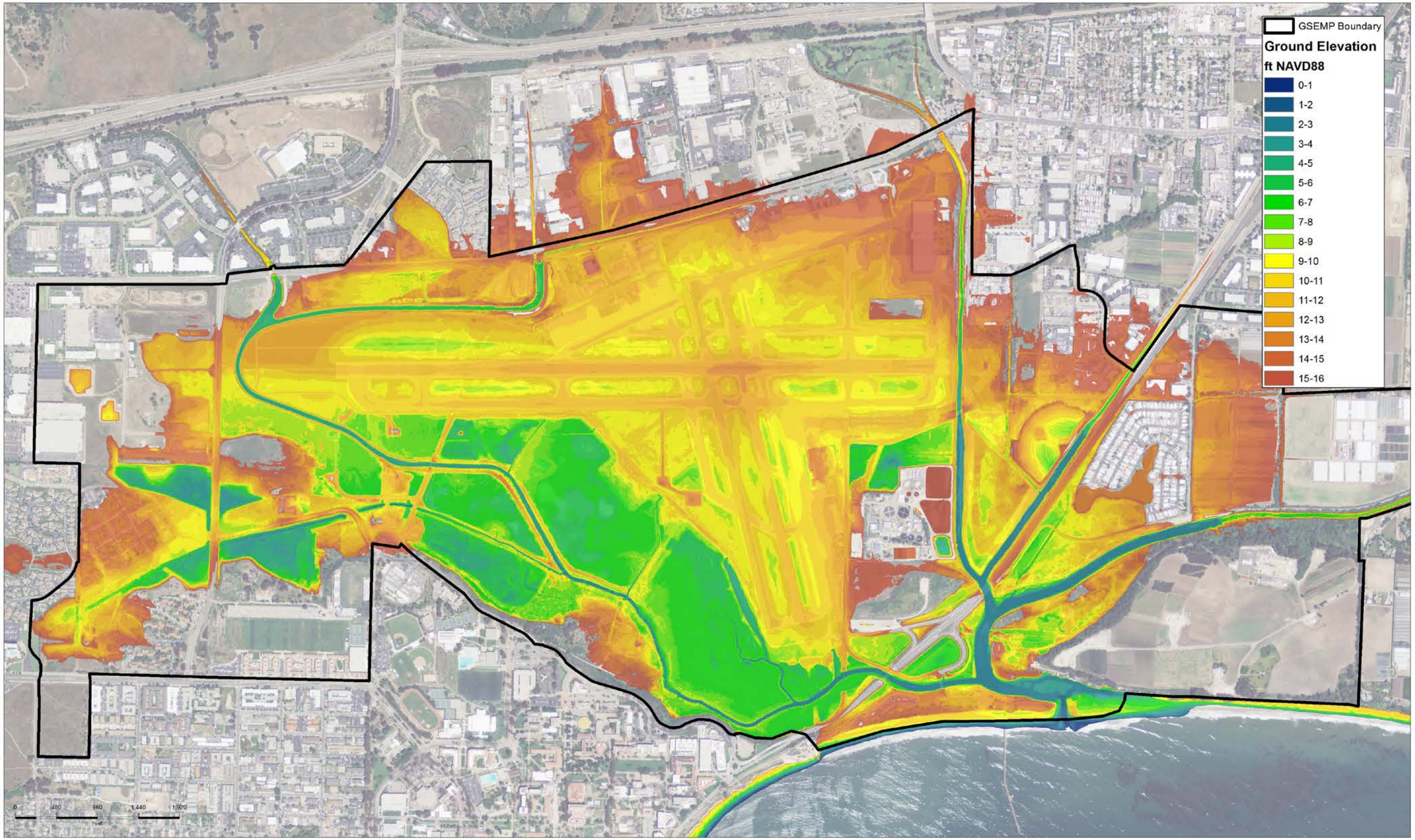
Figure 3-5 2010 Coastal LiDAR topography



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The method outlined above was used to map future habitats extents by shifting the elevations for each habitat type upward based on the expected amount of future sea level rise and accretion. This method can also project habitat changes for a non-tidally influenced Slough during which the inlet of the Slough is allowed to close based on observed water levels within the lagoon during closed conditions. Note that there is a high degree of uncertainty with respect to the future habitats under closed conditions due to the relatively infrequent occurrence of closed conditions at Goleta Slough in recent history for closed conditions and the lack of other large, frequently closed lagoons that might serve as reference sites. Figures 3-6 and 3-7 show the projected habitat extents under current conditions assuming open and closed inlet management. Figure 3-8 shows the projected habitat extents for the year 2100 with future sea level rise and open inlet conditions. The patterns of habitat transgression shown in these figures match the general patterns predicted using the SLAMM model for areas connected to tidal processes.

Figure 3-6. Habitat bands by inundation frequency under existing conditions and with open inlet management.

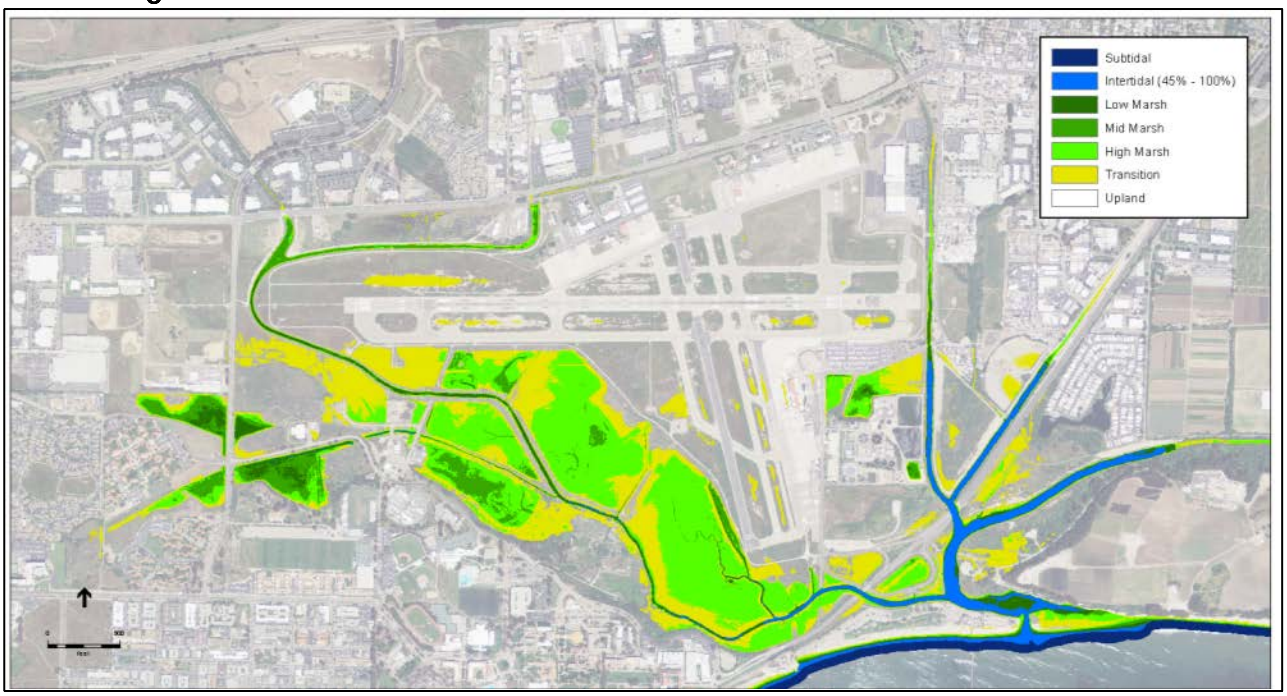


Figure 3-7. Habitat bands by inundation frequency under existing conditions and with closed inlet management.

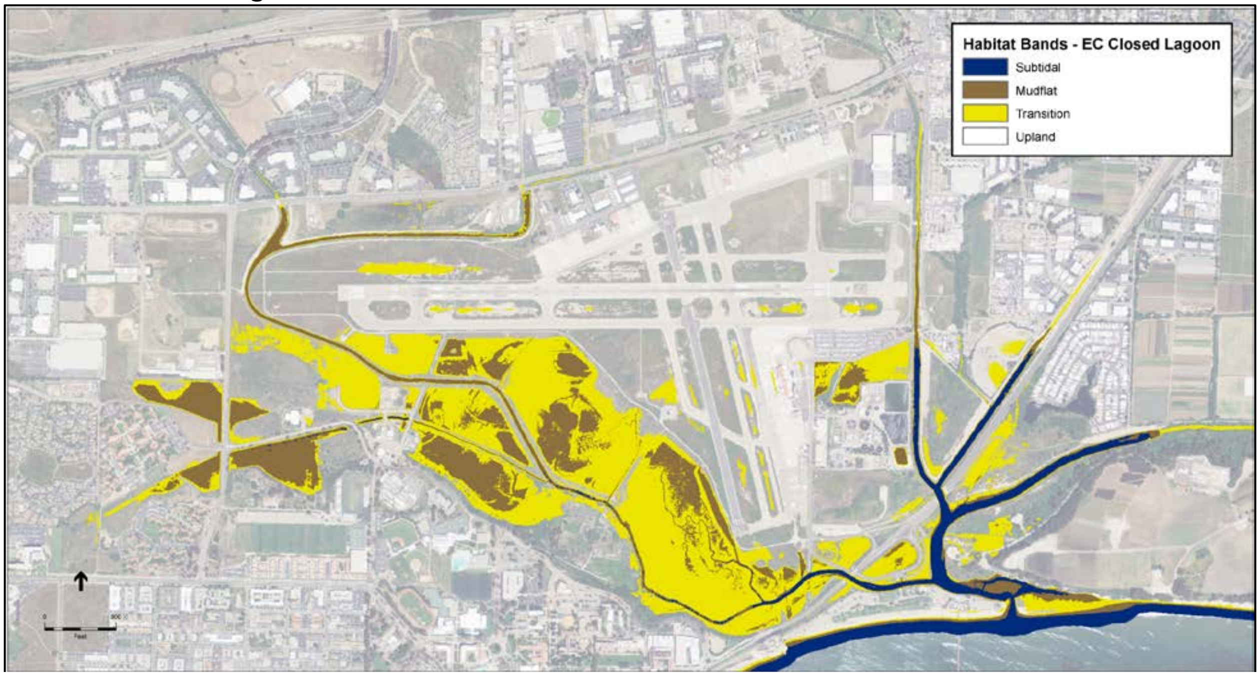
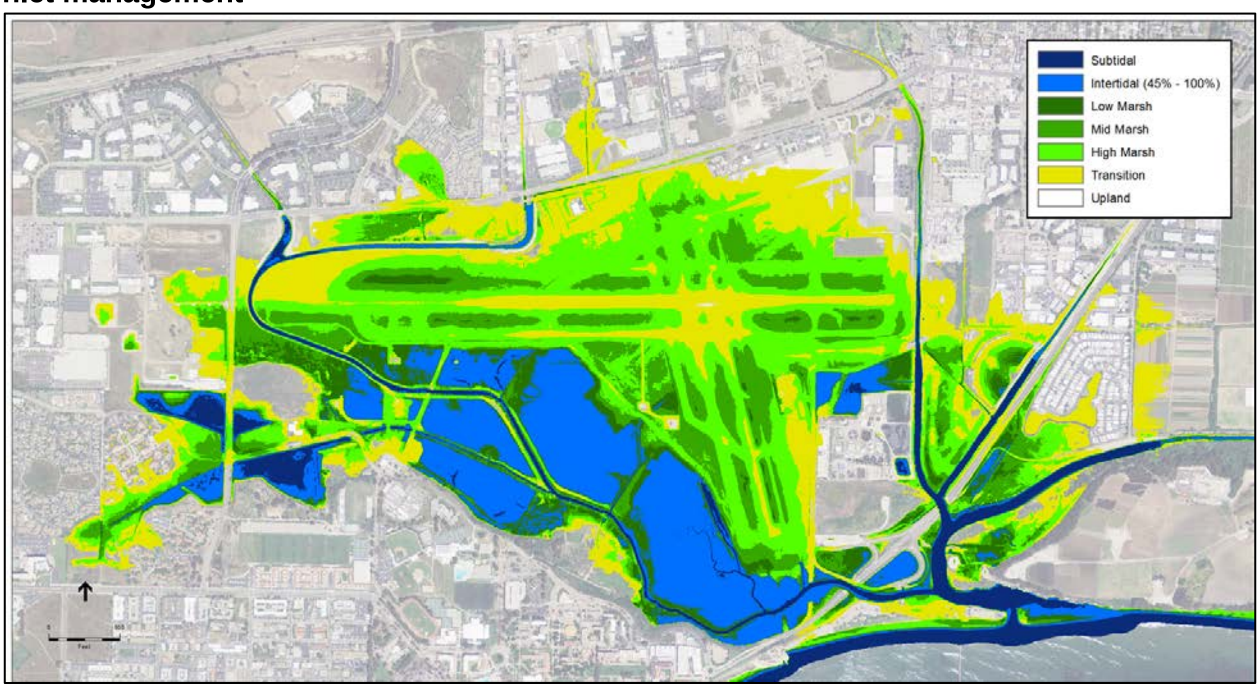


