Asset Inventory Development and Asset Selection

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2 Asset Inventory Development and Asset Selection

2.1 Introduction

The first step of the Federal Highway Administration (FHWA) conceptual model is to compile an inventory of all transportation assets that are to be evaluated. Example asset categories are provided by the FHWA conceptual model to assist in this task, with a suggested focus on the categories that correspond with the region's planning priorities. While the inventory is being compiled, information is also collected to help evaluate how resilient the asset is to climate stressors and how costly damage to the asset could be. Existing agency inventories of assets are suggested as the primary source of this information.

The second step of the FHWA model process is to "screen" the asset inventory based on the relative importance of each asset. Using existing priorities and metrics (such as volume of use, movement of goods, number of commuters, use as emergency route) the most important assets are identified for the region.

During this initial data collection and inventory development process, it became clear that due to a lack of readily available data in an accessible format and the extensive number of transportation assets in the selected region, an alternative approach would be required. This led to the iterative data collection and asset selection process described in this chapter rather than a sequential process of data collection followed by asset selection as described by the FHWA model. The data collection process in particular evolved to occur in phases, as follows:

1. Initial data collection for the larger subregion consisting mostly of geographic information system (GIS) and spatial data with some metadata,
2. Data regarding functionality and other characteristics collected to assist with selecting representative assets, and
3. Detailed stressor information collected following the selection of representative assets.

The approach for the shoreline assets was different from that used for the transportation assets since it was never the intention to conduct a full vulnerability assessment of the shoreline. The approach evolved to focus on the categorization of the shoreline assets and to use the elevation of these shoreline assets, coupled with the inundation maps (see Chapter 4) to assess which shoreline assets contributed to the inundation of the transportation assets over time.

Section 2.2 describes development of the asset inventory, including the data collection process and approach, a summary of information available and identified data gaps, and includes the data inventory that helped build the asset Inventory. Section 2.3 addresses the steps taken to select the assets for further analysis and subsequent data collection for these assets. Section 2.5 discusses insights on following the FHWA conceptual model and recommendations on refining the process.

Appendix A presents additional tables to support the following discussion, including more detailed versions of some of the tables provided in this chapter.

This process is summarized in Figure 2.1.

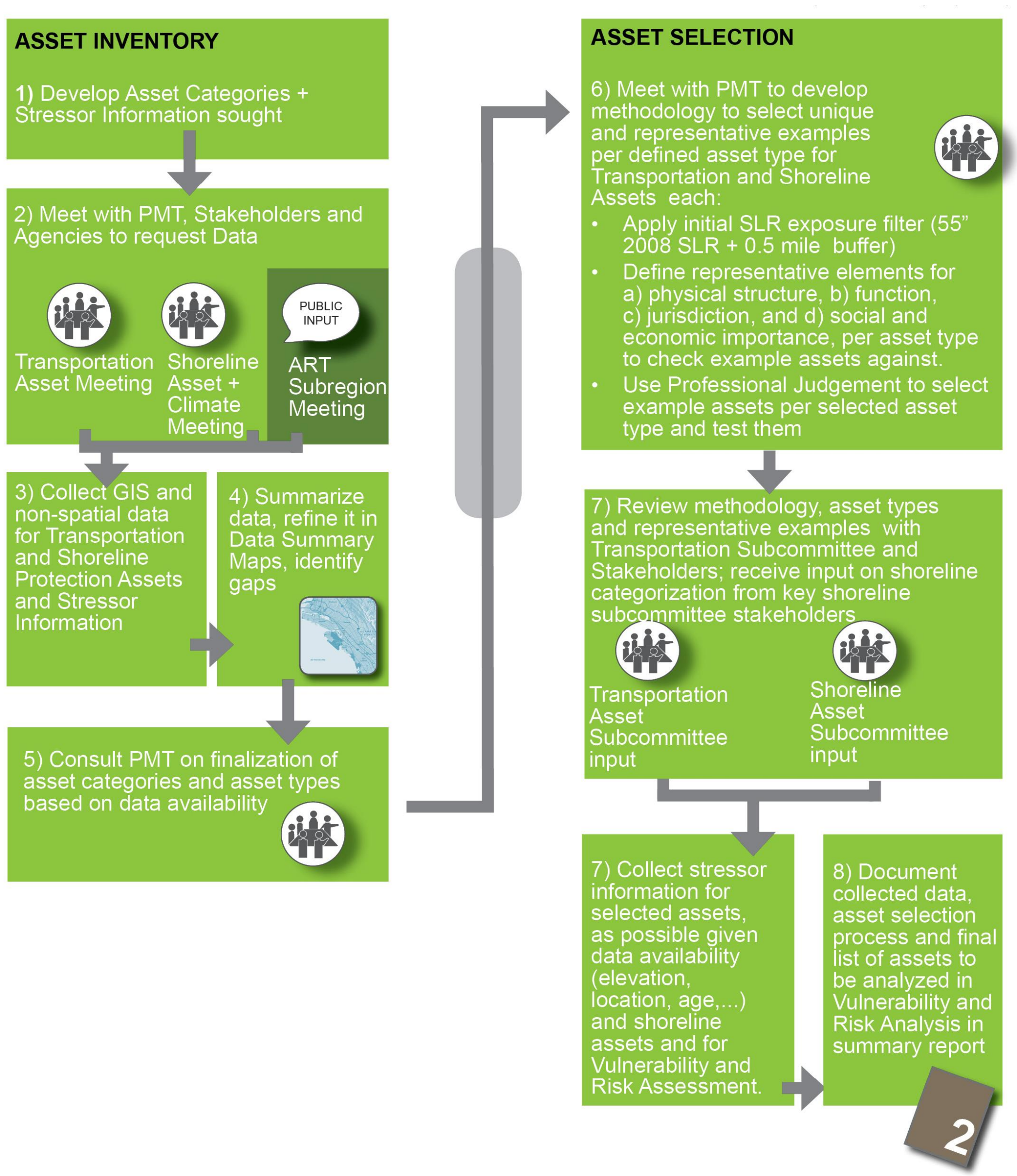

Figure 2.1 Asset Inventory and Selection Process

2.2 Asset Inventory Development

2.2.1 INITIAL TRANSPORTATION ASSET INVENTORY DATA COLLECTION

An initial list of asset types and attributes was developed based on the list suggested by the FHWA model and then expanded based on discussions with the Project Management Team (PMT) (Table 2.1). Stakeholder input was considered vital for identifying the most appropriate list of asset types and for robust data collection. At a meeting with the Transportation Asset Subcommittee, each agency or department provided information on its existing datasets related to each of the transportation asset types selected for the project. Lists of data needs guided the discussion on asset types, data types, and data sources Table 2.2). In addition, the team attempted to look ahead to gathering information to support the development of evaluation and prioritization criteria for the asset prioritization task (Table 2.3). During discussions with the Transportation Asset Subcommittee, it became apparent that detailed stressor information (Table 2.2) was not readily available for the majority of assets in the subregion, which led to focusing the initial data exercise largely on spatial information. This also prompted the decision to reduce the number of assets to be analyzed before requesting stressor information needed for the vulnerability assessment. See Tables A2.1 and A2.2 in Appendix A to see what type of information was available by agency for the asset types.

Table 2.1 Transportation Asset Types Identified for the Subregion

FHWA-Suggested Example Transportation Asset Categories	Transportation Asset Types Considered for the Selected Subregion by Transportation Asset Subcommittee and Project Management Team
Bridges and tunnels	Bridges
	Tunnels and tubes
Key road segments	Highways and state routes
Rail (passenger and freight)	Rail – passenger and freight
Transit system assets	Transit system assets (stations, yards)
Port and airport assets	*Not included in the pilot project*
Signals and traffic control centers	Signals and traffic control centers
Back-up power, communication, fueling, and other emergency operations systems	Emergency operations systems, communication
Intelligent Transportation Systems (ITSs), signs	ITSs
Pipelines	*Not included in the pilot project*
Evacuation routes	Lifeline routes; Evacuation routes for Oakland and other local jurisdictions
	Bike lanes and routes
	Designated truck routes
	Drainage systems associated with transportation assets
	Local streets and roads (assume these include sidewalks)
	Trails

2.2.2 INITIAL SHORELINE ASSET INVENTORY DATA COLLECTION

Similar to the transportation asset data collection exercise, a list identifying desired shoreline asset attribute information was developed to inform the asset discussion with the Shoreline Asset Subcommittee. The FHWA guidance provided on shoreline assets was limited to “Vegetative Cover; Wetlands and Floodplains,” so in the discussions it was expanded to include other potentially relevant asset types applicable to the Alameda County shoreline, as shown in Table 2.4. The data types and potential sources identified corresponding to these asset types can be reviewed in Table A2.4 in Appendix A.

Table 2.2 Transportation Stressors / Asset Information

Information Suggested by FHWA to Be Collected to Help Evaluate How Resilient the Asset Is to Climate Change	Stressor Information Further Defined by Transportation Asset Subcommittee and Consultant Team
Age of asset	Age of asset
Geographic location	Geographic location/coordinates
Elevation	Elevation/elevated structure
Current/historical performance or condition (Areas that flood currently require maintenance due to weather impacts)	Current/historical performance or condition (Areas that flood currently require maintenance due to weather impacts)
Level of use (traffic counts, forecasted demand)	Level of use (passenger/ridership, traffic counts, forecast demand, average daily traffic annual average daily traffic)
Replacement cost	Replacement cost
Repair/maintenance schedule and costs	Repair/maintenance schedule and costs
Structural design	Structural design
Materials used	Materials used/material type
Design lifetime and stage of life	Lifetime and stage of life/remaining service life
LIDAR (Light Detection and Ranging) remote sensing data	
Federal Emergency Management maps	
	Susceptibility to seismic hazard/retrofitted

Table 2.3 Transportation Asset Importance - Evaluation and Prioritization Criteria

Criteria
Traffic flow (annual average daily traffic volume, transit ridership, bicycle or pedestrian use)
Interregional travel, such as components of the Interregional Road System
Emergency management, potential loss of life, safety
Adaptability (potential to reroute, length of detour, time to repair/rebuild if damaged)
Lifeline route structure (routes deemed critical to emergency response/life-saving activities that must be serviceable or detours quickly implemented following an earthquake, flood, or other disruption)
Economic costs (e.g., goods movement, disruption of economic activity, commutes, delay)
Other criteria (e.g., Strategic Highway Network, Surface Transportation Assistance Act routes, Intermodal Corridors of Economic Significance)

Table 2.4 Potential Shoreline Protection Asset Types and Data Sources

FHWA-Suggested Example Asset Categories	Shoreline Asset Types Considered for the Selected Subregion
Vegetative cover, wetlands, floodplains	Nonstructural shoreline protection/baylands /wetlands/ vegetative cover/salt ponds
	Levee (coastal and riverine)
	Seawalls/revetments and nonlevee-engineered structures
	Berm
	Natural nonvegetated shorelines/beaches/cliffs
	Bayshore pump stations

During a Shoreline Asset Subcommittee meeting, representatives discussed the availability, quality, and format of data and how the data could be used for project analysis. During the meeting, it became apparent that additional modeling and updated mapping to show the depth to which transportation and shoreline assets would be inundated would be necessary to fully assess the vulnerability and risk rating of transportation and shoreline protection assets in the subregion. This is an additional step that is not part of the FHWA conceptual model. The methodology for developing the inundation maps is discussed in more detail in Chapter 4.

