Parks Recreation & Waterfront

Berkeley Waterfront Specific Plan

Supporting Infrastructure, Revenue, Parking, and Sea Level Rise Studies

The following studies were produced as part of *Waterfront Specific Plan* (formerly "Berkeley Marina Area Specific Plan") process, with the exception of the "Berkeley Marina Sea Level Rise AB 691 Assessment Study". These studies are not final and continue to be updated by City staff, Hargreaves Jones, and the consultants associated with each study.

The *Waterfront Specific Plan* process began in the spring of 2020, just as the global pandemic emerged, which extended the anticipated duration of the effort and has required continuing to update and revise data and analysis included in these documents. These studies have informed the development of the *Waterfront Specific Plan* to date, and will continue to be referenced and revised as this process continues.

Final versions will be released in coordination with the final *Waterfront Specific Plan* – following an upcoming environmental review process, further community and stakeholder engagement, and ongoing City Council review.

1. **Infrastructure Assessment *DRAFT*** (May 2021)
   Hargreaves Jones, Moffatt & Nichol, Nelson\Nygaard, Bkf Engineering

2. **Existing Amenities and Operations Assessment *DRAFT*** (March 2021)
   Keyser Marston Associates

3. **Implementation Strategy *DRAFT*** (April 2021)
   Keyser Marston Associates

4. **Hotel Food and Beverage Revenue Potential *DRAFT*** (September 2022)
   Keyser Marston Associates

5. **Dredging Needs Technical Memo *DRAFT*** (April 2021)
   Moffatt & Nichol

6. **Slip Mix Study *DRAFT*** (August 2022)
   Moffatt & Nichol

7. **Parking & Mobility Framework *DRAFT*** (January 2022)
   Nelson Nygaard

8. **Berkeley Marina Sea Level Rise AB 691 Assessment Study *DRAFT*** (August 2019)
   NCE

Parks Recreation & Waterfront

Draft Overview of Berkeley Waterfront Sea Level Rise AB 691 Assessment Study

Intent of Study

The intent of this Study is for planning purposes. For the year 2030, 2050, and 2100, the 100-Year Tide Elevation is combined with the upper end of the High Emission, "Likely Scenario" of Sea Level Rise Projections calculated by the Ocean Protection Council to create a scenario for planning purposes.

Probability of 2030, 2050, and 2100 Inundation Maps

The probability of the 100-Year Tide to occur in any given year is 1%. Sea Level Rise Projections have their own probability ranges. The Ocean Protection Council models a 66% probability that Sea Level Rise will be between 0.3 - 0.5 Feet by 2030 (High Emission Scenario), 0.6 - 1.1 Feet by 2050 (High Emission Scenario), and 1.6 - 3.4 Feet by 2100 (High Emission Scenario).

Sea Level Rise Values used in this study are the upper end of these ranges (0.5 Feet 2030, 1.1 Feet 2050, and 3.4 Feet by 2100). These values represent the upper limit of the "likely range" of Sea Level Rise. The Ocean Protection Council models a 83% chance that Sea Level Rise will be lower than these values while there is a 17% chance that Sea Level Rise will exceed these values.

As water elevation fluctuates base on the tide cycles of the Bay, the inundation maps in the attached report are shown as the static inundation probable conditions at the Berkeley Marina during the 100-year tide cycle plus the projected sea levels combined.

Effects to the Berkeley Waterfront

This Study identifies three locations in the Berkeley Waterfront that are most susceptible to intermittent inundation in the future due to Sea Level Rise. (1) Virginia Street Extension (north shore of McLaughlin Eastshore State Seashore) intersection with Marina Boulevard (2) South Shore of University Avenue (3) North-East side of the Berkeley Inner Harbor.

Unfunded Projects List & Next Steps

The City has identified three projects on the Unfunded Projects List to address these locations once funding becomes available. The Marina Boulevard Revetment Upgrade Project and University Ave Shoreline Stabilization Project will require collaboration with the East Bay Regional Park District as the locations are either immediately adjacent to or entirely within their jurisdiction.

The Effects of Sea Level Rise on Capital Improvement Projects

All current and upcoming capital projects in the Berkeley Marina near the shoreline band will be designed to be resilient to mid-century sea-level rise and be adoptable to end of century. These projects' sea level rise mitigation measures will be reviewed and approved by Bay Conservation Development Commission's permit review process ensuring the latest sea level rise requirements are being met by the design.