Figure 3-8. Habitat bands by inundation frequency under SLR scenario at 2100 with open inlet management



3.1.8 Assessing Infrastructure Exposure and Sensitivity

This study provides an estimate of the expected present and future extent of infrastructure vulnerability within the study area and attempts to identify infrastructure that is likely to be most vulnerable to future flood impacts based on the best available data. Due to the inherent uncertainty in the methods of this study, the results of this study are intended for informational purposes only and should not interpreted as a formal flood study or as an assessment of vulnerability for any specific property, structure or infrastructure. The vulnerability of specific structures or infrastructure should be assessed by a qualified professional.

Maps depicting the location of key infrastructure within the vicinity of Goleta Slough were developed based on input from local municipal agencies and utility companies (see Appendix F). The infrastructure elements for which elevation data is available have been color coded to reflect the relative vulnerability of each piece of infrastructure to increases in sea level. In general, the vulnerability of infrastructure in low-lying areas is expected to increase with time as sea levels rise over the next century. The vulnerability classification is based solely on the elevation of that infrastructure relative to the critical elevations identified in Table 3-2 plus any specific vulnerability identified during the stakeholder outreach process. The future vulnerability of infrastructure within Goleta Slough will also depend on the future management of the lagoon inlet and any new flood protection measures that may be implemented in the future.

These maps also contain an overlay identifying the area where the ground surface elevation is below each of the three critical elevations of 5, 10, and 15 feet NAVD as described in Table 3-2. This overlay is intended to indicate the approximate extent of inundation if water levels within the Slough are to pond at each of the three critical elevations.

While topographic elevation is generally a good indicator of an area's vulnerability to flooding, it is important to acknowledge the limitations of this method for vulnerability estimates. The elevation overlay does not reflect the flood protection provided by non-certified berms and other topographic features that, while not certified as flood control levees, may provide some level of flood protection for some low-lying areas. In addition, the elevation overlay does not represent variations in water level due to local hydraulic conditions such as creek inflows, weirs, and wave run-up/overtopping. Consequently, the actual extent of inundation during a real storm event may vary from that shown in the elevation overlay due to localized conditions.

For this analysis we have estimated the ground floor elevation of structures based on nearby ground surface elevations as shown in available LiDAR datasets. This method may over-estimate the vulnerability of structures with ground floor elevations that are raised above the adjacent ground surface.

3.1.9 Vulnerability Results

The methodology and conceptual framework described above was used to conduct the habitat and infrastructure vulnerability analyses and the results of these analyses are presented in Appendices E and F. These appendices contain a set of summary sheets which summarize the results of this analysis. An example summary sheet is shown in Figure 3-9. Each summary sheet addresses a different category of habitat or infrastructure and contains a map showing the location of the habitat or key infrastructure within the study area as well as a table describing the exposure, sensitivity and vulnerability of each category to sea level rise related impacts.

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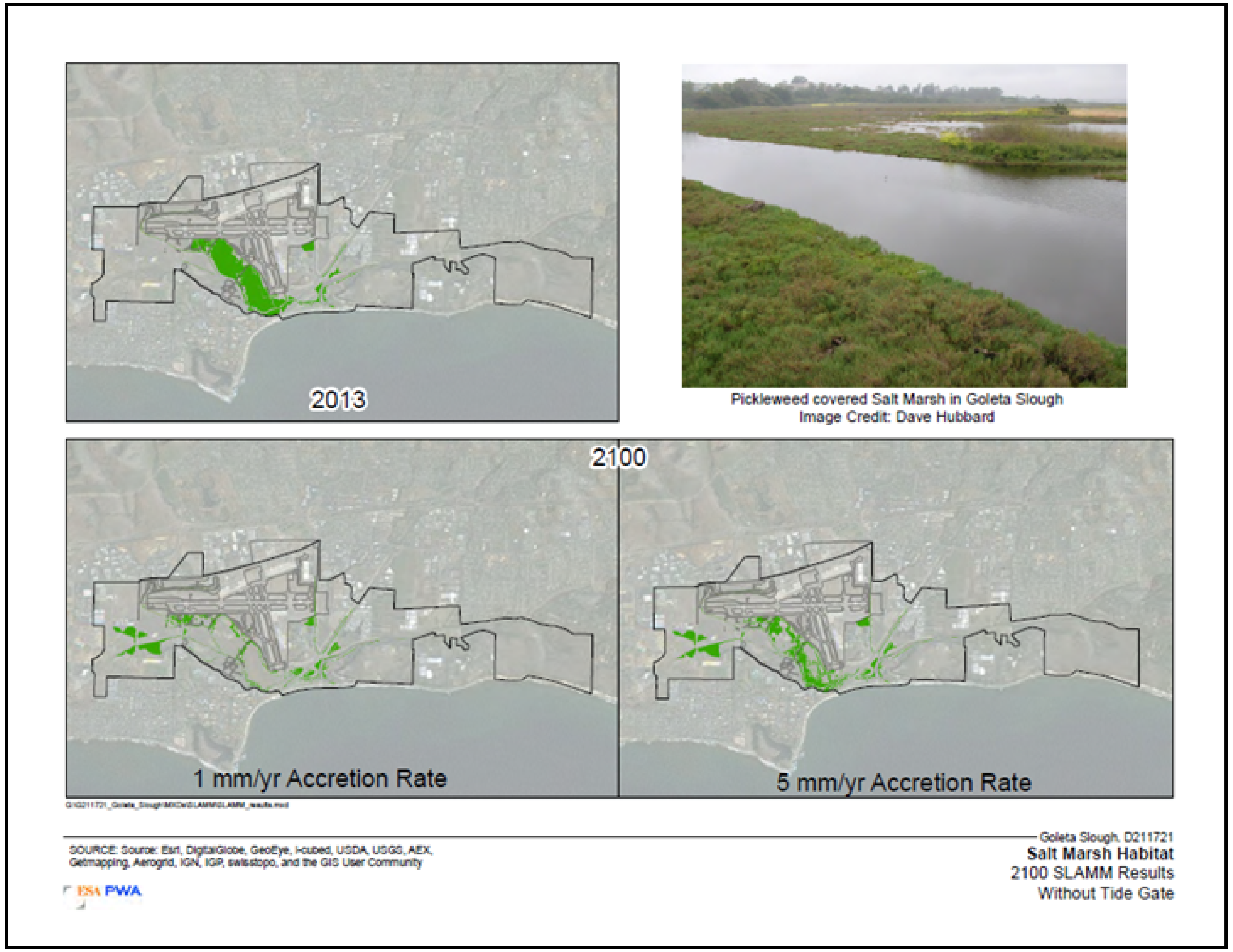
Figure 3-9 - Example of Vulnerable Habitat Summary Sheet included in Appendix E



Function	Salt Marsh
Location	Tidal salt marsh is a wetland habitat that is periodically inundated by saline water on rising tides. Tidal salt marsh habitats are characterizes by a collection of plant species, such as pickleweed *(Salicornia virginica)*, which are adapted to thrive in a frequently inundated, high salinity environment. Salt marsh species generally occur in areas that are tidally inundated 5% to 45% of the time. Under historic lagoon mouth management conditions at Goleta Slough, this habitat generally occurred at elevations ranging from 3.5 ft to 5.5 ft NAVD[1].
Types of Hazard	Conversion of existing habitat due to more frequent tidal and fluvial inundation. With modeled increases in sea level and water levels within Goleta Slough, salt marsh habitat would migrate upslope, replacing existing high marsh and transitional habitats, while being replaced by mudflats.
Proximity to Hazard	Habitat Evolution Modeling for the Goleta Slough ecosystem predicts the extensive conversion of salt marsh habitat into mudflat and the limited upslope migration of tidal high marsh habitat: • Large areas of Salt Marsh are found within the basins south of airport runways. • Limited pockets of salt marsh occur in areas adjacent to the Atascadero and San Jose Creek channels.
Anticipated Changes	• Increased sea level and inundation times across within Goleta Slough would lead to the conversion of existing salt marsh to mudflat and vegetated intertidal habitats. The conversion of salt marsh to mudflat due to rising sea levels, may be slowed or in some cases prevented by accretive processes related to sediment accumulation. • Loss of bio-geochemical cycling functions associated with vegetated marsh (carbon sequestration, nutrient uptake) may compromise lagoon water quality. • Salt marsh habitats may migrate upslope, replacing existing High Marsh habitats; however the local topography within Goleta Slough is such that there are few areas where this upslope migration is viable, the most notable being the pond areas near Los Carneros and Mesa Rd.
Severity of Changes	• Conversion of habitat types may lead to the loss of intertidal pickleweed habitats and loss of animals dependent on those plant species. • The loss of salt mars habitat would disrupt bio-geochemical cycling associated with vegetated marsh, including carbon sequestration and nutrient uptake.
Risk of Changes	Risks associated with the conversion of salt marsh habitats and associated losses are linked directly to rising water levels within the slough and increased inundation frequencies. Habitat evolution modeling predicts a significant loss of salt marsh habitat under future sea level rise conditions. The extent of habitat loss varies based on the availability of sediment within the water column. An increased sediment supply may reduce the risk of salt marsh habitat loss.