2.2.3 INITIAL DATA RECEIVED FOR TRANSPORTATION AND SHORELINE ASSETS

The majority of data collected as part of the initial effort were GIS based. The team processed the information into several maps, portraying the data received for review and analysis. This facilitated the selection of the most relevant data for further analysis. The key data sets received, their format, and the level of detail they provide are laid out in Table A2.5 and Table A2.6 in Appendix A. Where appropriate maps of the GIS data were created, see Figure 2.2 for an example. Lessons learned regarding the data collection exercise are summarized in Section 2.5 of this chapter.

2.2.4 IDENTIFICATION OF ASSET CATEGORIES AND ASSET TYPES

After the initial data collection effort, the project team identified four major asset categories of transportation assets:

a) Road Network
b) Transit Network
c) Transportation Facilities
d) Bicycle and Pedestrian Networks

The project team organized asset types under each of the four categories (Table 2.5) and identified the data required for each asset to facilitate further selection efforts.

2.3 Transportation Asset Selection Methodology

The FHWA conceptual model suggests selecting assets based on their importance to the region (see Table 2.3) (e.g., traffic flow, emergency management, movement of goods), using detailed information from the data inventory. However, after drafting and reviewing a preliminary framework to assess importance as per the FHWA model, the project team decided to change course due to the following factors:

- Most assets in the subregion are arguably important, and the subregion is relatively small (county size), so the team considered the number of assets per asset type to be compared to one another to be too small.
- The amount of data necessary to do a robust importance rating of each asset was beyond the budget and schedule of the project because detailed information was not readily available on individual assets in a readily usable format; also insufficient background information precluded making quantitative assessments/decisions on importance.
- The team did not want to pass over assets that may not meet the importance criteria but that may have intrinsic value for the region (e.g., the Bay Trail).

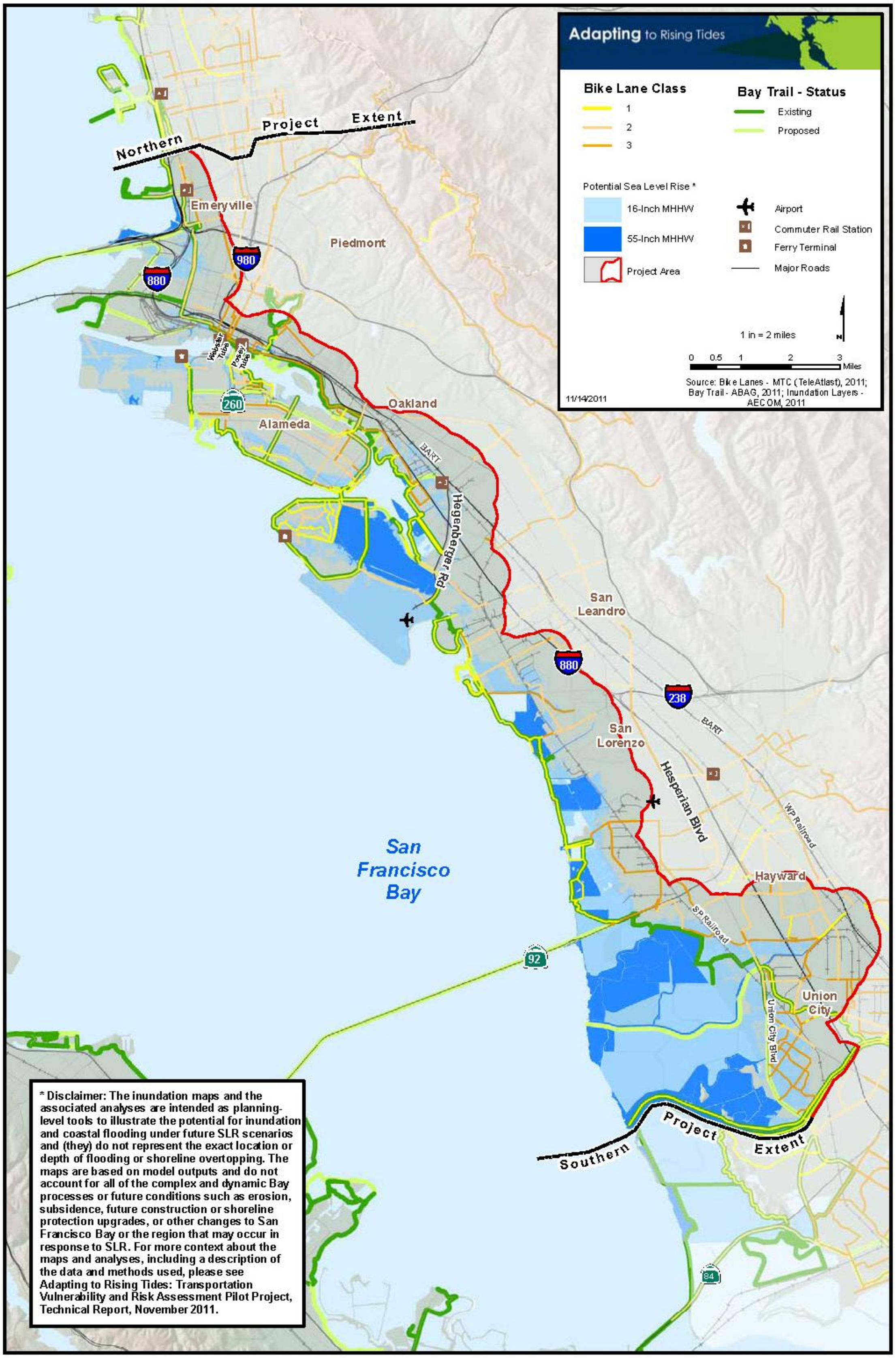

Figure 2.2 GIS Data Available - Example for Bike Lanes and the Bay Trail

Table 2.5 Asset Type Definitions

Road Network	
Asset Type	**Definition (Physical Characteristics, Examples)**
Interstates/ Freeways and State Routes	A freeway is a divided highway that features at least two lanes in each direction operating without signals, stop signs, or at-grade intersections. All interstates are freeways. Example: *Interstate 880.* Some freeways are state routes, but not interstates, such as *State Route 92*. Not all state routes are freeways. In an urban context such as the project area, nonfreeway state routes typically function as "arterials" (see below), such as *State Route 61* (bearing the name *Doolittle Drive*, among others).
Arterial, Collector, and Local Streets	Elements of the roadway network that are not interstates or state routes are identified as "arterials," "collectors," and "local streets" with the support of Google Maps. Streets colored yellow in Google Maps are considered "arterials" and "collectors"; streets colored white are "local streets." Professional judgment is used to differentiate "arterials" from "collectors." Generally, "arterials" have interchanges with the freeway system, while "collectors" do not; "arterials" connect between cities or form major corridors within cities, while "collectors" connect between these major corridors. Examples: arterial – *West Grand Avenue*; collector – *Mandela Parkway*; local street – *Third Street*.
Connectors to Isolated Neighborhoods	Connectors to isolated neighborhoods are identified as a type of unique asset in addition to other "arterial, collector and local streets," which provide the only means of vehicular access to a particular neighborhood or area. Examples: *Powell Street*, *Embarcadero.*
Tunnels and Tubes	"Tunnels and tubes" refers to the *Webster* and *Posey Tubes*, a pair of road tunnels that pass beneath the Oakland Estuary, connecting vehicles, bicycles, and pedestrians between Oakland and Alameda.
Toll, Interstate, and State Bridges	"Toll, interstate, and state bridges" refers to the two bridge crossings of San Francisco Bay, allowing vehicles to cross the bay between Alameda County and San Francisco or San Mateo County. Example: *San Francisco-Oakland Bay Bridge* and *San Mateo Bridge.*
Local Bridges	Local (Alameda) Bridges are a unique type of asset providing a bridge crossing of the Oakland Estuary for vehicles and pedestrians. Example: *Park Street Bridge.*
Transit Network	
Asset Type	**Definition (Physical characteristics, examples)**
Bus Routes	Bus routes are the path of operation of regularly scheduled transit service provided by buses, differentiated by other routes by a specific route number or letter. Bus stops along a bus route are typically marked with signs and may include benches, shelters, and information displays. For purposes of this project, these are not considered as separate assets, but as characteristics of the roadways they are operated on. The project includes as "bus routes" the services of AC Transit, Union City Transit, Emery Go-Round, Amtrak Thruway Buses, AirBART as well as the California Department of Transportation (Caltrans) Bay Bridge Bicycle Shuttle and the Estuary Crossing Shuttle.
BART Lines	BART (Bay Area Rapid Transit) lines are a specialized grade-separated passenger railroad facilitating the exclusive operation of BART trains. The tracks, or guideways, of BART may be supported on aerial structures, be built at grade, or operate in underground tunnels. Examples: *Oakland Wye tunnel* or *West Oakland aerial structure.*
BART Stations	BART stations are facilities designed to receive BART trains, outfitted with (a) platform(s) for passenger boarding and alighting. They are typically elevated or underground. BART guideways are grade-separated; thus stations include circulation areas and elements such as stairways, escalators, and elevators. They may include parking lots, bus transfer facilities, and bicycle lockers, which are not considered separate assets but included as part of the BART station for purposes of this project. Examples: *Lake Merritt Station* and *West Oakland Station.*
Railroads	Railroads support the conveyance of passenger or freight on wheeled vehicles running on rail tracks. In the project area, railroads are used by both passenger (Amtrak) and freight trains. Example: *Union Pacific Coast Subdivision.*
Rail Stations	Rail stations are facilities designed to receive passenger trains, outfitted with (a) platform(s) for passenger boarding and alighting. They may include ticketing, waiting areas, and other amenities. Examples: Amtrak's *Emeryville* and *Oakland-Jack London Square* Stations.