DRAFT Berkeley Marina Sea Level Rise AB 691 Assessment Study

August 30, 2019

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NCE Collaboration. Commitment. Confidence.SM

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EXECUTIVE SUMMARY

To comply with California statute AB 691, the City of Berkeley is conducting a sea level rise assessment study for the Berkeley Marina, defined as the area of University Avenue, Berkeley Marina, César E. Chávez Park, and McLaughlin Eastshore State Seashore. The assessment is meant to determine the projected impacts of sea level rise on the natural and built resources of the public facility, the economic and social damage of the impacts, and an estimated cost and schedule for mitigation. The sea level rise values projected for 2030, 2050, and 2100 have been considered in this study.

The Berkeley Marina is a valuable public resource that has free entry and public and privately-owned amenities. It is constructed on landfill with rock-slope revetment protection of variable quality around its perimeter. The revetment protection is of higher quality along the western edge of the Marina and lesser quality around the more protected areas of the east and south. The interior of the Marina where the majority of the boat storage facilities are located is protected by two breakwaters. Valuable public features of the Project Area include its recreational and educational facilities (including a portion of the San Francisco Bay Trail), public access to the San Francisco Bay, and boat storing and servicing facilities. Privately-owned accommodations include a hotel and restaurants.

Sea level rise elevation projections are taken from the California Coastal Commission Sea Level Rise Policy Guidance document, last updated in 2018. Because the facility's use is primarily recreational, values from the likely range for low risk aversion were utilized to calculate impacts. These values were added to varying tidal and storm surge conditions. Damages and mitigation measures were analyzed using the 100-year extreme tide (based on the Alameda Gage data from the Federal Emergency Management Agency/San Francisco Bay Conservation and Development Commission "San Francisco Bay Tidal Datums and Extreme Tides Survey") plus projected sea level rise. The still-water values for the low risk aversion sea level rise plus 100-year extreme tide are 10.1, 10.7 and 13.0 feet North American Vertical Datum of 1988 for years 2030, 2050 and 2100, respectively. Extreme wave runup and storm surge most impact the north, west and upper portion of the east side of the Marina.

Damages to the Berkeley Marina are projected to be moderate by 2030 and rise considerably by the end of the century without mitigation. By 2030 there will be some roadway and parking facility inundation, particularly on Marina Boulevard and northeast of the protected area of the Marina, and flooding of McLaughlin Eastshore State Seashore. By 2050, parts of the Double Tree buildings will be flooded with finished floor elevations below the projected water surface elevation, as well as most of Marina Boulevard, portions of the San Francisco Trail, parking areas near the Doubletree Hotel, most of the McLaughlin Eastshore State Seashore and the revetment protecting University Avenue. By 2100, most of the land surrounding the protected area of the Marina, several buildings, significant parking areas, and the majority of University Avenue and Marina Boulevard will be inundated. By that time, there will be significant risk to the revetment, particularly by wave action and storm surge. Access to the Berkeley Marina via University Avenue will begin to be an issue periodically by 2030 and become more consistently difficult by near the end of the century. By 2050, access to some existing docks will be inundated and by 2100, the access to all the docks in the protected area of the Marina will be impacted by high water.

The damage impact of a still-water high tide event plus sea level rise is projected to be approximately $0.3 million by 2030, $4.2 million by 2050, and $30.1 million by 2100.

Two types of mitigation were considered for the Project Area. The primary mitigation would be upgrades to the breakwater and revetment facilities. An alternative and possible supplemental

mitigation we considered was construction of floodwalls around the perimeter of the Project Area. Protection against sea level rise and associated risk from wave action and storm surge for the revetment and breakwater facilities are estimated with cumulative totals of $3.2 million by 2030, $5.4 million by 2050, and $60.5 million by 2100. Floodwalls are estimated to cumulatively cost $14.3 million for protection for the 2050 sea level rise and $31.5 million for protection for the 2100 sea level rise.

Because the prediction and projection of sea level rise is inexact and can change drastically with global and regional actions, a long-term maintenance plan, adaptation schedule and monitoring strategies are proposed for the implementation of mitigation.