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Generally, Goleta Slough can expect to experience significantly more frequent occurrence of high water levels due to sea level rise. Increased water levels may lead to significant shifts in the distribution of wetland habitats within the Slough. Most notably, pickleweed marsh is expected to convert to mudflat due to increased inundation, and a net loss in mid and high-marsh habitats will occur unless upland areas are made available for habitat transgression.

Habitat Changes

For the given sea level rise scenarios, and assuming that the lagoon continues to be managed for open inlet conditions and no special actions to address sea-level rise, the following habitat changes are expected:

1. Low marsh would convert to mudflats in the basins south of the Airport runways;
2. Upland habitats adjacent to the Slough are expected to convert to high marsh; however the current land use for many of the uplands adjacent to the Slough are not compatible with a conversion to wetland habitat (e.g., Airport operations areas); and,
3. Freshwater wetlands located near the downstream reaches of the Slough are expected to convert to saltmarsh due to elevated tide levels.

Infrastructure Vulnerability

Several key infrastructure assets within the Slough are already vulnerable to flooding under existing conditions, most notably the airfield runways and stormwater systems, the Placencia Street neighborhood east of the Terminal, and low-lying sections of Mesa and Fowler Roads (see Appendix F). These areas will experience more frequent flooding with sea level rise.

Additional infrastructure assets will become exposed to frequent flood impacts due to rising sea levels. These include the Goleta West Sanitary District pump station (near the UCSB Police Station), and numerous commercial and residential structures in areas adjacent to the Slough. Existing storm water and sewer infrastructure in these areas may also become compromised due to the increased frequency of flooding.

3.2 Sea Level Rise Adaptation Measures

3.2.1 Habitat Adaptation Measures

Goleta Slough has been managed for high tidal function and water quality for more than twenty years, primarily through periodic mechanical opening of the Slough inlet when it naturally closes. Maintaining tidal functions and restoring more tidal habitat have been stated goals of the GSEMP since 1997. Goleta Slough currently has a much smaller tidal prism[6] than it did historically as a result of the following historic events:

- Large volumes of sediment moved into the system after land use practices changed in the watershed in the post-European contact period and subsequent fires, flooding and erosion;
- Filling of a portion of the estuary occurred during the construction of the Marine Corps Air Station (now the Airport) during World War II; and,
- Some potential tidewater area is cut off by a tide gate that was installed near the Goleta West Sanitary District plant about 50 years ago.

The reduction of Goleta Slough's tidal prism has reduced the ability of the tidal channel to stay open without active management. While the lagoon historically functioned as a primarily open tidal system, these reductions in tidal prism have increased the tendency for the inlet to close and the

[6] Tidal prism – the volume of water that flows into or out of a tidal basin during an average tidal cycle.

lagoon to become impounded and cut off from the tides. The inlet has been mechanically opened an average of twice a year over the last twenty years to reduce flooding potential, maintain tidal circulation and manage water quality.

For the Goleta Slough system the most notable management adaptation issue is the decision whether or not to continue to breach the Slough inlet following natural closure events. A Draft Biological Opinion issued by National Marine Fisheries Service (NMFS) in early 2013 changed the management of the Goleta Slough inlet from a regime where the lagoon inlet was breached within two weeks of closure to the current practice where the lagoon mouth is breached only when there is an imminent threat of flooding. The management regime for the Slough inlet is still being studied; therefore this report considers two general scenarios for Goleta Slough in the future:

1. The Inlet is managed open conditions and for high tidal circulation trough managed breaches, and,
2. The Inlet is allowed to close naturally and remains closed until non-tidal for some of the year and is breached during or immediately prior to large precipitation events where there is the potential for flooding.

In 2014 ESA conducted a detailed study to evaluate the likelihood of open or closed inlet conditions in the absence of active inlet management under a range of potential future scenarios. The results of this study are discussed in detail in Section 3.3.

In the case that Goleta Slough inlet is managed to remain open and tidally connected most of the year, the model results indicate that estuarine habitats are expected to migrate upslope as increasing sea level increases the frequency of inundation at lower elevations. Although there is little data for suspended sediment in the Goleta Slough system, the modeled sea level rise scenarios include two alternatives representing low and high sediment accumulation rates (estimated based on typical sedimentation rates in San Francisco Bay). These two scenarios are intended to highlight the important role that sediment supply plays in determining potential ecological responses to rising sea levels. The modeling for this study and observations in other systems (San Francisco Bay) show that even moderately high suspended sediment loads seem unlikely to prevent major changes in marsh ecosystems with high sea level rise rates, however higher sediment concentrations will reduce the rate at which tidal marsh habitat is lost and may allow for greater opportunities for the marsh to successfully transgress to adjacent uplands (Stralberg et al. 2011).

If the inlet remains closed for extended periods of time, then salt marsh systems subject to prolonged impoundments will not necessarily track the rising sea level in a linear way because the habitats will not be consistently connected to tidal processes. Under closed inlet conditions species that are dependent on regular tidal action or on consistent salinities and high water quality may be lost from the system. Habitats in impounded systems may be exposed to prolonged periods of very low or very high salinities, low oxygen levels, high temperatures, and periods with hypersaline soils during dry years. Under such conditions it will become increasingly difficult to maintain healthy tidal marshes, however the extent of subtidal and mudflat habitats would be expected to increase. The habitat adaptation measures described below first look at improving hydraulic connectivity and then altering the topography by sediment placement. These measures are shown in Figure 3-10 and 3-10 and are evaluated in Table 3-6. All the measures described below are limited at some point by constraints of infrastructure flooding and the consequent maximum water surface elevation. Measures to increase the maximum water surface elevation before flooding occurs are described in section 3.2.2.

Improve hydraulic connectivity (Figure 3-10 and Table 3-6)
In addition to managing the inlet, there are opportunities to encourage greater tidal flows into and out of the Slough by breaching dikes and restoring tidal action. There are several areas within the Goleta Slough system where the existing ground elevations are suitable for the establishment of marsh vegetation but that are currently colonized by upland plants due to poor hydraulic connectivity. These areas offer significant opportunities for the creation of new tidal wetland habitats. In the case of the leveed basins south of the airfield runway, habitat creation and restoration could be achieved by breaching the existing berms adjacent to the Los Carneros Creek channel at key locations. Section 3.3 provides greater detail regarding the expected impact that increasing the volume of the slough will have on the natural patterns of breaching and closure of the lagoon inlet. The general finding of the inlet study is that small restoration efforts are unlikely to cause a shift in lagoon dynamics, as the relatively small increase in tidal prism due to a small restoration would not be enough to create a self-scouring inlet. In contrast, a large scale restoration effort (one in which all of the areas indicated on Figure 3-10 were opened to tidal action) would be expected to shift the lagoon towards more frequently open conditions. This is because the much larger increase in tidal prism under such a scenario would increase tidal scour at the inlet to the point that the tidal flows would self-scour out the inlet channel under most tide and wave conditions.

Remove or relocate the tide gate near Goleta West Sanitary District
The tide gate located near the Goleta West Sanitary District pump station currently restricts tidal flows to the low-lying areas near Los Carneros Road and Mesa Road. The tide gate, installed in the mid-1950s by Thomas Storke, was built to provide flood protection to grazing land, homes and businesses to the west of Goleta Slough, however it also has caused noticeable changes in the wetland habitats in the area.

ESA has applied the SLAMM model to evaluate the evolution of wetlands habitats under future conditions with and without the tide gate. The results of this modeling indicate the potential for the areas behind the tide gate to convert to tidal marsh habitats, and that the future extent of these habitats is highly sensitive to the rate of sediment accretion within these new tidal wetland areas. Additional flood protection may be needed to prevent flood damage to low-lying structures in nearby areas, particularly if the tide gate is to be opened or removed.

Enhance Sediment Supply to Tidal Wetlands
Tidal wetlands grow over time following changing sea levels. Marsh vegetation traps sediment from the water column, and the accumulation of vegetation biomass also contributes to the accretion of the marsh plain, allowing marshes to increase their elevation to match rising sea levels. Marsh accretion can be enhanced by increasing the amount of available sediment reaching the marsh plain. Figure 3-11 shows the five sediment basins currently maintained by Santa Barbara County Flood Control. The material from these basins is currently removed from the Slough and used as offsite fill materials, for beach nourishment and/or is sent to landfills. Sediment removed from these basins as part of ongoing flood control activities could instead be used to improve habitat resilience through marsh sediment augmentation efforts that could increase marsh plain accretion rates. Increased marsh plain accretion would enhance the overall resiliency of the marsh to sea level rise. Marsh plain accretion could be increased by:

- Improving the connection between the creeks and neighboring marsh plains, which would allow natural deposition of sediment on the marshes
- Delivering thin layers of sediment to the marsh through mechanical methods, potentially through the use of low-impact grading techniques or hydraulic delivery methods

Upland areas adjacent to marshes can provide valuable habitat, increase connectivity between habitat areas and create areas that are suitable for future upland transgression of marshes as sea levels rise. In addition to using sediment to enhance marshplain accretion, there are opportunities to use the material from the sediment basins within the Slough to increase the extent of upland transitional areas, especially along the southern and western perimeter of the airport. There may be opportunities to acquire open space areas adjacent to the Slough for conservation purposes, and material from the sediment basins is a valuable resource that could be used for grading and shaping such areas to promote the establishment of target habitats as part of restoration and habitat enhancement efforts.