Ferry Terminals	Ferry terminals are facilities designed to receive ferries and allow for passenger boarding and alighting. They may include ticketing, waiting areas and other amenities. Examples: *Jack London Square* and *Alameda Gateway* ferry terminals, serving ferries to San Francisco.
Transportation Facilities	
Asset Type	**Definition (Physical characteristics, examples)**
Traffic / Transportation Management Centers	Traffic or transportation management centers are operated by cities, counties, transit providers, and regional agencies to manage and coordinate traffic and emergency operations and communications. Example: *City of Alameda Traffic Management Center.*
Caltrans Maintenance Facilities	Caltrans maintenance facilities include maintenance yards, weigh stations, fueling and power stations, and other facilities that support the operations of Caltrans roadways (interstate highways and state routes). Examples: the *Webster/Posey Tube Facilities* and the *Interstate 80* and *State Route 92 Toll Plazas*; these are not considered separate assets but as components of the respective roadways.
Bus Service Facilities	Bus service facilities provide storage, operations and maintenance and control facilities for bus service providers. Example: AC Transit is the primary bus-based transit provider in the project area and maintains one of a number of maintenance facilities at *1100 Seminary Avenue* in Oakland.
BART System Assets	Aside from BART guideways and stations, BART system assets include facilities providing storage, operations and maintenance and control facilities for BART operations. Example: *BART O&M Shop* at the south tunnel portal of the Oakland Wye in Oakland.
Rail Yards and Depots	Rail yards and depots provide storage, operations and maintenance (O&M) and control facilities for freight and/or passenger rail operations. Example: *Capitol Corridor Northern California O&M Yard* in Oakland.
Ferry Maintenance Facilities	Ferry maintenance facilities provide storage, operations and maintenance, and control facilities for ferry operations. Example: the Bay Area Water Emergency and Transportation Authority has a planned ferry maintenance facility in Alameda.
Bicycle and Pedestrian Networks	
Asset Type	**Definition (Physical characteristics, examples)**
Trails / Class I Bike Facilities	Trails are off-street, paved, or gravel paths for pedestrian and/or bicycle use. Class I bicycle facilities are separated from motorized vehicular traffic by open space or a barrier (in which case they may be located along a street). Examples: components of the *San Francisco Bay Trail* along the Alameda County shoreline.
Class II Bike Facilities	Class II bicycle facilities are separate bicycle lanes adjacent to the curb lane on a roadway. For purposes of this project, these are not considered as separate assets, but as characteristics of the roadways they are a part of. Example: bike lanes on *Mandela Parkway.*

Thus, the project team amended the process to select representative assets for each asset type and refine the number of assets for which additional data would be requested. Considerations developed for the initial framework, including environmental, economic, and equity considerations that are also used in the larger Adapting to Rising Tides project, were included to develop characteristics and functionalities for the assets (discussed in Section 2.3.1 below). This aided in the selection of representative assets in the project area.

For most asset types, the high number of assets prevented a comprehensive analysis within the scope of this study. Instead, the project team decided to use two filters to narrow down the assets within each type to a short list of representative assets. The first filter limited the assets to only those that would be touched by sea level rise (SLR), as identified using preliminary inundation mapping. Only the portions or segments of these facilities that are projected to be inundated are considered as "assets." The second filter further limited the number of assets using physical functional and socioeconomic characteristics.

Generally, assets with greater functionality or representing a broader range of characteristics were carried forward. In most cases, this resulted in the desired reduction to three or fewer assets per asset type (see Section 2.3.1 below for full explanation of both filters).

In the case of the "Arterial, Collector, and Local Streets" asset type, hundreds of discrete assets can be identified, requiring a more focused approach. The PMT and Transportation Asset Subcommittee participated in an exercise at a Transportation Asset Subcommittee workshop (see Section 2.3.1 below) to identify a particular focus area within which to select representative assets for this type. Participants affixed stickers to maps of the project area showing areas of inundation to "vote" for the areas they deemed would best serve as the focus area. West Oakland and the Oakland waterfront emerged as the focus areas, and representative collectors and local streets were selected from these areas only.

The PMT and stakeholders felt it was important to include transportation facilities from all asset categories and types. Additionally, it was determined that some asset types include within them unique assets, which would be identified in addition to the broader number of assets in that asset type. For example, "Connectors to isolated neighborhoods" were identified in addition to other "Arterial, Collector, and Local Streets" to ensure that assets that might provide the only means of access to a particular area are included. Similarly, "Local Bridges" were identified in addition to other bridges because of their importance to the island City of Alameda. Even for these unique asset types, two to three representative assets were selected, applying the filters described above.

2.3.1 FUNCTIONALITY AND OTHER CHARACTERISTICS TO SELECT REPRESENTATIVE ASSETS

A critical question for the project was whether a transportation asset was "in" or "out" of the potential exposure (inundation) zone for the anticipated end-of-century SLR scenario (see Chapter 4). The transportation assets that were not exposed to SLR were not included in the inventory. (Note that early on in the project, the team did not have the improved inundation maps developed for the project [mentioned earlier; see Chapter 4 for full details] and therefore used the USGS (Knowles 2009) extent of inundation maps and added a half-mile buffer zone to be applied as a first filter.) This resulted in a first shortlist of assets per asset type likely to be inundated. Later in the process, this preliminary list was verified with new inundation maps.

In addition to considering exposure to SLR, additional characteristics outlined below in Table 2.6, were used to narrow down the number of assets further for each asset type. Generally, assets exhibiting more functionalities or with a greater number of quantified characteristics were retained, filtering out assets serving fewer functions or having lesser importance. It should be noted that all assets that are within the SLR exposure zone but were not further assessed as part of the project should be evaluated for vulnerability using the process described in this report by the appropriate agency in the future.

TRANSPORTATION ASSET SUBCOMMITTEE ASSET CATEGORIZATION AND SELECTION WORKSHOP

After the transportation asset categories and types had been established and representative assets selected, a stakeholder workgroup meeting was held for all the transportation stakeholders to comment on the process and provide input on the selection of representative assets. During the meeting, stakeholders received an update on the project, and the preliminary transportation asset categories and types were presented. Printed maps were available showing all the assets per asset type in the SLR exposure zone. The committee was asked to review the asset categories and shortlisted representative assets based on the identified characteristics. This allowed the stakeholders to raise any "red flags" concerning the selection of certain assets.

Table 2.6 Functionalities and Characteristics of Transportation Assets

Characteristic or Functionality	Description
Physical Characteristics	Indicates whether an asset is built at-grade, below grade, or elevated on embankments or structures, through inspection of Google Maps satellite images. For bridges, the structural type was identified as an additional physical characteristic and determined by referencing pertinent Websites. This was intended to ensure that the selected assets reflect a complete range of physical characteristics.
Functionality	
Lifeline Route	Denotes whether or not an asset is included in the Caltrans network of "Lifeline Highway Routes," as shown on a map prepared by Caltrans District 4's Office of System and Regional Planning. This applies only to the interstate highways and state routes of "Road Network" assets.
Evacuation Route	Denotes whether or not an asset is designated as an "Evacuation Route" by the cities. This applies only to "Road Network" assets.
Goods Movement	Denotes whether an asset is identified as part of the "Truck Network" in Caltrans GIS data, is a roadway within Port of Oakland property (both seaport and international airport), or provides a direct connection between the Truck Network and Port of Oakland property, by inspection of Google Maps. This applies only to "Road Network" assets and the railroads included in "Transit" assets.
Transit Route	The local bus routes operating on a particular asset ("Road Network" assets) or serving a particular BART or Amtrak station ("Transit" assets) are identified, as determined by inspection of current AC Transit, Emery-Go-Round, and Union City Transit system maps.
Bike Route	Denotes whether an asset is identified as having bike lanes in Metropolitan Transportation Commission (MTC) GIS data (2011), or is included in Figure H.4, "Existing Bikeways," of the City of Oakland Bicycle Master Plan (2007), or is indicated as an on-street portion of the San Francisco Bay Trail, as indicated on the East Bay map of the San Francisco Bay Trail (2011). This applies only to "Road Network" assets.
Number of Routes	The number of routes serving a bus transit center or ferry terminal, or lines serving a BART segment, is noted, based on inspection of current bus, ferry, and BART schedules and maps. This applies only to "Transit" assets.
Route Type	The bus service route type is indicated, as set forth in the AC Transit District Board of Directors GM Memo No. 11-055, March 9, 2011. This applies only to AC Transit routes of the "Transit" assets.
Ridership	Expressed as daily entries/exits, for BART stations only, as calculated from BART Station Entry/Exit Data (October 2010).
Passenger/Freight function	For railroads only, it is indicated whether passenger service, freight service, or both are served.
Average Daily Passengers	For AC Transit routes, as indicated in the AC Transit District Board of Directors GM Memo No. 11-055 (2011), and for BART line segments, as calculated from BART Entry/Exit Data (October 2010).
Line load	For BART stations only, as calculated from BART Entry/Exit Data (October 2010).
Jurisdiction	Indicates the agency, city, or other entity with ownership and/or management responsibility for the asset.
Social/Economic Considerations	
Commuter Route	Using professional judgment, freeways, Transbay bridges, and the Alameda tubes in the "Road Network" assets are selected and noted as primary commuter routes connecting to jobs. Using professional judgment, BART lines and stations in the "Transit" assets are selected and noted as the primary transit assets connecting to jobs. For "Bike/Ped" assets, it is noted whether a facility provides direct access to a transit asset, as indicated by PMT input.
Regional Importance	Using professional judgment, freeways, Transbay bridges, and roadways connecting the freeway system to Oakland International Airport were selected and noted as assets with regional importance. This applies only to "Road Network" assets.