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LIST OF ACRONYMS AND ABBREVIATIONS

BCDC	San Francisco Bay Conservation and Development Commission
BFE	Base Flood Elevation
FEE	Finished Floor Elevation
FEMA	Federal Emergency Management Agency
MLLW	Mean Lower Low Water
NAVD '88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
U.S.	United States
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WSEL	Water Surface Elevation

1.0 INTRODUCTION

The City of Berkeley is conducting a study to comply with California statute AB 691 for the area of University Avenue, Berkeley Marina, Berkeley Marina Harbor, César E. Chávez Park, and McLaughlin Eastshore State Seashore (Project Area). This study's purpose is to assess the impacts of sea level rise on the natural and built resources and facilities of the Project Area, map the impacts of predicted sea level rise occurring by 2030, 2050, and 2100, estimate the financial costs of the predicted sea level rise, and describe measures to protect and preserve resources and structures that would be impacted by sea level rise.

1.1 Project Area Description

The Berkeley Marina (Marina) is owned by the City of Berkeley and operated by the Parks, Recreation, and Waterfront Department. It is located on the San Francisco Bay (Bay) at the western end of University Avenue, less than 2 miles west of downtown Berkeley and the main campus of the University of California, Berkeley. The Project Area includes, in addition to the terminus of University Avenue, three additional roads – Spinnaker Way, Marina Boulevard and Seawall Drive as well as César E. Chávez Park and McLaughlin Eastshore State Park (**Figure 1.1**).

1.1.1 Current Use

The Project Area includes facilities for commercial and private boating, recreational areas, commercial properties, and protected habitat and natural areas. The boating facilities include ferry service, charter boats, the Berkeley Yacht Club, 1000 rental berths, and a fueling dock. Public recreation features within the Marina area, César E. Chávez Park and McLaughlin Eastshore State Park include several miles of trails, picnic areas, beach areas, public docks for small boats, kayaks, and sail boats, the Adventure Playground, and a large dog park. Protected natural areas include a large area within César E. Chávez Park, a western burrowing owl habitat, and the Shorebird Park Nature Center. Commercial properties include a Double Tree Hilton Hotel and two restaurants (Skates on the Bay and Hana Japan Steak and Seafood).

1.1.2 Project Area History

Historic photos are included in **Appendix A**. The first facility established within the Project Area was the original Berkeley Municipal Pier, built during 1926-1927 by the Golden Gate Ferry Company. The Berkeley Municipal Pier was 3.5-miles long measured from the original shoreline. A ferry service ran from the Berkeley Municipal Pier to the Hyde Street Pier in San Francisco. The ferry service lasted from 1927 to 1936. After discontinuation of the ferry service, the Berkeley Municipal Pier has been used periodically for fishing and site seeing, last closing in 2015.

The Marina was constructed adjacent to the Berkeley Municipal Pier in the late 1930s by Works Progress Administration and has been in use since 1939. Aerial photographs of the Marina taken shortly after 1939 opening are included in **Appendix A**. During World War II the Marina was taken over for use by the United States (U.S.) Navy.

The landfill dike to the north of the Marina was constructed starting in 1958. The dike was constructed of riprap on fill over existing sand following removal of the existing mud. This appears to be the standard form of construction at that time for the entire 90-acre landfill area dike. The dike was constructed to approximate elevation +12 from mean lower low water (MLLW). The Berkeley Refuse Disposal Site was constructed behind the dike as a landfill shortly

after the dike was constructed. The landfill was used until the late 1980s at which time it was sealed and converted into a park originally called North Waterfront Park. The park was renamed César E. Chávez Park in 1996.

The detached rock breakwater at the entrance of the boat harbor was constructed in 1965. Information on the structural concrete breakwater at the entrance is unknown. It may have been constructed in the 1970s when similar type of construction was used on the San Francisco waterfront.

In 1968, the portion of revetment between the Marina entrance and Skates on the Bay was upgraded with armor rock, which was placed over the site rubble or quarry rubble.

The shoreline protection at the south east corner of the Marina area was upgraded in the 1970s from concrete block waste to armor rock revetment.

In 1976, the riprap slopes of most of the landfill area were covered with impervious filter rock and an armor rock revetment constructed above. No major changes to the perimeter of the Marina have occurred since completion of the landfill at the northerly portion of the Marina.