Figure 3.10 – Hydraulic Connectivity Measures

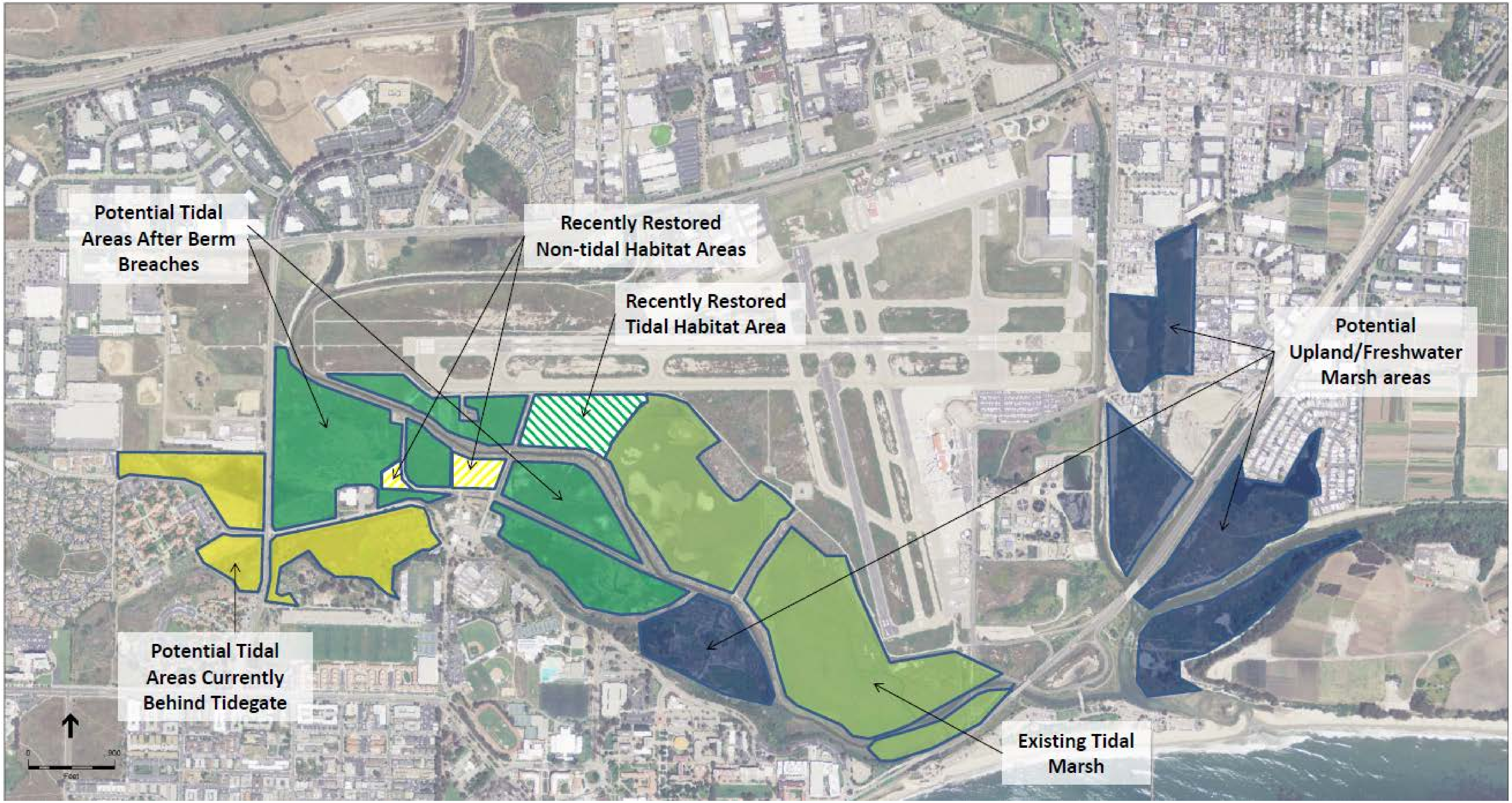

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Figure 3.11 – Topographic Adjustment Measures

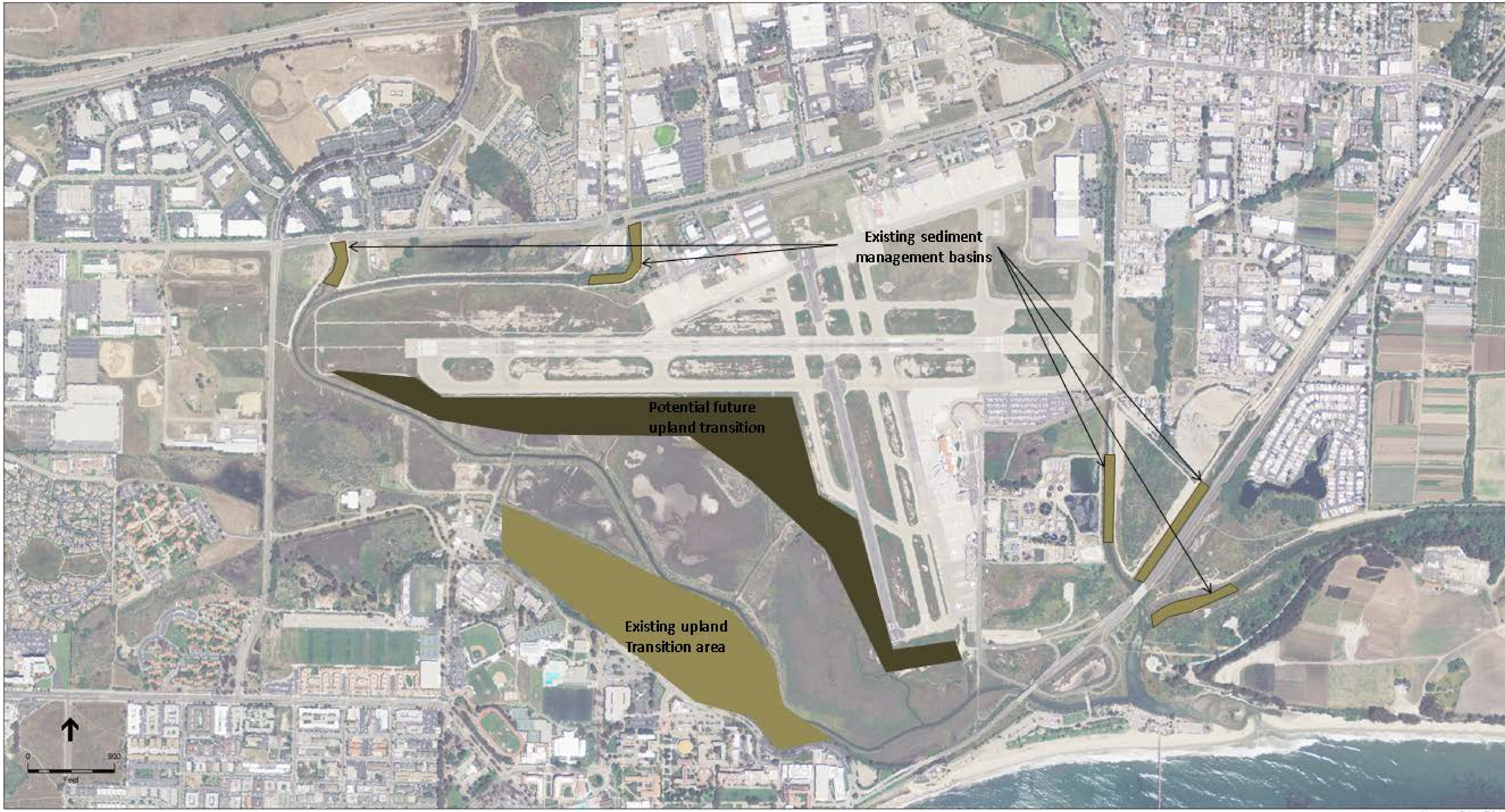

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Table 3.6 Comparison of Adaptation Measures for Tidal Wetlands and Prerequisites for Implementation of Individual Measures

Adaptation Strategy	Individual Adaptation Measure	Benefits	Drawbacks	Sea Level Rise Accommodation	Relative Cost	Estimated Lead Time and Prerequisite
No Action	No managed inlet breaches, emergency inlet breaches only as need to protect the airfield and other low-lying areas from flooding.	• More mudflat in dry period. • Potential benefits to tidewater goby and steelhead.	• Potential loss of tide dependent species, functions and ecosystem services. • Specifically loss of Belding Savanah Sparrow (BSS) nesting habitat. • Vector control and bird strike issues may lead to intervention.	Limited by infrastructure constraints. Little opportunity for habitats to transgress upslope.	$	*Status quo*
Inlet Management (Managed Breaches of Beach Berm)	Manage inlet breaches to maintain open tidal conditions; fully tidal.	• High tidal function. • Increased tidal range and prism. • Increased circulation – water quality benefits. • Supports widest range of tide dependent species, functions and ecosystem services. • Maintain and enhance BSS habitat. • Minimizes vector control and bird strike issues.	• Requires management and resources to breach. • Needs to account for needs of special status species.	Limited by infrastructure constraints. Potential to transgress upslope because of tides.	$$	Done before, Short lead time– but needs regulatory discussion.
Control Hydrology Option #1	Breach channel levees and remove berms along tidal basins south of airport.	• High tidal function. • Increased tidal prism. • Increased biocomplexity and diversity. • Connection to uplands. • Increased habitat patch size and connectivity between patches. • Supports widest range of tide dependent species, functions and ecosystem services. • Maintains and enhances BSS habitat. • Minimizes vector control and bird strike issues.	• Potential loss of seasonal ponds used by waterfowl and wading birds.	Limited by infrastructure constraints. Potential to transgress upslope because of space and connectivity.	$$	Planning, permits, resources Precursor – needs inlet management.
Control Hydrology Option #2	Modify tide gate to allow tidal flows in western basins.	• Increase tidal function. • Increased tidal prism. • Increased biocomplexity and diversity. • Connection to uplands. • Increased parcel size and connectivity between parcels. • Supports widest range of tide dependent species, functions and ecosystem services. • Maintain and enhance BSS habitat. • Reduces vector control and bird strike issues.	• Lose freshwater habitat. • Potential loss of seasonal ponds used by waterfowl and wading birds. • Limited by culverts and gates. • Low-lying, poorly drained areas may become shallow ponds – potential to attract ducks. • May increase flood risk to existing development.	Limited by infrastructure constraints. Increased space balanced by hydraulic controls in place.	$$	Needs preparation of infrastructure before modification. Precursor – needs inlet management.
Sediment Management	Beneficial reuse of sediment from flood control sediment basins. Encourage natural sedimentation by reconnecting creeks to marshplain.	• Natural process. • Reconnects water, nutrients, fish and sediment to the marshplain. • Balance accretion of marsh with sea level rise. • Creation of natural marsh levees adjacent to channels to increase heterogeneity.	• Less control of accretion location. • Potential sedimentation in the Slough reducing conveyance, also requires measures to increase tidal prism. • Large event may convert marsh to high marsh ahead of sea level rise.	Limited by infrastructure constraints. Increases resiliency of marshes to sea level rise.	$$	Need permits, sediment quality, needs removal of berms first Precursor - needs inlet management and berm removal.
Grade Topography	Selectively grade and place material to create upland areas to improve potential for upland marsh transgression with sea level rise.	• Immediate benefit of restoration of upland habitat. • Transgression of marsh habitat with sea level rise. • Upland habitat can be planned to maximize contribution to ecosystem.	• Infrastructure constraints. • Best marsh habitat in Slough not necessarily adjacent to upland opportunities. • Conversion of existing upland habitat.	Limited by infrastructure constraints. Increase adaptive capacity of marshes.	$$$	Precursor – needs inlet management.
Easement on Adjacent Uplands	Opportunistic use of new open space.	• Potential future benefits of restoration of upland habitat or wetland transgression. • Connectivity of adjacent parcels.	• Not many opportunities and not located in best places. • Cannot control timing.	Limited by infrastructure constraints. Increase adaptive capacity of marshes.	$-$$$	Precursor – needs inlet management.

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3.2.2 Infrastructure Adaptation Measures

There is a broad range of infrastructure present in the study area, some of which has been identified as vulnerable to rising sea levels. Measures that promote the protection of vulnerable infrastructure have been identified and are presented in Appendix F. These measures are classified according to the estimated ability of each to reduce the vulnerability of exposed infrastructure in terms of the amount of sea level rise accommodation that each may offer. These estimates are based on a conceptual understanding of the physical response of the Slough system to the various strategies, as well as feedback received from local planners, city and regional government agencies, utility representatives and past project experience.

For each measure, anticipated challenges related to the implementation of that strategy are also listed. The listed challenges were identified through discussions with local agencies and stakeholders. These lists are not necessarily all-inclusive and unanticipated challenges may arise during project implementation.

Each measure is categorized based on the anticipated level of expense and time to implement each strategy. These categorizations are based on discussions with the agencies responsible for the upkeep and maintenance of the various infrastructure assets. These categorizations are intended to inform the relative comparison of different strategies for planning purposes. These categorizations not intended to represent engineering cost estimates or assessments of project feasibility.