Characteristic or Functionality	Description
Supports Transit-dependent Populations	MTC data on household car ownership by Census Block (2011) was divided into quintiles. It is noted whether an asset is located in a Census Block in the lower three quintiles, corresponding to Census blocks where 81 percent or fewer of the households own cars. Applies to "Transit" and "Bike/Ped" assets only.
Multimodal	By inspection of current bus, ferry, BART, and Amtrak schedules and maps, it is noted if an asset supports transfers between these modes; for "Transit" assets only.
Maintenance	For "Facilities" assets, it is noted whether a facility supports the maintenance of other transportation assets.
Management	For "Facilities" assets, it is noted whether a facility supports the management of other transportation assets
Recreational Use	For "Bike/Ped" assets, it is noted whether a facility supports recreational use; using professional judgment, all components of the Bay Trail are considered recreational assets

Questions for the Transportation Asset Subcommittee included the following**:**

- Did we pick the "right" criteria/characteristics to determine representative assets?
- Reviewing the asset list, are we missing any characteristics that you would use to determine representativeness of the asset type?
- Which assets do you think are the most representative based on your professional judgment? Would they be determinable with the characteristics chosen?

There was general consensus among the stakeholders on the developed approach and the asset categories and types. Most comments received during and after the meeting applied to characteristics of the assets and information that is available to support the analysis.

The long list of representative assets is shown in Table A2.7 in Appendix A.

SHORT LIST OF REPRESENTATIVE ASSETS AND STRESSOR INFORMATION

The list of selected representative assets was still considered too long for taking forward to the vulnerability assessment stage (see Chapter 5) due to the amount of stressor information that still needed to be collected for that stage and due to budget and schedule considerations. Therefore, decisions needed to be made to further reduce the number of assets.

"CRITICAL, UNIQUE" ASSETS

For a number of asset types, all assets were moved forward to the vulnerability assessment on the basis of their unique nature/criticality as transportation assets for the Bay Area and Alameda County (e.g., all tunnels/tubes). This was particularly applicable where an asset type had only one or two examples. Using the revised inundation data plus functionality characteristics (e.g., whether the asset is a commuter route, goods movement route, transit route, Lifeline Route) already collected, these critical and unique assets were selected from the following asset types:

- Interstates/freeways,
- Arterial streets,
- Road tunnels/tubes (including associated facilities),
- Bay bridges (including toll plazas),
- Alameda bridges,
- BART stations (including associated bus and parking facilities),

- BART alignments,
- Amtrak stations (including associated bus and parking facilities),
- Passenger/freight rail alignments,
- Ferry terminals,
- Transportation management centers,
- Bus maintenance facilities,
- BART system assets, and
- Passenger and freight yards and depots.

The number of arterial assets was reduced to include only those that connect the port or airport to the larger network and/or contain bus routes (e.g., selected based on functionality). One representative Alameda bridge and one representative ferry terminal were selected based on exposure, sensitivity, and level of use. During this phase of asset selection, in order to help rationalize the number of assets, the following decisions also were made:

- A bus route, in contrast to the road that it operates on, was considered a service and not a physical facility that can be protected. Therefore, it was noted which parts of the road network (from freeway to neighborhood street) facilitate a bus route.

- Certain facilities were grouped with the adjoining assets they supported. For example, the BART O&M Shop (near the eastern approach of the Oakland Wye) was considered with Oakland Wye East Portal as a single asset; the Interstate 80 (I-80) Toll Plaza was considered with the landside I-80 segment as a single asset.

- Bus facilities were considered as part of the respective rail station.

- Webster/Posey Tube Facilities (415 Harrison), approaches, and the tubes themselves were considered as a single asset

REPRESENTATIVE ASSET TYPES

The project team used the information collected on inundation and functionality again to further refine the list of “representative” assets/asset segments to undergo a vulnerability assessment for the following asset types:

- Collector streets,
- Neighborhood streets,
- Connectors to isolated neighborhoods, and
- Trails/Class I bicycle facilities.

For example, neighborhood streets were selected if they had additional functionality, such as having transit routes and/or a bike lane. Parts of the Bay Trail were selected that were commuter routes and were in low-car ownership areas. Class II bike facilities were considered as part of the streets they operate on.

SHORT LIST OF ASSETS FOR VULNERABILITY ASSESSMENT

The list of selected assets moved forward for the Vulnerability Assessment is shown in Table A2.8 in Appendix A. This short list of assets was sent to the following relevant agencies—Metropolitan Transportation Commission (MTC), BART, Water Emergency Transportation Authority, California Department of Transportation (Caltrans), Bay Trail, City of Alameda, AC Transit and Capitol Corridor—to collect the final detailed stressor information outlined below that would contribute toward assessing the sensitivity of the asset to inundation by SLR.

DETAILED STRESSOR OR "SENSITIVITY" TRANSPORTATION DATA COLLECTION

The project team met to discuss what the most appropriate stressor criteria should be given the difficulty of accessing data and the availability of data. The stressor criteria provide information on the potential sensitivity of the asset to inundation to SLR. As a result, seven criteria were developed and data was requested from the responsible agencies for selected assets to support the vulnerability assessment (Table 2.7).

Table 2.7 Stressor or "Sensitivity" Criteria

Criterion	Definition
Age of Facility	Defined or recorded in terms of the year the facility was built or the number of years the facility has been in service.
Level of Use	Quantifying traffic volumes for cars and trucks, which may be defined or recorded average daily traffic volumes, annual average daily traffic volumes, annual average weekday daily traffic volumes, peak-hour volumes, peak-period volumes, and/or the percent of trucks that use the facility during a given period. For transit assets, level of use may be expressed in terms of various ridership metrics.
Seismic Retrofitting	Indicating whether structures have been strengthened in order to improve resistance to seismic activity, ground motion or soil failure due to earthquakes. Seismic retrofitting is usually required for structures built prior to 1975, as seismic codes were not as rigorous at that time. For the roadways, seismic retrofitting would typically be expected on bridges or similar structures along the specified segments. Seismic retrofitting of bridges involves strengthening columns with steel casing and in some cases may also involve the strengthening of footings, abutments, and hinges.
Operations and Maintenance (O&M) Costs	Recorded in terms of annual O&M costs for each facility, estimated lifetime O&M cost, and/or annual O&M cost per lane. Maintenance includes activities to keep pavement, shoulders, slopes, and drainage facilities functioning properly, which may include grading, resurfacing, crack sealing, patching potholes, asphalt concrete overlaying, and spot rehabilitation. Maintenance does not include building shoulders or widening roads.
Condition	Depending on the asset type, other methodologies or rating schemes, which may be proprietary, may be in place to assess the "condition" of particular assets with respect to other assets.
Liquefaction Susceptibility	Provided by ABAG (2011). The liquefaction susceptibilities of points within the subregion are assigned a ranking of "very low," "low," "moderate," "high," or "very high."
Foundation Condition	Foundations or subgrades supporting roadway segments and any structures, such as bridges, along the segments. Data may include the type of foundation, the age of the foundation, the extent of the last maintenance in regards to the foundation and any existing foundation issues. Foundations may be shallow or deep, isolated or combined and with and without piles. Foundation issues may include movement, settlement, and cracking.

Within the schedule required for the project, information was generally available only for the road network. Data exist for the transit facilities but were not easily accessible in the timeframe required. The information collected is summarized on the risk profiles of the most vulnerable assets; see Section 5.4, Chapter 5.

2.4 Shoreline Asset Categorization

The shoreline assets were categorized using a method different from that used for transportation assets. The shoreline categorization focused on identifying the main line of shoreline defense (and protection assets) along the subregional coastline because the primary focus of the FHWA conceptual model is to understand the risk and vulnerability of transportation assets. However, the vulnerability of shoreline assets clearly plays an important role in the vulnerability of transportation assets. For this project, the primary drivers affecting transportation asset vulnerability and risk related to the shoreline assets were as follows:

- Shoreline asset type (or suite of types creating a flood protection system that protects a transportation asset) and elevation,
- Inundation level at the shoreline asset (e.g., the depth of inundation directly over a flood protection levee, not inland of the levee), both under daily tidal inundation (mean higher high water [MHHW] plus SLR) and under 100-year storm events (stillwater levels and stillwater levels plus wind wave effects), and
- Wave climate (wave height, period, and velocity) outboard of the shoreline asset(s).

To conduct this analysis, stretches of shoreline were categorized in a GIS mapping exercise. This allowed the project team to analyze the shoreline near a transportation asset to better understand inundation behind the shoreline asset. The five agreed upon shoreline categories for this project are as follows:

- Engineered Flood Protection Structures
  - Levees
  - Flood Walls
- Engineered Shoreline Protection Structures
  - Bulkheads
  - Revetments
- Nonengineered Berms
- Wetlands
  - Natural
  - Managed
  - Tidal Flats
- Natural Shorelines (Nonwetland)

These shoreline asset categories attempt to collapse a highly varied and diverse shoreline into distinct classes that will support the vulnerability and risk assessment. The categories were defined based on their primary function and are presented in order from those assets that provide the most potential protection from inundation to those assets that have the least potential for inhibiting inland inundation.

The engineered flood protection structures protect inland areas from flooding and inundation; engineered shoreline protection structures harden the shoreline to reduce erosion and prevent land loss; nonengineered berms protect marshes and ponds from wave erosion and provide flood protection to inland developments and, in some cases, serve to maintain hydraulic separation between the bay and the protected/ managed areas; wetlands dissipate wave energy and provide ecological habitat value; and other natural or managed nonwetland shorelines, such as natural or artificially maintained beaches, can provide some wave energy dissipation. Figure 2.3 shows locations of example shoreline asset categories.

Figure 2.3 Location of Shoreline Asset Examples

2.4.1 ENGINEERED FLOOD PROTECTION STRUCTURES

LEVEE

Engineered levees are one of the most common forms of riverine and coastal flood protection. The primary purpose of a coastal levee is to prevent inland flooding from major storm events and extreme water levels that may also be accompanied by large, powerful waves. Figure 2.4 depicts an aerial view of an engineered levee at the Oakland International Airport. The roadway is located along the levee crest. The outboard slope (or embankment) of the levee is armored with a riprap revetment that protects the levee from wave- induced erosion. Figure 2.5 presents a generalized schematic of a coastal levee. Levees are engineered to meet certain design criteria with respect to freeboard (distance between the 100-year stillwater elevation (SWEL) plus wave run-up and the levee crest), embankment protection, embankment and foundation stability, and settlement. Levees are generally designed, at a minimum, to provide protection from the 100-year coastal event (high-water levels and waves).

The protective value of a levee changes as sea level rises. As sea level rises, MHHW and the 100-year SWEL also rise. This could result in a reduction or elimination of the levee freeboard, resulting in an increase potential for levee overtopping and inland inundation of the protected areas behind the levee. The list below presents the progression over time of the level of protection provided by a levee as sea level rises, assuming no levee upgrades occur:

- The 100-year SWEL and the maximum wave run-up associated with that SWEL do not overtop the levee, but the levee no longer meets its original freeboard design criteria.

- The 100-year SWEL is below the levee crest, but the combination of the 100-year SWEL and the maximum wave run-up condition results in levee overtopping; therefore, levee overtopping occurs primarily during extreme events with large waves.
- The 100-year SWEL is above the levee crest, resulting in levee overtopping. The levee would be routinely overtopped during extreme high-water events regardless of the wave conditions.
- MHHW is above the levee crest, resulting in levee overtopping. The levee would be routinely overtopped.

An additional vulnerability factor not considered in the above scenarios is the impact on the existing levee conditions as sea level rises. SLR may be accompanied by larger and more frequent waves, which could result in erosion of the levee embankment. In addition, levee overtopping, whether frequent or infrequent, could result in erosion along the levee crest and the backside of the levee, thus weakening the levee and increasing the potential for levee failure.

Most engineered levees are regularly maintained by the agencies responsible for the levee; therefore, it is likely that the levees would be upgraded in order to accommodate changing conditions and maintain existing levels of flood protection. Levees can be upgraded by increasing the height (and also the overall footprint of the levee). If the levee footprint cannot be expanded due to land use constraints, levees could be upgraded by combining them with other means of flood protection, such as constructing a flood wall along the levee crest.

Figure 2.4 Engineered Levee with Revetment: Oakland International Airport, Oakland; Roadway Is Levee Crest

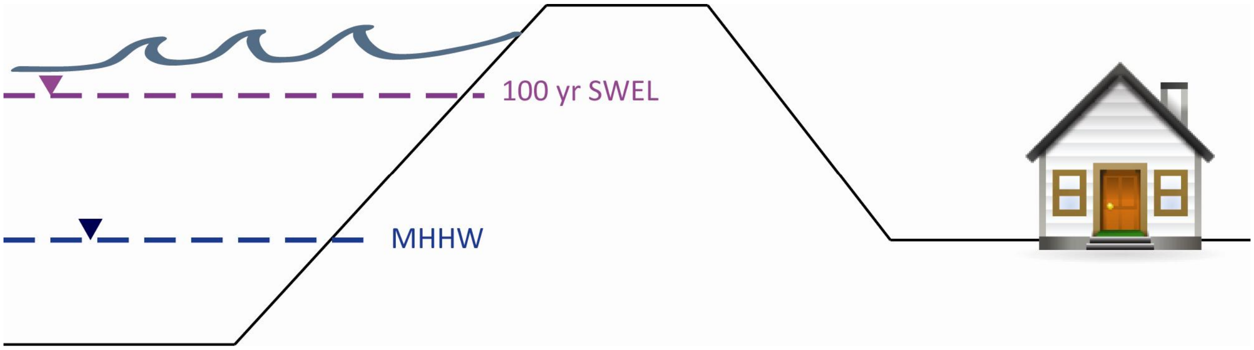

Figure 2.5 Schematic of Levee Cross Section

FLOOD WALL

A flood wall is a vertical barrier designed to protect inland areas from flooding. Figure 2.6 shows the flood wall protecting the Eden Shores neighborhood adjacent to the Eden Landing Complex in Hayward. The design standards for flood walls are similar to those of an engineered levee in that the critical components are the amount of freeboard and overall stability. Flood walls are also vulnerable to SLR in a manner similar to engineered levees.

Figure 2.6 Flood Wall: Eden Shores, Landward of Eden Landing Complex, Hayward (Nonengineered Berm also Pictured to the Right of the Floodwall with Roadway as Berm Crest)

2.4.2 ENGINEERED SHORELINE PROTECTION STRUCTURES

Although engineered levees are one of the most common forms of engineered flood protection, other forms of engineered structures also exist along the San Francisco Bay shoreline. Along the Alameda County shoreline, bulkheads and revetments are the most common engineered shoreline protection structures. Shoreline protection structures differ from flood protection structures because their primary purpose is to harden the shoreline and reduce land erosion and land loss. Shoreline protection structures are not designed to provide protection from inland flooding.

BULKHEAD

A bulkhead is a vertical retaining structure designed to reduce land loss. Its secondary purpose is to protect inland areas from wave damage. Bulkheads can be cantilevered over the water surface or solid structures with earthen backfill behind them. Figure 2.7 depicts a bulkhead in the Port of Oakland Inner Harbor Turning Basin. Bulkheads are not designed to provide flood protection. As sea level rises, the functionality and stability of the bulkheads can be compromised, leading to bulkhead collapse and failure of the bulkhead support structures.

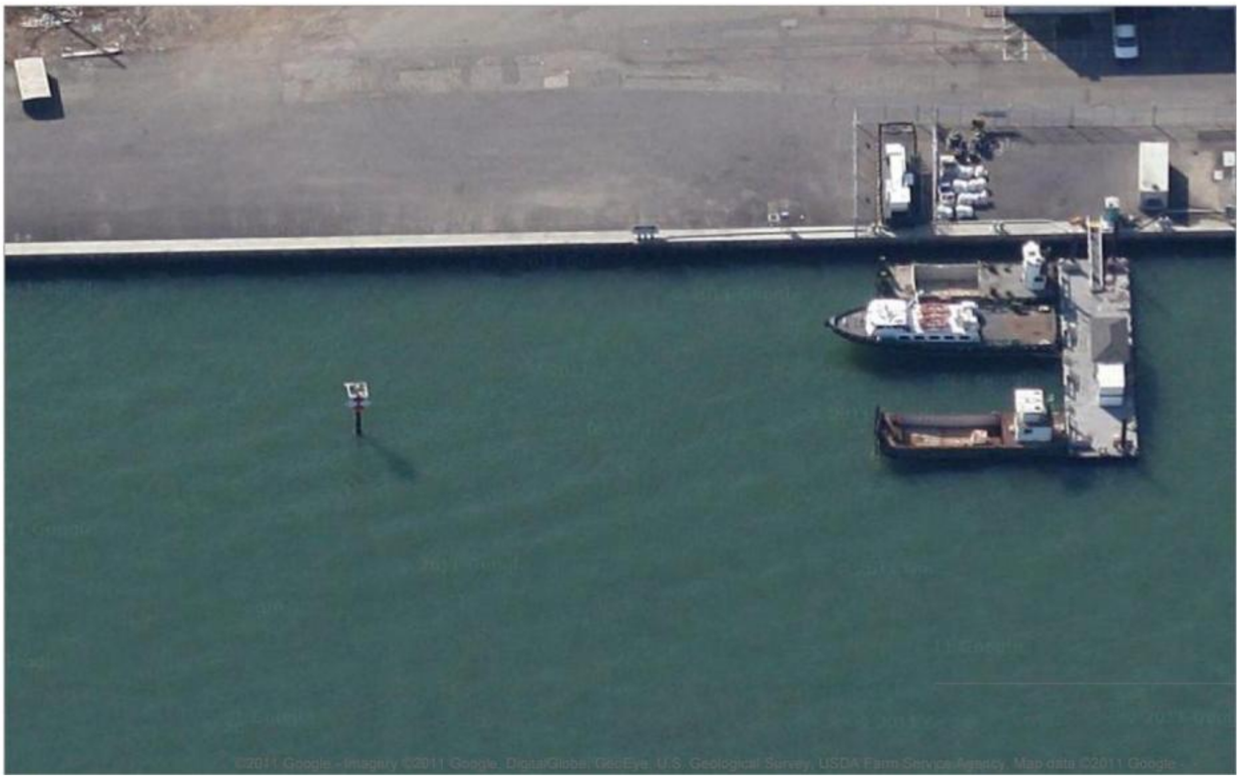

Figure 2.7 Bulkhead, Port of Oakland, Oakland

REVETMENT

Revetments are designed to protect the shoreline from waves and strong currents and to inhibit wave-induced erosion and land loss (CEM 2006). In general, revetments are a cover, or facing, of erosion-resistant material (such as concrete or riprap) placed on an existing slope or an engineered embankment to protect the area from waves. A revetment hardens the shoreline and maintains its position. The three major components of an engineered revetment are a stable armor layer, a filter cloth or underlayer, and toe protection. Along the San Francisco Bay shoreline, revetments are common. Revetments can exist alone, as shown for the Shoreline Park (Figure 2.8), or they can exist in combination with other structures.

For the Port of Oakland, revetments exist alone and/or underneath pier structures (Figure 2.9). Revetments can also exist in combination with other forms of coastal flood protection, such as along engineered levees (Figure 2.4), nonengineered berms (Figure 2.10), and inland of wetlands (Figure 2.11). Along nonengineered berms, most often the visible riprap armoring is not truly a revetment because the structure has not been engineered and it does not contain the three major components noted above. In this case, riprap is often added in an ad hoc manner as erosion is noted. Revetments, by themselves, are not designed to provide flood protection. As sea level rises, the functionality and stability of revetments can be compromised. The primary failure modes as sea level rises are:

- Armor layer damage: the armor layer is designed for existing wave conditions. In the case of a riprap revetment, the riprap size (or rock/stone size) is selected so that it will remain in position under strong currents and wave conditions. As sea level rises, wave heights and velocities may increase, thus conditions could exist where the armor is mobilized.
- Overtopping: overtopping could result in a loss of foundation material.