The Santa Barbara Airport stands out as the largest and most vulnerable facility within the Ecosystem. The Airport faces two primary vulnerabilities:

1. Flooding of the low-lying sections of runways and taxiways (see photos in Section 2, Background); and
2. Failure of the storm-water management system during high Slough water levels.

In addition, there are other low-lying areas where specific measures that could be implemented in the short-term to raise the maximum water surface elevation. These include not just specific assets but also roads that provide access to those assets such as the Airport Terminal, GSD plant, and Goleta Beach. Adaptation measures to address these vulnerabilities that appear likely to provide the most immediate benefits include:

Raise Airport Runways/Taxiways

The 2010 Coastal LiDAR shows that portions of the taxiways are located at elevations as low as 9.5’ NAVD88 making them prone to flooding under existing closed Slough inlet conditions. The runway low point is at 10.5 feet NAVD. Significant flooding of the runways and taxiways occurred during the 1969 and 1995 storm events. As sea levels rise the tarmac will flood more frequently, creating the potential for more frequent disruption of Airport operations.

One strategy for reducing the risk of flooding at the Airport is to increase the elevation of the tarmac by applying thicker pavement during the regular resurfacing of the runways, taxiways and safety areas. Applying thicker pavement at regular intervals over the lifetime of the Airport may significantly reduce the potential for flooding on the tarmac. This adaptation strategy has considerable potential effectiveness for the near term, as it can be readily incorporated into regular Airport capital improvement plans. This will also require the elevation of infield and overrun areas, some of which provide some habitat. The effectiveness of this strategy over the long-term may be reduced due to increased ground settlement as the thickness and therefore the weight of paving increases.

Improve the Airport Stormwater Management System

The network of storm drains, pipes and outfalls which currently convey storm water for the Airport tarmac and infields into Goleta Slough is a gravity driven system that drains into the Slough at elevation 5'. As water levels rise above 5' either from closed Slough or sea level rise, the stormwater system becomes increasingly ineffective. As the water level within the Slough increases, this could lead to ponding on the infield areas and eventually the runways and taxiways. Elevated Slough water levels may occur due to fluvial flows during storms, inlet closure, high tides and/or extreme wave events, and will occur more frequently under future sea level rise conditions.

Airport planners should anticipate implementing improvements to the storm water system within the near term in order to avoid disruption of Airport operations. The necessary level of improvement will depend on the future management of the Slough inlet, and may include improvements to the tide gates; the installation of swales, basins or cisterns to provide increased retention capacity; and/or the installation of pumps to provide increased drainage capacity.

Improve Flood Protection/Implement Land Use Changes at the Placencia Neighborhood

The neighborhood near Placencia Street on the east side of the Airport contains the most vulnerable commercial and residential buildings within the Goleta Slough plan area. The access road to this neighborhood floods under existing conditions when Slough water levels approach 9 feet. This area will flood more frequently over time, potentially resulting in property damage and water quality impacts due to the increased likelihood of sewer overflows.

Eventually more frequent flooding will make this area less habitable and more difficult to manage unless there are improvements to the existing flood control berms and levees. In addition, some retrofitting of the sewer lines may be required to seal the manhole covers and minimize the intrusion of Slough water into the sanitary sewer system. City Public Works planners should determine whether improved flood protection is feasible for this neighborhood. Alternately, if enhanced flood protection is not feasible, the City of Goleta may want to pursue opportunities to change the existing land use zoning in this neighborhood to open space/habitat in order to minimize future flood impacts.

3.2.3 Sea Level Rise Adaptation Strategies

The measures described in the preceding two sections describe near-, mid- and long-term habitat and infrastructure adaptation measures that need to be developed into a comprehensive strategy that includes specific thresholds for triggering actions. These thresholds may be the amount of sea level rise and the frequency of inundation, or they may be related to opportunistic structural changes such as capital improvement plans. To be effective, this strategy needs to move away from piecemeal habitat restoration and have a coherent vision and implementation plan. In addition, the strategy needs to accommodate the uncertainty inherent in the management of climate change risks.

To move forward in developing a vision of the future habitat, protection of vulnerable infrastructure and a plan for implementation will require a feasibility study of measures in order to develop priorities for implementation. This should be a next step together with the identification of some smaller habitat restoration opportunities that can serve as demonstration projects while funding and land use rights are secured to allow for larger scale habitat enhancements.

3.3 Goleta Slough Inlet Management

Since the mid-1990s, the Santa Barbara County Flood Control District (SBCFCD) had maintained the Slough inlet for open conditions through routine artificial breaching of the beach berm within 2 weeks of inlet closure. This practice was intended to reduce the flood risk to infrastructure adjacent to the Slough, and to avoid stagnation and thus improve water quality. The result of this management action is that it also supported the presence of tide-dependent species and habitats in the Slough. This Section discusses the key role that inlet management plays in shaping that habitats and function of Goleta Slough, and presents the results of a technical study conducted by ESA in 2015 to evaluate patterns of breaching and closure of the lagoon inlet under natural and managed conditions.

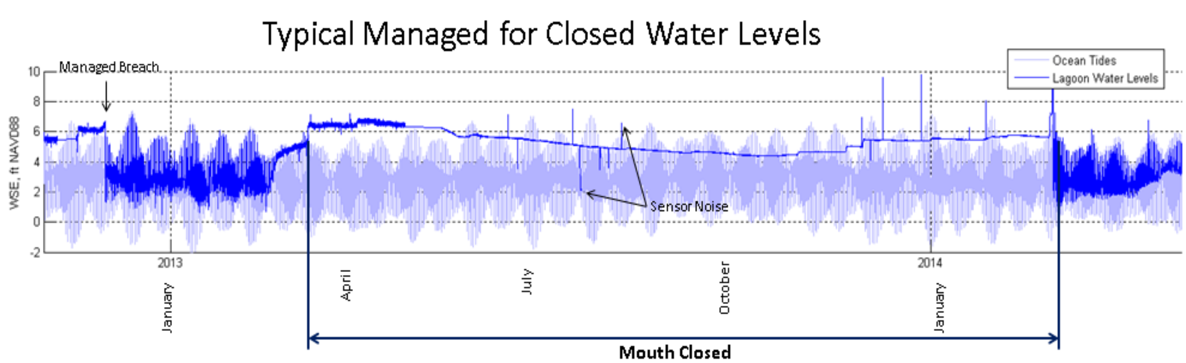
The Flood Control District's (FCD) *Final Subsequent EIR for Maintenance Activities in the Goleta Slough* (2010) that addresses maintenance activities, indicates that from 1994 through 2009 the inlet was opened 28 times or an average of just less than two openings per year. The inlet was opened three times in 1994, 2004 and 2009. Managed breaches were typically conducted using mechanized earth-moving equipment within 2 weeks of the Slough inlet closure.

In 2013, the National Marine Fisheries Services produced a draft Biological Opinion regarding the presence of steelhead within Goleta Slough, which led to the FCD stopping the managed breach program. In 2014, the Airport began studying the issues associated with Slough inlet management, with a final report expected in 2015.

3.3.1 Recent Management Actions and Flooding

When the Slough inlet closed in the spring of 2013 it was not artificially breached, and instead the Slough was allowed to remain under closed conditions for nine months until the imminent threat of flooding lead to an emergency inlet breach on March 1, 2014. The observed water levels in the Slough during this period are shown in Figure 3-12.

Figure 3-12 Ocean and Slough water levels between November 2012 and April 2014.



The fall and winter of 2013 were unusually dry. Between September 1, 2013 and February 1, 2014 the precipitation gage at the Goleta Fire Station recorded only 4 minor rain events, resulting in a combined total of 1.1 inches of cumulative precipitation. This is significantly less than the average rainfall for these months (the mean cumulative precipitation at the Goleta Fire Station for September through January is 9.8 inches). One consequence of this below average rainfall was that the Slough inlet remained closed for nearly 9 consecutive months. During this period wave action caused the beach berm to grow to an elevation exceeding 10 feet NAVD. This 10+ foot beach berm crest elevation at the Slough inlet is consistent with beach berm elevations measured elsewhere along the Santa Barbara County coastline. Anecdotal reports suggest that this was one of the highest beach berm elevations observed at the Goleta Slough inlet since managed breaching of the Slough inlet began.

On February 27, 2014 the first major rains of the season arrived, with 3 inches of rain falling over 48 hours between February 27 and 28. This rain event led to modest stream discharges (e.g., 600 cfs measured at Atascadero Creek gage). Water levels within the Slough increased steadily, and approached 9 feet NAVD during the night of February 28th. Water levels were still rising when an emergency managed breach was conducted by FCD on the morning of March 1, 2014.

The elevated water levels within the Slough were attributed largely to the high beach berm at the time of the storm, which formed a dam at the Slough inlet and caused water to pond within the Slough. The continued rainfall during the days following the emergency breach suggests that the Slough inlet likely would have breached naturally during the falling tide on Marsh 1st, however by that time the rising water levels within the Slough may have flooded parts of the airfield and low-lying neighborhoods adjacent to the Slough.

Figure 3-13a shows the marsh south of the airfield during a typical high tide. The water level is approximately ~6.9ft NAVD and the water surface can be seen between patches of pickleweed and in the salt panne areas, but the top of the vegetation remains clear above the water surface. Figure 3-13b shows the same area of marsh on February 28, 2014. In this image, the high water level covers the entire marsh, submerging all but the tallest marsh vegetation. This image also illustrates the airfield relative to the flooded marsh. At the time of the photo water levels were approximately 1ft below the elevation of the airport tarmac.

Figures 3-13 a & b Photos comparing typical high tide water levels with peak water levels prior to March 1, 2014 breach.

This event was a dramatic demonstration of how a high naturally equilibrated beach berm can cause elevated water levels within the Slough during moderately sized rain/stream flow events. During a major rain event we would expect higher stream flows and a more rapid rise in Slough water levels. Under such a scenario, while the flows may naturally breach the lagoon inlet, there may also be a shorter window to mobilize earthmoving equipment for an emergency breach before damaging flooding occurs or the elevated Slough water levels cause the sand bar at the inlet to naturally breach.

3.3.2 Habitat Implications

When the inlet is open, Goleta Slough experiences muted tidal conditions, with the tide range varying between 0 to 4 feet depending on the size and elevation of the Slough inlet. In such conditions, different areas within the Slough experience varying frequencies of inundation depending on their elevation. The varying water surface elevation results in a diverse range of hydrologic conditions that support a variety of tidal wetland habitats.

Figure 3-14 shows the inundation-frequency curve for the Slough for open inlet conditions and identifies the typical elevation range where various wetland habitat types are expected to be found under full tidal conditions. Figure 3-15 shows the expected spatial distribution of these habitat types mapped across Goleta Slough based on the existing ground surface elevation (2010 NOAA Coastal LiDAR). This figure illustrates the potential extent of various habitat types within the Slough if existing hydraulic restrictions (berms, tide gates, etc.) are removed, and reveals opportunities for the restoration of additional tidal habitat by improving hydraulic connectivity. In particular, the areas that are at elevations that would be suitable for the establishment of marsh vegetation include:

- Basins southwest of the Airport runway which are separated from the Los Carneros creek channel by large berms
- Areas currently behind the tide gate near the Goleta West Sanitary District pump station

These areas are not currently high functioning salt marsh because these areas have poor hydraulic connectivity with the rest of the Slough.