Figure 2.8 Revetment, Shoreline Park, Alameda

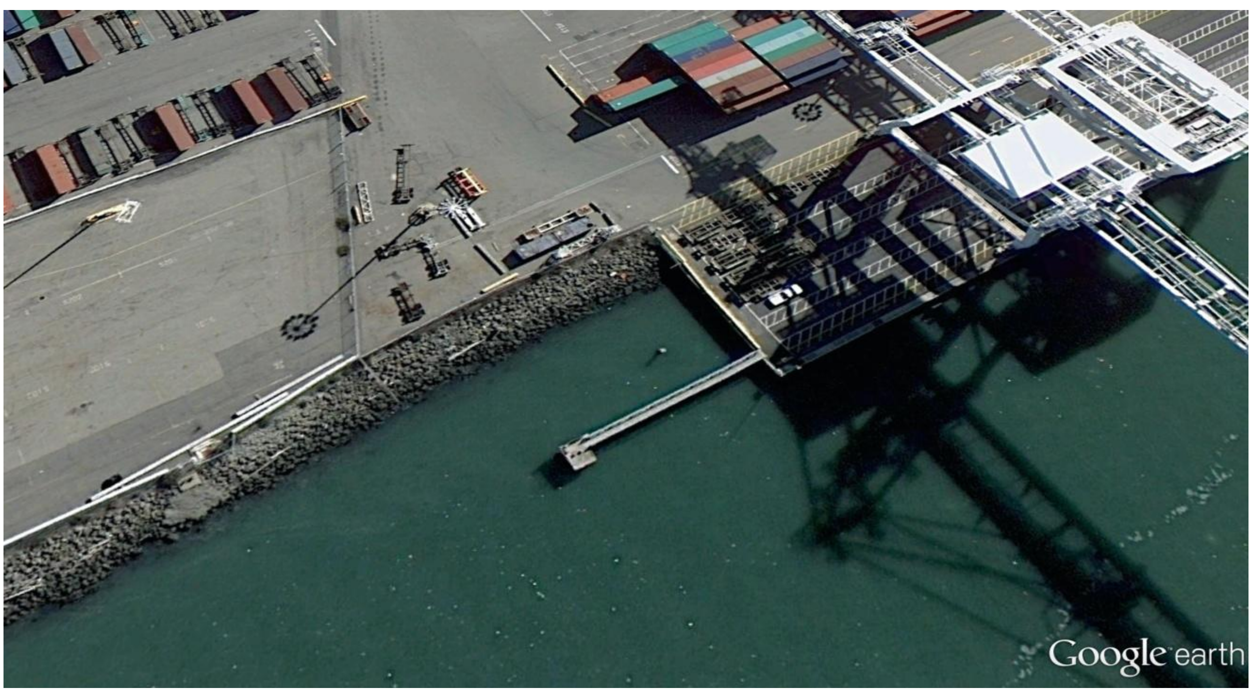

Figure 2.9 Revetment, Port of Oakland, Oakland

Figure 2.10 Nonengineered Berm with Riprap Protection, Hayward; Roadway Berm Is Berm Crest

Figure 2.11 Riprap Protection for Wastewater Treatment Plant, San Leandro (Wetlands and Tidal Flats Outboard)

- Toe failure: the toe protection provides support for the revetment. As the wave and current conditions change and exceed the design conditions, the toe could experience undercutting and the entire revetment could unravel.

- Revetments can be upgraded over time as sea level rises. This may result in placing an additional armor layer with larger rock/stone sizes that are sized for the increasing wave conditions. The height of the revetment along the slope would also need to increase to account for the higher water levels and wave heights, and the toe protection would need to be increased to account for the increased size of the overall structure. If the revetment has reached its maximum size, limited by the height of the slope it is protecting, and additional protection is still required, the revetment may need to be coupled with an engineered flood protection structure.

2.4.3 NONENGINEERED BERM

Nonengineered berms are similar to engineered levees in appearance; however, there is a very notable difference between the two. Nonengineered berms have not been engineered to meet the design criteria for a levee. The most common nonengineered berms around San Francisco Bay are the salt pond berms. These berms are essentially mounds of bay mud that have been excavated from the bay floor and piled and/or stacked in a mound. As the mound settles, grading equipment can be used to shape the structure and create a roadway surface, if desired. Figure 2.12 shows the "Mallard," a specialty dredging machine that is used to build and maintain the salt pond berms. The characteristics of salt pond berms vary greatly. Some appear more structurally sound, particularly along the bayfront where the berms are often large in order to provide wave protection. Many berms contain maintenance roadways along the crest (Figure 2.13) and riprap protection on the wave-exposed sections (Figure 2.14). The riprap protection found along these berms can consist of concrete construction debris.

Figure 2.12 Maintenance of a Nonengineered Berm in Eden Landing by the Mallard, Hayward

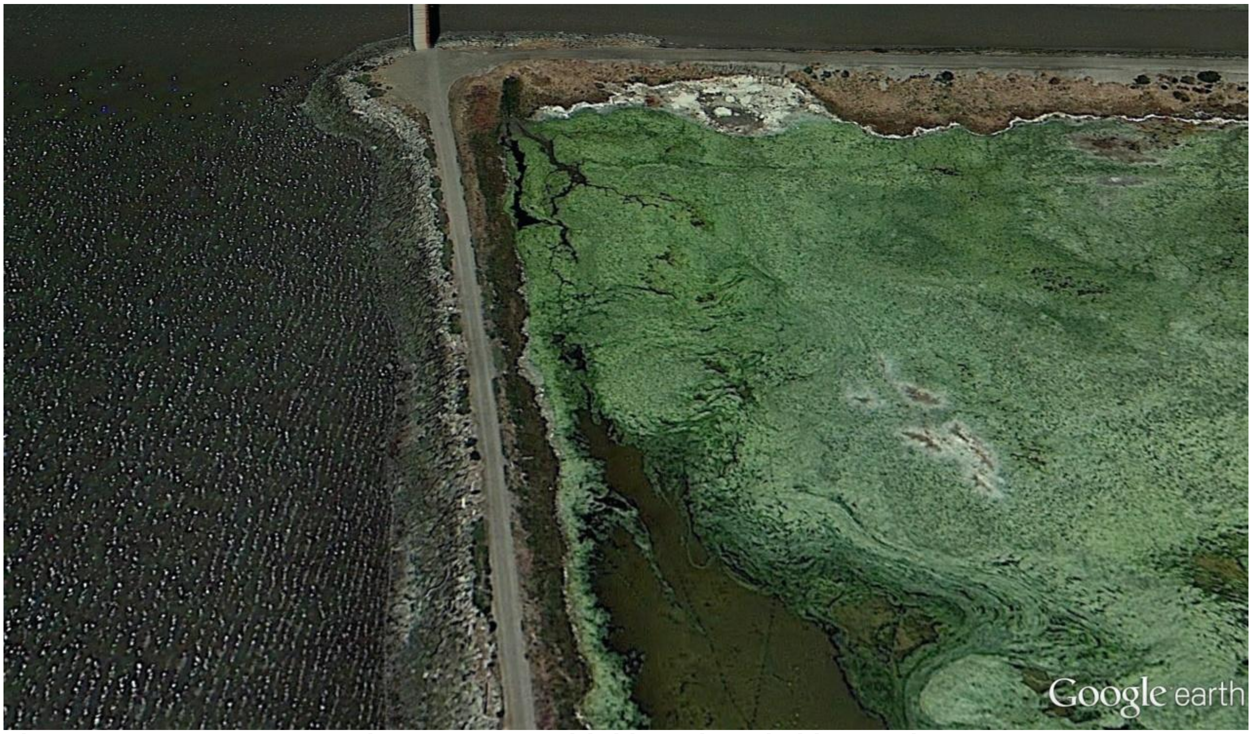

Figure 2.13 Former Salt Pond Berm, Hayward (with Outboard Tidal Flats)

Nonengineered berms are often maintained in a reactive fashion as erosion is observed or as failures occur. Many berms undergo maintenance on a regular cycle based on the level of wave exposure (e.g., outboard berms are maintained more often than inland berms). This type of structure was not designed or intended to provide flood protection to inland areas. However, they do provide some level of ad hoc flood protection to inland developments. Many of the salt pond and former salt pond networks are expansive, thus providing a substantial buffer between bay water levels and waves and inland developed areas.

Nonengineered berms are extremely vulnerable to SLR. The berms can continue to be built up over time. However, current maintenance practices with the Mallard rely on adjacent borrow of bay mud (i.e., the bay floor directly adjacent to the berm is excavated and placed on top of the berm). Many of these adjacent borrow pits are already very deep; therefore, this source of material could be exhausted over time, requiring suitable material to be imported. Due to the nonengineered nature of these structures, there may also be a maximum height limit to which they can be built.

2.4.4 WETLANDS

The value of wetlands for flood protection and wave dissipation purposes is not well understood. Although it may seem intuitive that a large expanse of wetlands would help dissipate waves propagating inland, quantifying this can be difficult. Several different types of wetlands exist along the Alameda County shoreline. Figure 2.15 depicts the Emeryville wetlands to the north of the Oakland-Bay Bridge, directly adjacent to I-80. These wetlands have a natural marsh edge that is fully exposed to the bay. Figure 2.16 depicts a range of wetland habitats at the confluence of the San Lorenzo Creek and the bay. The habitats transition landward from shallow subtidal, to tidal flats, to fringing marsh, to managed marsh on the inland margin. Some of the inland developed areas, in particular the wastewater treatment plant, have a riprap armored shoreline. The Hayward shoreline is a complex mosaic of managed marshes and managed ponds

Figure 2.14 Nonengineered Berm with Riprap-Protecting Tidal Marsh from Wave Erosion, Hayward (see Hayward Marsh Figure 2.17 below under “Wetlands”)

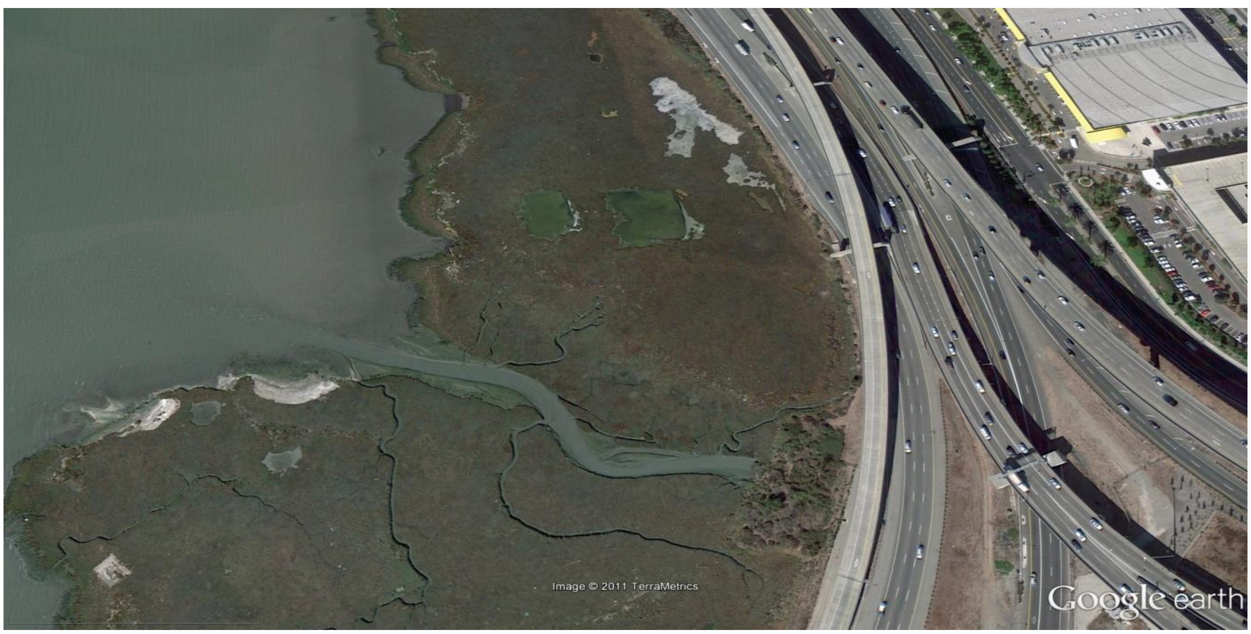

Figure 2.15 Wetlands with Natural Marsh Edge, Emeryville

Figure 2.16 San Lorenzo Creek Tidal Flats, San Leandro (Some Inland Areas Have Riprap-Armored Shoreline; see Figure 2.21)