Figure 3-14 – Inundation Frequency for Open Slough Inlet

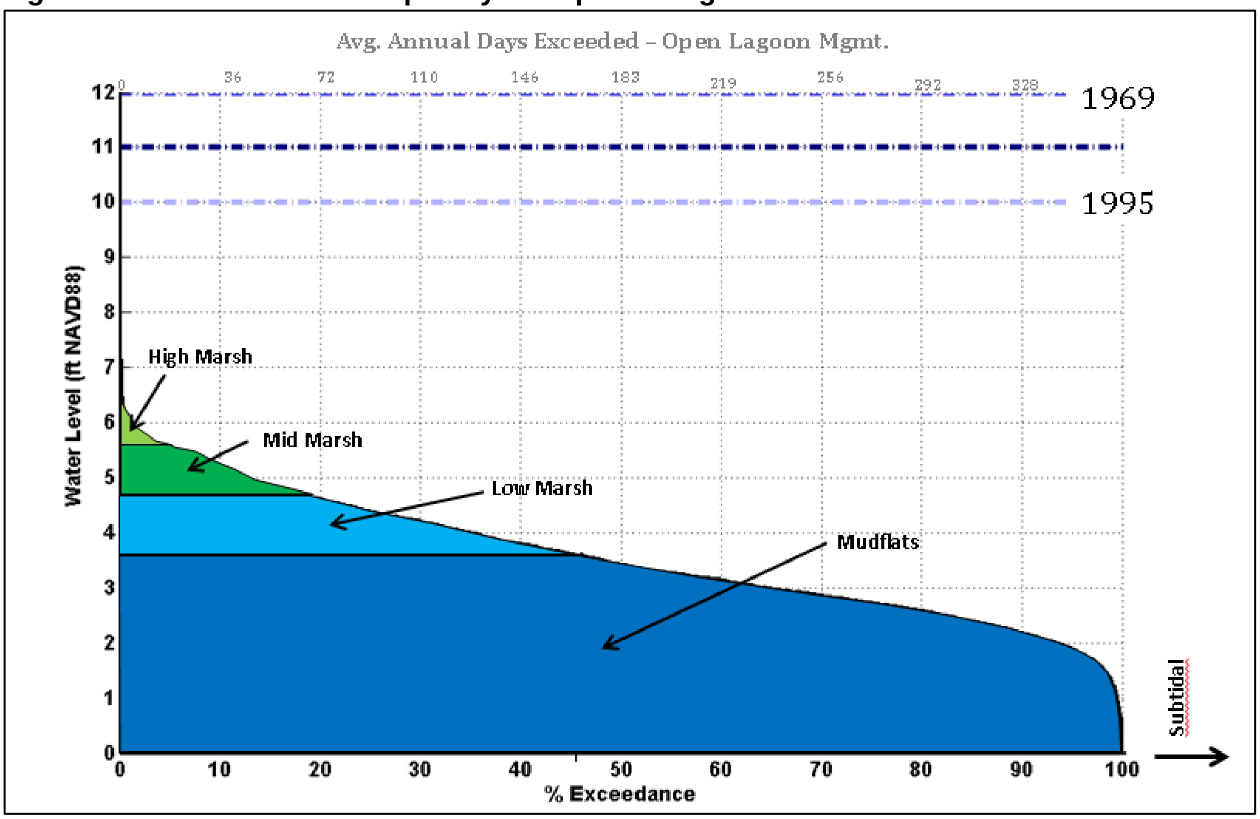


Figure 3-15 – Spatial Habitat Distribution for Open Slough Inlet

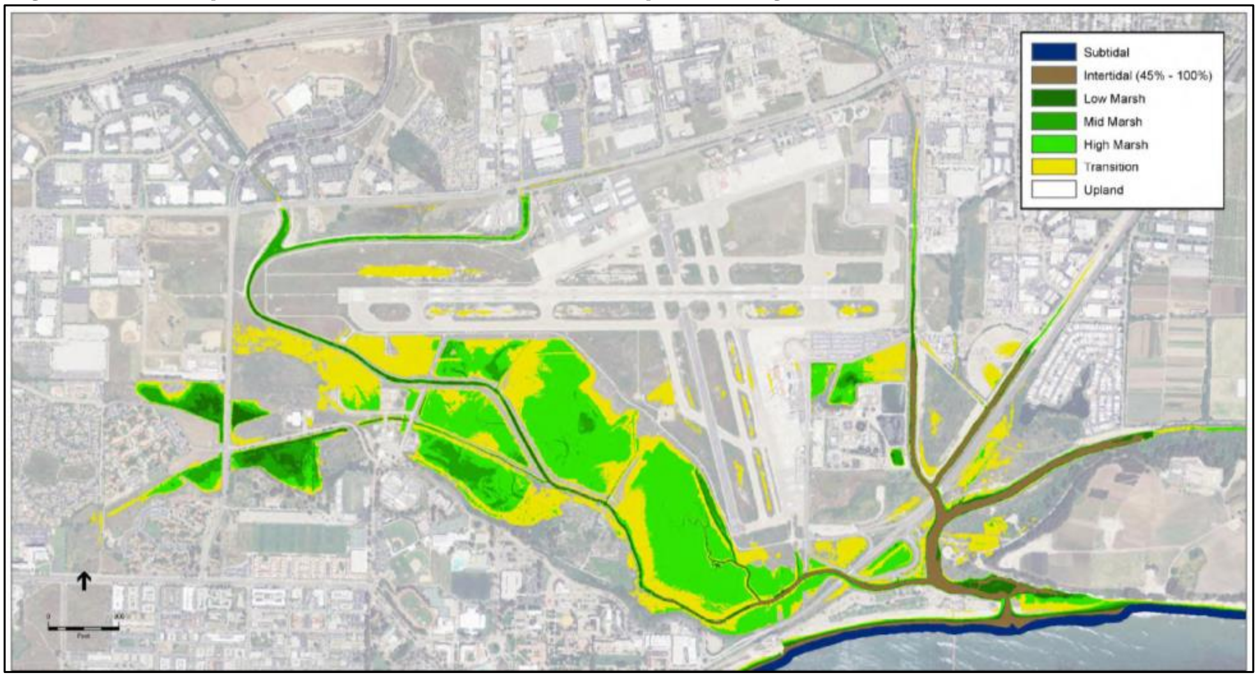


Figure 3-15 shows the inundation frequency curve and habitat elevations for closed inlet conditions. When the inlet is closed, the Slough does not experience tidal variations in water levels. Instead water levels within the Slough are driven primarily by watershed inflows, evaporation, and seepage through the beach berm. During the summer months there is minimal inflow from the watershed, and water levels within the Slough remain relatively low, varying between 4 and 5ft NAVD. During the winter months inflows from the watershed increase which leads to increased water levels within the Slough, ranging from 5 to 6ft, and rising up to more than 8ft immediately after major rain events.

The lack of tidal variation and change in inundation regime within the Slough creates a very narrow elevation range for most wetland plant species. Consequently, with the Slough inlet closed, mudflats and uplands become the most favored habitat types. Figure 3-16 shows the expected extent of habitats within the Slough if it were maintained for closed conditions for an extended period of time. The closed Slough inlet would block tidal action, resulting in significant shift in the habitat distribution within Goleta Slough. Closed inlet conditions favor a binary habitat structure, where most existing wetland areas convert to uplands as they would no longer be inundated during high tides. The remaining areas of marsh would convert to seasonally inundated mudflats, which would be dry during the summer months, but then would be submerged for most of the rainy season. Only a narrow band of tidal wetland vegetation would survive under sustained closed Slough inlet conditions. The extensive mudflats and open water areas at nearby Devereux Slough, located 2 miles west of Goleta Slough, are a good example of the expected habitat conditions that are expected to become prevalent at Goleta Slough if the Slough inlet were to remain closed for a significant portion of the year.

Figure 3-16 – Inundation Frequency for Closed Slough Inlet

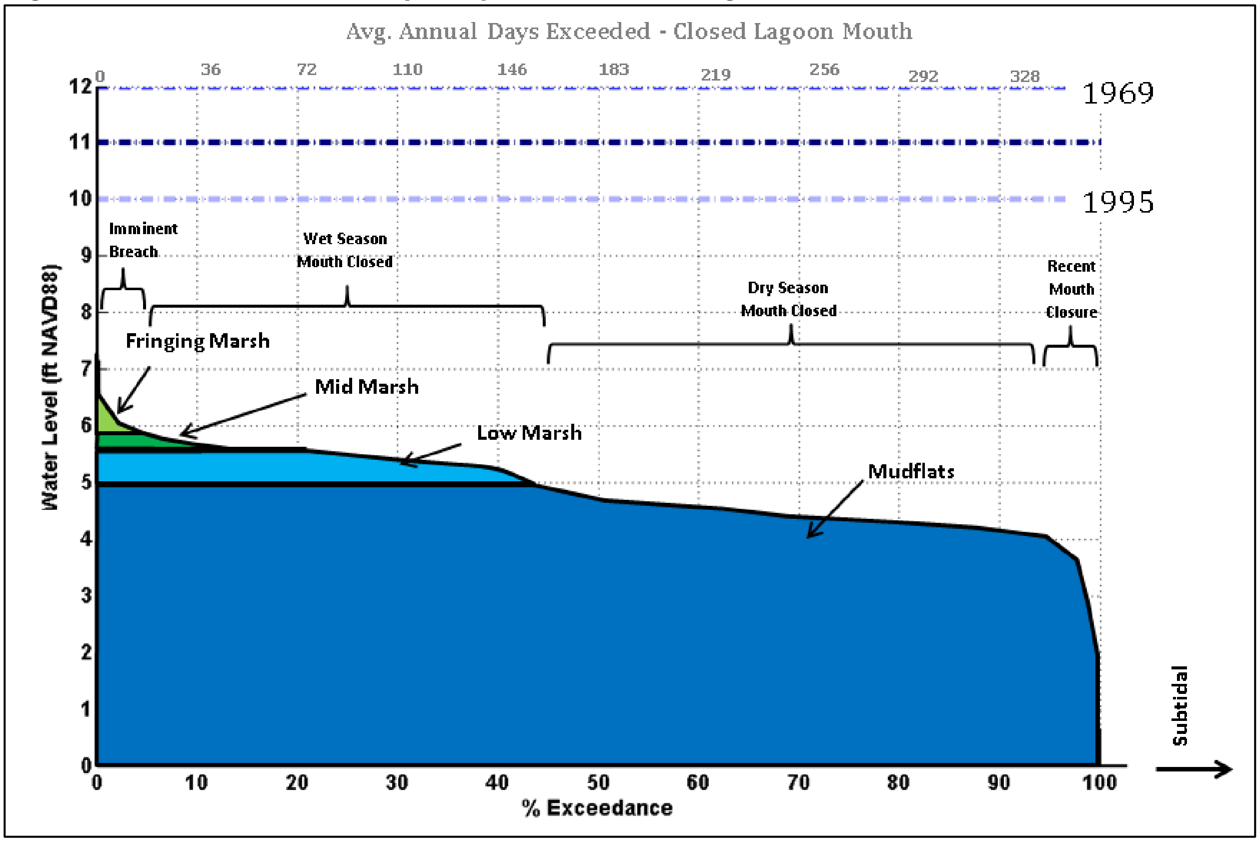
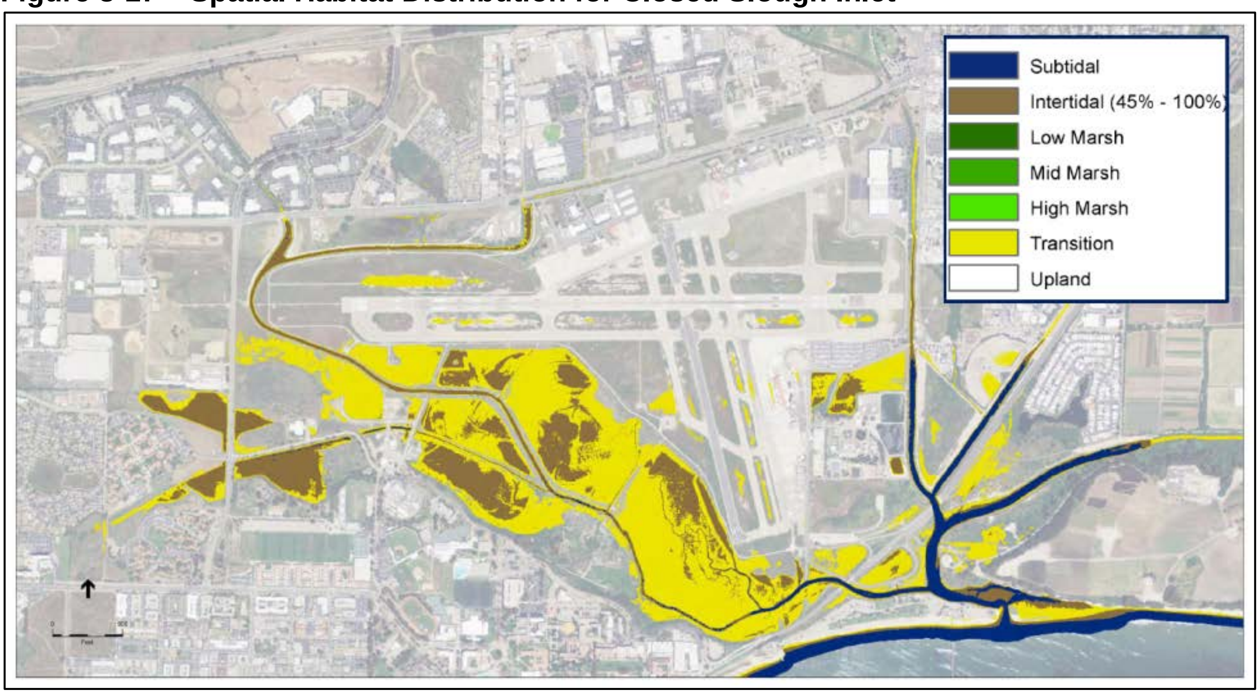


Figure 3-17 – Spatial Habitat Distribution for Closed Slough Inlet



3.3.3 Goleta Slough Inlet Modeling Study

This section presents the results of the Goleta Slough Inlet Modeling Study, which was conducted by ESA in 2015. The goal of this study is to apply a Quantified Conceptual Model of lagoon dynamics to evaluate and compare several potential lagoon management strategies under existing conditions and for future sea level rise scenarios. The evaluation of changes in watershed hydrology due to climate change was outside the scope of this inlet modeling study. Expected changes in watershed runoff may have a significant impact on dynamics of the lagoon inlet, including the frequency of breach and closure events, and future investigation of this process is recommended in the near term.

Appendix G includes additional background and technical detail related to the Quantified Conceptual Model used for this analysis.

3.3.4 Quantified Conceptual Model (QCM)

A Quantified Conceptual Model is a numerical model that attempts to simulate the evolution of complex physical systems through the use of numerical parameterizations of each of the key processes that control how that system behaves. The QCM used for this inlet modeling study was first developed by ESA to evaluate the Russian River lagoon inlet. The model has since been applied to several other lagoons along the California Coast, including Devereux Slough and Mission Creek Lagoons.

The coastal lagoon QCM used for the inlet modeling study represents the key processes which control water levels within the Slough. These include the growth and erosion of the beach berm due to waves, tidal scour of the inlet channel, and scour due to stream flows; inflows to the lagoon due to precipitation and watershed inputs; and outflows from the lagoon due to evaporation, groundwater seepage, and flow through the lagoon channel. By tracking these several processes over time, the QCM can be used to predict water levels within the lagoon and to evaluate the periodic opening and closure of the lagoon inlet.

The QCM uses observed historic data to represent the influence of coastal and watershed processes on the lagoon. Key input parameters include:

- Near shore wave data derived from prior ESA studies at Goleta Beach
- Synthetic stream flow time series based on hydrologic analysis of the Goleta Slough watershed.
- Evaporation and rainfall data from CIMIS Station #94 (Goleta Foothills)
- Seepage estimated based on basic beach geometry, observations of beach sediment size, and nearby seepage studies.
- Beach growth rate parameters estimated from local observations of beach elevation

See the "The Inlet Quantified Conceptual Model" section of Appendix G for a detailed description of the model set-up, further detail documenting each of these input parameters, and a discussion of the limitations and uncertainties of the model results.

The QCM was validated based on observed water levels in Goleta Slough from 2010 to 2014. The aim of the validation process is to use the QCM to reproduce observed historic conditions as closely as possible, in order to establish confidence that the QCM produces a realistic representation of the physical system and to reveal potential shortcomings or limitations of the model. This period includes dry and wet years, as well as varying degrees of active lagoon inlet management. Several managed breaches are believed to have occurred during the validation period: July 11, 2011, October 25, 2011, February 12, 2012, and March 1, 2014 (Andrew Bermond, pers. coms. 2014). For the validation scenario managed breaches were specified to occur on these dates in order to accurately model these events, since these breaches were not the result of natural physical processes, and therefore would not otherwise have been captured by the model.

Figure 3-18 shows the measured and modeled lagoon stage within Goleta Slough for the validation period.

The model was found to perform well during the simulation of the validation period. The model was found to accurately predict most breach and closure events, and produced predictions of lagoon water levels that generally matched the observed water levels. The model demonstrated minor deviations in the timing of breach events, and appears to slightly over estimate the rate of inlet closures during times when the lagoon experiences muted tidal conditions. There is no measured data tracking rates of outflow, wave over wash, beach seepage and evaporative losses at Goleta Slough, however modeled values were within the range of expectation based on observations of the lagoon system and measured values from similar lagoon systems.

The model appears to underestimate the depth of scour during large rain events, including the 2010 winter rains and the spring 2014 breach event, however it appears to accurately capture scour during moderate rain events. The model does show minor errors in the predicted timing of breach events, and appears to slightly overestimate the speed at which the lagoon inlet closes during times when the lagoon experiences muted tidal conditions. Such errors are to be expected given the difficulty in modeling a complex coastal system.

See Appendix G for a detailed discussion of model limitations and uncertainty.

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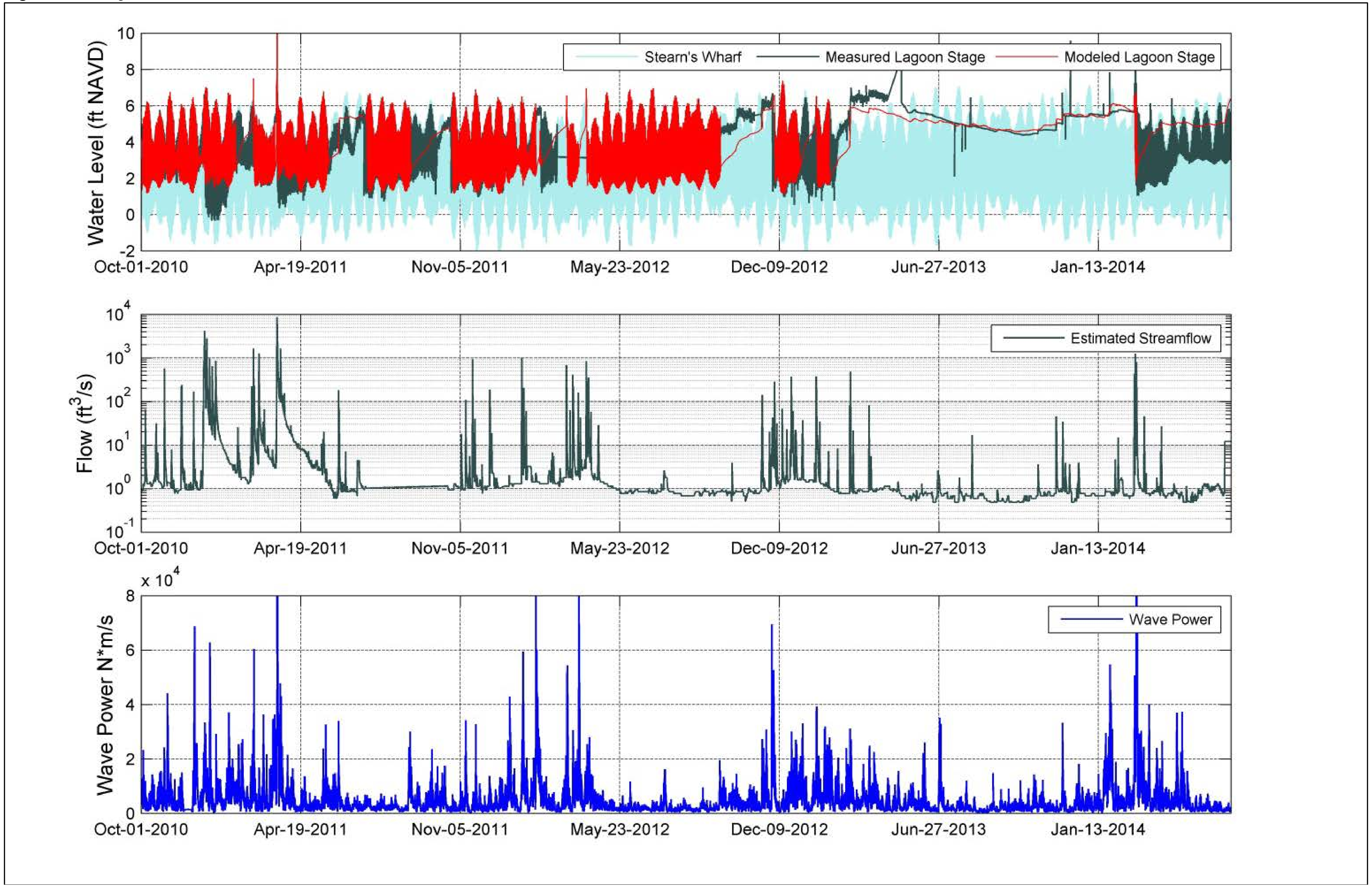
Figure 3-18 – QCM Validation Time-Series



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3.3.5 Modeling of Scenarios

The QCM was used to evaluate a range of potential future scenarios in order to provide additional understanding of the role that key processes play in driving lagoon dynamics, and to inform future lagoon management. These scenarios were developed in order to evaluate the following topics:

- **Changes to the Lagoon Storage Volume** - For these scenarios, the Stage-Storage relationship that is used to represent the volume of the lagoon was increased and decreased by +/-25% in order to represent the hydrodynamic impact of potential future projects that may cause alterations to the Goleta Slough landscape, changing the size of the lagoon. Additional sensitivity tests representing larger changes to the lagoon Stage-Storage relationship were also conducted in order to evaluate the sensitivity of the system to larger scale landscape alterations.