(Figure 2.17). The outboard regions of the wetlands all contain nonengineered berms to provide wave protection, with the exception of Whales Tail marsh in the Eden Landing Complex just south of the San Mateo Bridge (Figure 2.18).

Historically, wetlands have kept pace with SLR in the bay by accumulating sediment and organic material at a rate similar to SLR. It is not known if wetlands will keep pace with accelerated rates of SLR. For most wetlands, such as the Emeryville wetlands shown in Figure 2.15, there is no inland space for landward migration of the wetland. The wetlands along the Alameda County shoreline will either keep pace with SLR, or they will drown and disappear, unless provision is made for their landward migration. Fringing wetlands directly outboard of developed areas are at greatest risk of disappearing. A recent study by PRBO Conservation Science (PLoS 2011) however indicates that it is unlikely that Bay Area marshes will be able to keep pace with anticipated sea level rise at the end of the century. Changes to wetlands are a focus of the larger ART project.

2.4.5 NATURAL SHORELINE (NONWETLAND)

Natural nonwetland shorelines also exist along the Alameda County shoreline. The most notable stretch of natural shoreline is Robert Crown Memorial State Beach in Alameda (Figure 2.19 and Figure 2.20). The beach is 2.5 miles long, backed by sand dunes. The beach is maintained with imported sand and engineered sand-retaining structures.

Although the beach and the dunes do provide protection to the inland area from large waves, both the beach and the dunes are erosional. As sea levels rise and wave intensity increases, natural shorelines such as these will be extremely vulnerable to SLR. Over time, the sand dunes could require a revetment to harden the shoreline and protect the roadway, and the beach would entirely disappear if it were not maintained with continued sand import. Vegetation can also be added to protect against erosion in the short term.

Figure 2.17 Managed Wetlands, Hayward (Protected Tidal Marsh, Managed Marsh, Managed Ponds – Extensive Nonengineered Berm Networks)

Figure 2.18 Whales Tail Marsh, Eden Landing, Hayward

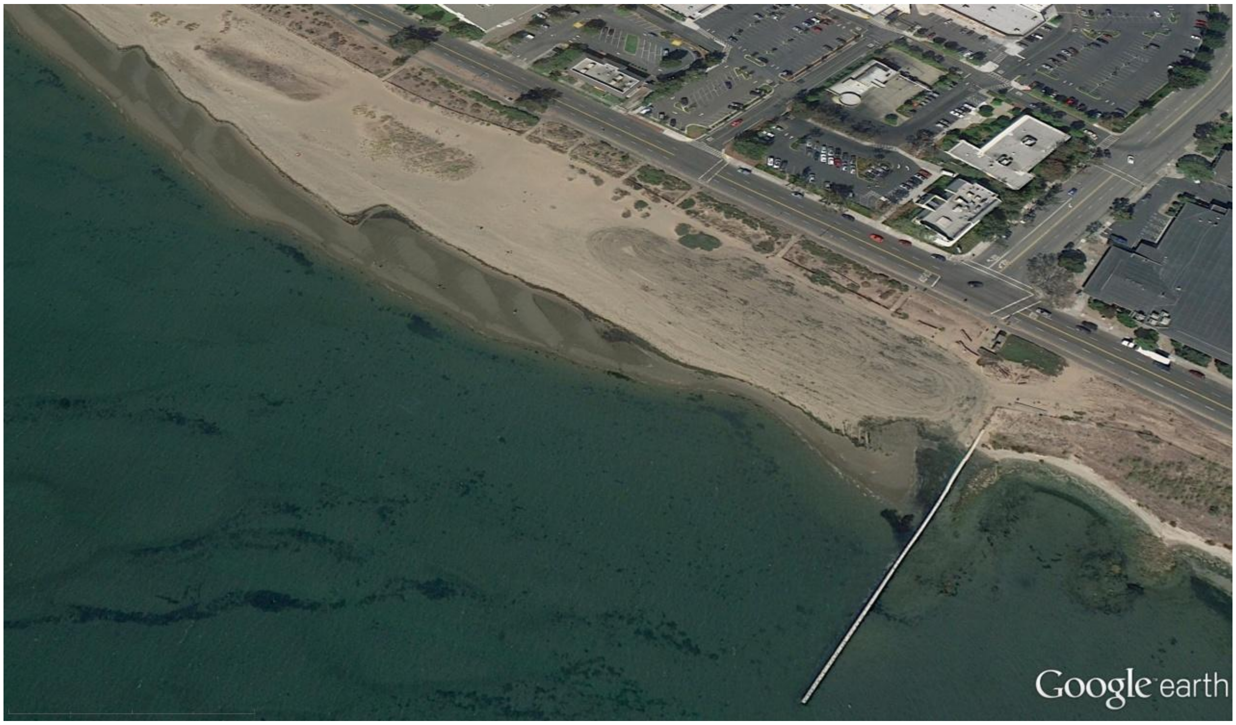

Figure 2.19 Beach – Robert Crown Memorial State Beach, Alameda (Beach Is Erosional and Maintained through Beach Nourishment [i.e., Imported Sand])

Figure 2.20 Beach – Robert Crown Memorial State Beach, Alameda (Steep Sand Dunes Lead to Bicycle Trail and Roadway)

2.4.6 SHORELINE CATEGORIZATION MAPS

This project specifically developed shoreline categorization maps (Figure 2.21and Figure 2.22), using the shoreline categories defined above, because existing data did not meet project needs. Several agencies have "classified" the San Francisco Bay shoreline for different purposes using various classification schemes. The San Francisco Estuary Institute (SFEI) has developed detailed maps that classify habitat types along the shoreline; the National Oceanic and Atmospheric Administration (NOAA) classifies the shoreline using an "environmental sensitivity index" that ranks the sensitivity of various shoreline categories to an oil spill; the Federal Emergency Management Agency (FEMA) has divided the shoreline into distinct reaches for transect-based onshore coastal wave hazard analysis, where each distinct reach has uniform characteristics along its length (e.g., type of protection, slope, land use, wave climate). Although both SFEI's and NOAA's classifications are helpful, neither approach fits the criteria or categorization needs laid out by the project. FEMA's classifications most closely match the project's needs, but the data were not in a readily usable GIS format.

SHORELINE CATEGORIZATION MAP METHODOLOGY

On a county-wide scale, a combination of NOAA data (the ESI index and the NOAA shoreline delineation) and SFEI data (the EcoAtlas and Bay Area Aquatic Resource Inventory data), along with Alameda County's levee alignment file and aerial imagery from Google Earth, was used to classify the shoreline into the five categories listed above. This approach maximized the use of readily available data sets and limited the need for manipulation and conversion of non-GIS to GIS formats. NOAA's environmental sensitivity index data provided a detailed breakdown that could be parsed into the five categories created for this project; however, the data categorize the shoreline based on its most outboard land use and its sensitivity to fouling in the event of an oil spill. The most outboard land use may not adequately capture the most relevant land use for the risk assessment of a transportation asset. For example, NOAA's designated shoreline categories adjacent to the Oakland International Airport are "riprap" and "tidal flats." However, an engineered flood protection levee is landward of the riprap and tidal flats. For this project, the engineered flood protection levee is the most important shoreline asset for the vulnerability and risk assessment. The draft shoreline categorization maps were shared for review with the San Francisco Bay Conservation and Development Commission and Alameda County Flood Control and Water Conservation District, whose comments were included in the final maps.

Figure 2.21 and Figure 2.22 show the different shoreline categories in the pilot area.