- **Sea Level Rise** - Sea Level Rise scenarios were developed by applying a vertical shift to the tidal boundary condition in order to represent +0', +1', +3' and +5' of sea level rise.

- **Inlet Management Practices** -The Inlet Management scenarios simulate mechanical breaches of the lagoon inlet whenever lagoon water levels within the lagoon exceed a pre-determined threshold elevation.

The QCM was used to model each scenario based on wave and watershed conditions observed during a continuous period spanning from 2010 to 2014. Results tracking the duration of closures and breach frequency were tabulated for separately for Wet (2011) and Dry (2013) years in order to highlight the range of variability which may occur due to year-to-year variations in precipitation.

3.3.6 Results

This section presents the key findings of the Inlet Modeling Study. See Appendix G for a detailed discussion of the study results and findings, as well as discussion of sources of uncertainty and limitations related to the modeling effort.

Testing the Sensitivity to Changes in Lagoon Volume

ESA has evaluated a set of model scenarios that test the sensitivity of the lagoon inlet to adjustments to the storage volume of the Slough. This sensitivity analysis evaluates the expected impact of large changes to the Goleta Slough landscape on the dynamics of the lagoon. These scenarios are representative of landscape-scale changes to the Goleta Slough topography, such as large-scale habitat restoration projects and major flood protection projects. The following are the key findings of this study related to storage volume adjustments:

- **Alterations to the Goleta Slough landscape** which increase the volume of the Slough are predicted to have two main effects on the lagoon inlet:
    1. An increased lagoon volume delays natural inlet breaches that are caused by watershed inflows due to the larger storage capacity below the breaching water level; and
    2. An increased lagoon volume delays the closure of the lagoon inlet due to increased tidal scour associated with the increased intertidal volume, also called “tidal prism”.

- **Specific projects** can be designed to emphasize open conditions or closed conditions by adding or removing storage volume within certain elevation ranges. Storage volume added in the intertidal range enhances tidal scour, which encourages open conditions. Storage volume added between the high tide elevation and the elevation of the beach berm encourages closed conditions by increasing the potential for ponding during rain events.

- **Decreasing the Slough volume by 25%** is predicted to cause a small increase in the percent of time that the lagoon inlet is open since the lagoon will breach more quickly during rain events, but it will also reduce tidal exchange and increase the likelihood of closure during dry conditions.

- **Increasing the Slough volume by 25%** is predicted to cause a small increase in the percent of time that the lagoon inlet is closed, since the larger lagoon will require a greater volume of watershed inflow in order to initiate a natural breach. A 25% increase in lagoon tidal prism was not found to cause a significant increase in tidal scour at the inlet channel.

- **Sensitivity analysis** suggests that increasing the tidal prism of the lagoon by ~600-800 ac-ft (+300-400% of the existing tidal prism) would result in an almost-always open system. Such an increase in lagoon tidal prism may greatly reduce the frequency of mechanical breaches required in order to achieve flood protection and habitat goals. There does not appear to be sufficient open space available near Goleta Slough to achieve this level of tidal prism enhancement through the creation of intertidal habitat without significant land use changes.

- **Smaller increases in lagoon volume**, on the order of ~200-400 acre feet (+100-200% of the existing tidal prism) may increase the frequency of natural open conditions, but would still require intermittent lagoon inlet management to reduce the risk of flooding during closure events. This result suggests the potential for multi-benefit projects through the creation of new tidal wetlands in areas of the Slough that are currently diked off from tidal action.

- **Potential restoration -** Figure 3-10 identifies nearly 100 acres of undeveloped land adjacent to Goleta Slough that could be potentially restored to full or near full tidal action. Constructing intertidal habitat on these parcels, combined with the expansion of the network of distributary channels in the Slough, could increase the tidal prism of the Slough by 200-300 acre-ft. This increase in tidal prism could shift the dynamics of the lagoon inlet toward more frequently open conditions; however, occasional inlet closure events would still be expected should these parcels be converted to intertidal habitat.

Testing the Sensitivity to Sea Level Rise

ESA has evaluated several scenarios that represent existing conditions and expected future conditions at the Slough based on projected rates of sea level rise. These scenarios consider conditions at the lagoon assuming no inlet management; see the “Inlet Management” section for scenarios that consider sea level rise and inlet management. The following are the key findings of this study related to sea level rise:

- Rising sea levels are predicted to increase the elevation of the beach berm, which will in turn increase the storage volume of the lagoon and decrease the likelihood of the lagoon breaching naturally during small and medium sized rain events.

- For small amounts of sea level rise (up to +1 foot) the model results indicate an increased likelihood of extended periods of inlet closure, especially during dry years (assuming no managed breaches occur) relative to existing conditions.

- If the lagoon inlet is not managed, model results predict an increase in the duration of ponded conditions at the lagoon for sea level rise up to +1 foot. The increased occurrence of ponding causes predicted average water levels within the lagoon to rise faster than the rate of sea level rise under unmanaged conditions for up to +1 foot of sea level rise.

- As sea levels continue to rise, eventually the tidal prism of the lagoon will grow large enough that the lagoon channel will become self-scouring. At this point the lagoon will transition to an almost always open system, with water levels controlled primarily by the tide elevation. Model results indicate that the lagoon inlet will almost always be open once sea levels rise +3 feet above existing conditions, with or without inlet management.

Testing Sensitivity to different Inlet Management Scenarios
ESA has evaluated several scenarios representing potential future inlet management strategies where the lagoon inlet is mechanically breached by excavating a shallow channel whenever water levels within the lagoon exceed a pre-determined threshold elevation. Several threshold elevations have been evaluated:

- El. 6.5’ NAVD (1.25’ above MHHW) – An elevation low enough to avoid ponding on the existing pickleweed marshes.
- El. 7.5’ NAVD (2.25’ above MHHW) – An elevation which would allow extended ponding on the marsh plain while providing ~1.5 feet of freeboard before existing infrastructure is threatened.
- El. 9.0’ NAVD (3.75’ above MHHW) – The elevation above which significant extents of existing infrastructure becomes threatened.

It was assumed that these management threshold elevations will shift upwards over time, tracking rising sea levels. The following are the key findings of this study related to these management strategies:

- Existing infrastructure near the Slough is at risk of flooding when water levels in the Slough reach approximately El. 9.0’ NAVD. Model results indicate that the managed breaching threshold elevations of 1.25 and 2.25 feet above MHHW (El.6.5’ and 7.5’ NAVD) greatly reduces the frequency of occurrence of water levels above El. 9.0’ NAVD in the Slough for scenarios with +0 and +1 feet of sea level rise.

- Model results for managed breaching at 3.75’ above MHHW (El. 9.0’ NAVD) and for unmanaged conditions showed the regular occurrence of water levels greater that El. 9.0’ in the Slough, indicating a significant risk of inundation of nearby infrastructure under these scenarios.

- Model results indicate that managed breaching at any elevation cannot prevent the occurrence of water levels in the Slough above El. 9.0’ NAVD for scenarios with +3 and +5 feet of sea level rise. The predicted frequency of occurrence of elevated water levels within the Slough continues to increase as sea levels rise.

- Sensitive pickleweed marsh habitat in the Slough may become degraded if inundated (water levels >7.0' NAVD) for an extended duration. Model results indicate that managed breaching with threshold elevations at 1.25 and 2.25 feet above MHHW (El.6.5' and 7.5' NAVD) can greatly reduce the frequency of occurrence of water levels above El. 7.0' NAVD relative to unmanaged conditions, both for existing sea levels and for scenarios with +1 feet of sea level rise.

- Based on these results, we conclude that active inlet management is likely to be a viable strategy for achieving flood protection and habitat goals in Goleta Slough during the short- to medium-term for conditions on the order of +1 foot of sea level rise. The model results indicate that inlet management will become less effective at achieving flood protection and habitat goals under conditions with +3 or more feet of sea level rise.

- The model results indicate that the selection of a lower threshold elevation results in an increase in the number of predicted managed breaches, and a corresponding increase in the frequency of open lagoon conditions.

3.3.7 Recommendations

Based on the results of the Inlet Modeling Study, we offer the following recommendations to help guide future planning actions in the Goleta Slough:

- We recommend the development and implementation of a long-term management plan for Goleta Slough which clearly and specifically articulates goals and objectives for habitat management, land use and flood protection.

- The QCM results suggest that flood protection can be achieved under a range of managed breach thresholds (e.g.. 6.5' and 7.5' NAVD). We recommend further refinement of the proposed mechanical breach thresholds to achieve optimum benefits for the local ecology.

- The QCM results do not predict the occurrence of elevated water levels above El. 6.5' NAVD during the summer months for scenarios with +0 and +1 feet of sea level rise (with or without inlet management). This finding indicates that summer time pumps/siphons are unlikely to be needed under typical conditions.

- Long-term plans for the Goleta Slough region should anticipate the decreasing effectiveness of inlet management as a management tool for achieving flood protection and habitat goals as sea level rises reaches +3 feet.

- Long term plans for the Goleta Slough area should incorporate adaptation strategies that anticipate significant increases in lagoon water levels and near-continuous open-lagoon conditions by the end of the century.

- We recommend additional study to evaluate the feasibility of large-scale landscape shaping and to evaluate specific opportunities for multi-benefit projects for habitat enhancement, restoration and lagoon management. We recommend that the evaluation of potential project alternatives include a refined analysis of impacts on local channel hydraulics and lagoon inlet dynamics.

- We recommend that future studies include a statistical analysis of coastal and hydrologic processes in order to better characterize the expected frequency occurrence of extreme conditions including prolonged droughts, El Niño and extreme rain/flood events.

- Finally, while the Inlet Modeling Study has not considered the impacts of climate change on watershed inflows and evaporation rates, these impacts may be significant in shaping future conditions at Goleta Slough. We recommend that future studies evaluate the projected changes in hydrologic conditions and the potential impacts of these changes on water levels and breach and closure patterns at the lagoon.

In addition, we encourage local planning agencies to continue data collection efforts to enhance the understanding of the physical processes which shape Goleta Slough. In particular, we feel that the following monitoring actions would provide highly valuable data for refining the QCM model:

- Continued monitoring of water levels within the Slough

- Regular surveys of the elevation of the beach berm and the dimensions of the lagoon channel. Survey data collected immediately before and after the lagoon inlet breaches is expected to be most useful for continued model refinement.

- Documentation of future managed and natural breaches, including timing of the breach, excavated channel width and depth, and the timing of future lagoon inlet closures.

We hope that these findings and recommendations are informative for the development of future inlet management practices and local planning efforts. Goleta Slough is a unique natural resource that provides great value to local flora and fauna and to the Goleta community. By continuing to improve our understanding of this complex and vibrant system we can work to develop management practices that enhance the ecosystem while allowing for the protection of nearby infrastructure. In this way the Slough may continue to benefit the Goleta community for present and future generations.