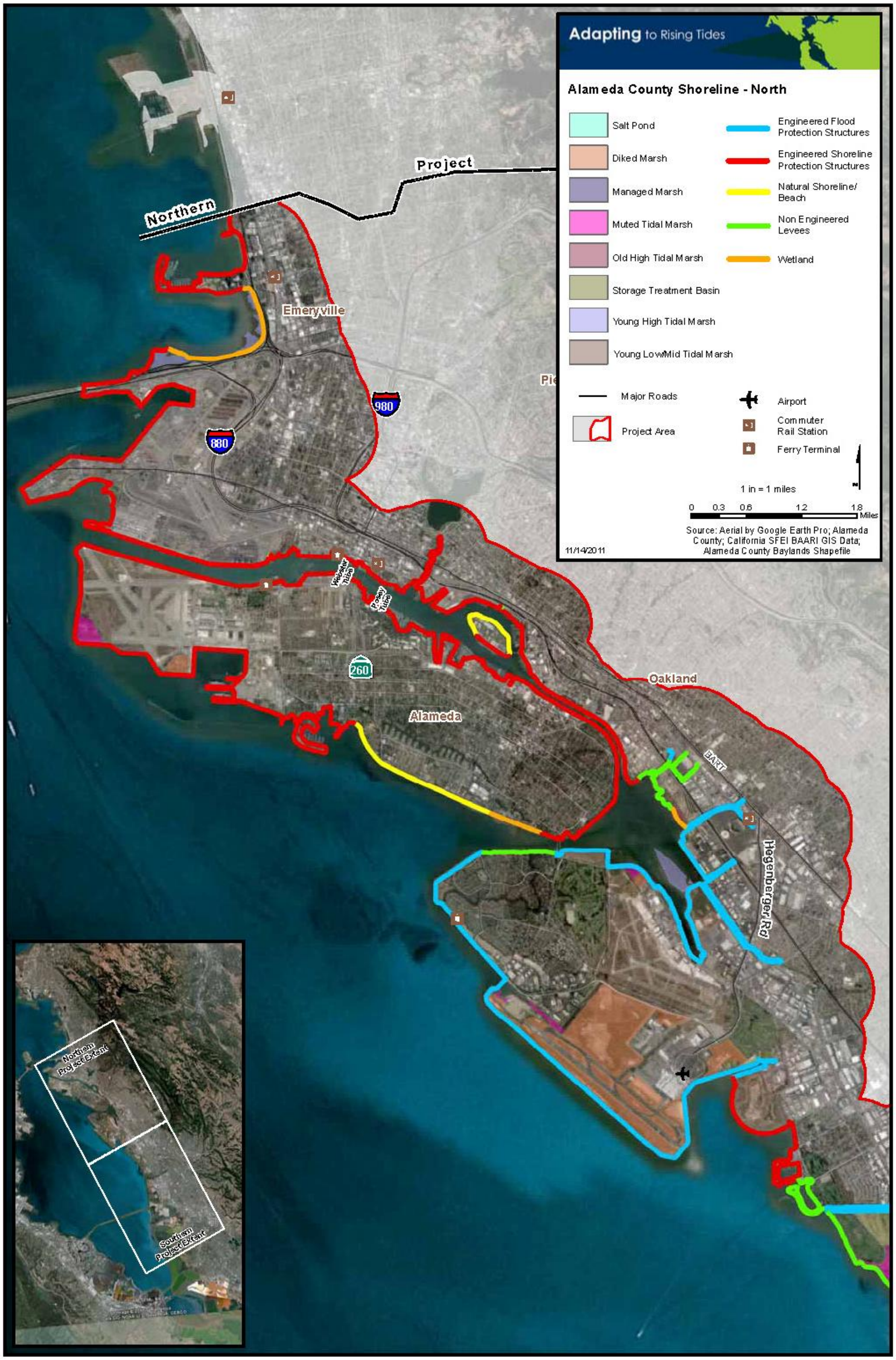

Figure 2.21 Shoreline Categorization Map – Northern Extent

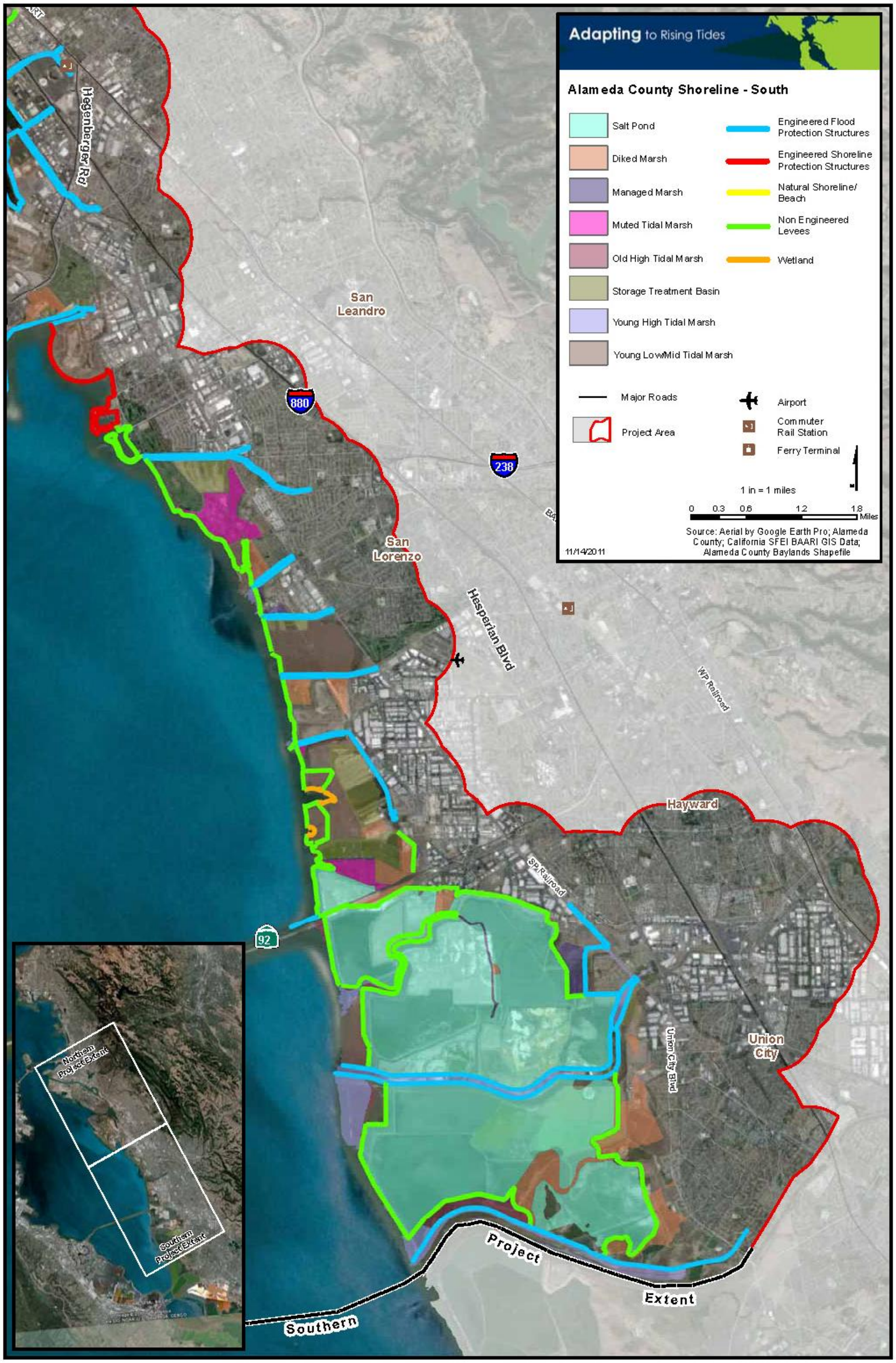

Figure 2.22 Shoreline Categorization Map – Southern Extent

2.5 Recommended Refinements to the FHWA Conceptual Model

This section provides feedback on the FHWA conceptual model and its application in the selected Alameda County subregion in terms of the data collection process and working with local stakeholders.

2.5.1 DATA COLLECTION AND SYNTHESIS ISSUES

Overall, the FHWA conceptual model provided useful guidance for requesting transportation and shoreline asset information. The model also allowed the team to clearly outline the overall process of the vulnerability and risk assessment to stakeholders, the need for data collection, and how the data would be applied.

The process of retrieving and compiling the data from stakeholders was a challenging and lengthy task that took several months longer than initially expected because data were readily retrieved only if specifically requested. Overall data was not readily accessible in useful formats. Even though MTC and Caltrans provided the majority of the transportation data, some were available only from local agencies and stakeholders. It became evident that the collection of more detailed and asset-specific attributes or “stressor” information required paring down the number of transportation assets and selecting a smaller subset of transportation assets in the subregion due to the time consuming nature of the data collection activity. However, the initial collection of regionwide GIS data provided important insights for the subsequent data and asset selection effort.

In addition, the shoreline asset data proved difficult to collect. The project team had assumed that the Alameda County Flood Control and Water Conservation District would provide detailed information on the majority of the shoreline protection assets (e.g., location, elevation, protection type) in GIS format. However, this information was only partially available, which was also the case with information from NOAA and SFEI. A great deal of effort was therefore put into the shoreline categorization, inundation mapping, and overtopping analysis. It would have been helpful for the FHWA conceptual model to mention how important this information is, and to provide guidance on the treatment of shoreline assets in this process, along with different approaches for its inclusion into the asset selection and subsequent steps.

2.5.2 LESSONS LEARNED

The following lessons were learned as part of the pilot project, with a focus on data collection:

- Many datasets are available only in a nonspatial, tabular, or report format, making data extraction and analysis for such a large area very difficult and work-intensive.
- The transportation base data (roadway networks by a third-party provider), despite having a hundred-page user guide, unfortunately were not helpful in determining attribute information.
- Some data sets contained little or no metadata (background information about the data provided).
- To manage the level of effort required to extract the information embedded in reports, data were not requested for all transportation assets initially.
- Data collection was not, therefore, restricted to one phase of the project but continued throughout, as functionality and other characteristics narrowed the asset list to a more manageable length.

- Readily accessible information was critical to the selection of assets for further analysis, in order to facilitate timely project completion.
- One of the biggest difficulties was not necessarily obtaining the data but managing the expectations of the project team regarding what can be done with the data received because many data sets did not provide much detail beyond the location of assets (e.g., very little physical attribute data was readily available in a usable format).

2.5.3 RECOMMENDATIONS FOR FUTURE APPLICATIONS

Recommendations for the data inventory component of the process include the following:

- Creating the data inventory was a helpful first step to understanding the benefits and limitations of the data available. However, a project with numerous assets and a limited budget or timeline will likely require the collection of more detailed data for a refined list of assets during the vulnerability assessment phase. Thus, we recommend splitting up the data collection effort into overall and focused exercises.
- The suggested importance criteria development was not useful for the Alameda County subregion, and an alternative approach assisting in the selection of representative assets may be useful for future projects involving a subregional analysis.
- Determining the criticality of one asset over another was not politically acceptable, given that the assessment would have been largely based on professional judgment and limited data.
- The most important asset selection filter was exposure to flooding and inundation (location of an asset in the projected inundation zone); characteristics and functionality were only marginally involved in reducing the list of assets. (This is consistent with the Guidance on SLR by Caltrans, May 16, 2011.)
- The USGS (Knowles 2009) SLR extent raster data were useful for preliminary mapping and asset selection purposes, especially for prioritizing potentially exposed transportation assets. The team initially used the original extent of inundation maps from USGS for a rough indication of transportation assets at risk of exposure. Without this information available, it would have been more difficult to pinpoint the necessary geographic information, and it helped the stakeholders visualize vulnerable assets.
- Agencies should be advised of the data required to carry out vulnerability to SLR and should start to collate this data going forward in order to facilitate future assessments in database and GIS formats.

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