1.2 AB 691 Criteria / Goal of Study / Scope of Work

AB 691 was passed in 2013 by the State of California and applies to certain tidelands and submerged lands that have been legislatively granted to a local trustee for the purposes of commerce, navigation, fisheries, and for other public trust purposes. The law requires that the local trustee prepare and submit to the State Lands Commission an assessment of how it proposes to address sea level rise. This report represents that effort for the City of Berkeley, the trustee, for the Berkeley Marina, the granted public trust land. Per AB 691, the assessment is required to contain the following:

1. Assessment of the impact of sea level rise on the public trust lands. This includes impacts of storms and extreme events with sea level rise, changing shorelines, and the identification of potential impact to public access, commerce, recreation, coastal habitats and navigability.
2. Maps showing the areas that may be affected by sea level rise in the years 2030, 2050, and 2100.
3. An estimate of the financial cost of sea level rise. This includes:
    - Potential cost of repair of damage caused by sea level rise
    - Value of lost use of improvements and land due to sea level rise
    - Anticipated cost to prevent or mitigate potential damage
    - Cost of loss of or damage to non-market values such as recreation and ecosystem services.
4. A description of how the City of Berkeley proposes to protect and preserve natural and manmade resources.

As part of the assessment, the City will collaborate with its lessees, appropriate local, state and federal agencies, and other users of the land. This assessment will be made public once it has been approved by the City and State Land Commission.

The assessment uses the 2018 Update of the State of California Sea-Level Rise Guidance as the source of sea level rise projections and follows guidance from the City of Berkeley Climate Action Plan, the City of Berkeley's Resiliency Strategy and the City of Berkeley 2014 Local Hazard Mitigation Plan.

2.0 ASSESSMENT OF IMPACT OF SEA LEVEL RISE

2.1 Historic Flooding and Erosion

The water within and surrounding the Marina is within Federal Emergency Management Agency (FEMA) flood zones. The boat harbor itself and the area east of César E. Chávez Park is an AE Zone (where a base flood elevation (BFE) has been determined) with a BFE equal to 10 feet in North American Datum of 1988 (NAVD 88). The remaining areas around the Marina have been designated VE Zones or areas subject to high velocity water due to waves with BFE's ranging from 12 to 14 feet (NAVD 88). The McLaughlin Eastshore State Park land is within a shaded Zone X, or 500-year flood zone. FEMA flood zones are shown in **Figure 2.1.**

Along the westerly edge of the Marina from the existing Berkeley Municipal Pier to the Spinnaker Way turnaround there are a few locations where the existing rock revetment has moved down slope and undermined the existing asphalt concrete paved trail. Along the easterly edge of the Marina south of University Avenue by the old His Lordships Restaurant parking lot, the bank is almost vertical due to erosion. Along the southerly edge of the Marina adjacent to the existing boat launch the existing steel sheet bulkhead is very corroded and in some areas is failing.

2.2 Inventory

Field investigations were done on March 11 through March 13, 2019, to inventory human-made and natural assets within the Project Area (**Appendix B**). Aerial topographic photos were taken on February 18, 2019, which generated an orthotopographic map and a digital elevation model of the site. Information about assets such as utility and drainage facilities, paths, monitoring wells, docks, and park features within the Project Area was collected with GPS data collector. Information about revetment and breakwater was collected via field survey and research of historic data. A land survey was completed in spring 2019 along with the aerial survey to obtain finished floor elevations (FFE) of the buildings (**Appendix B**).

2.2.1 Revetment

Revetment protection was constructed and upgraded at the shoreline around most of the Project Area at different times in its history. Typical construction designs of the existing revetment and breakwaters are included in drawings provided by the City (reproduced in **Appendix C**). The condition of the revetment protection around the different Shoreline Zones around the Marina is described below based on field-evaluation and review of the City As-Builts starting at the southwest corner of the Berkeley Marina and proceeding clockwise. The Shoreline Zones are shown in Figure 2.2. A current evaluation of the revetment value is shown in **Appendix B**.

- **Shoreline Zone 1- From Southwest Corner to Berkeley Municipal Pier:** The length of revetment from the southwest corner to the Berkeley Municipal Pier is in relatively poor condition with a slope that is slightly steeper than elsewhere and has variable rock size and thickness. Larger sized rock was placed at the bottom of the slope with smaller sized rock to the crest. The underlying rockfill has been placed at close to its natural slope of 1.3:1 horizontal to vertical and the revetment armor placed as a wedge of material reducing at the top of the slope. The upper rock appears to be generally of single layer thickness and gaps are present which expose underlying rockfill material.
- **Shoreline Zone 2 - West Side from Existing Pier to entrance of the protected portion of the Marina (Marina Basin)**: North of the Berkeley Municipal Pier, the slope of the revetment rock varies from 1.7-2:1 horizontal to vertical. In 1968, the section of revetment between the Marina entrance and the Skates On the Bay restaurant 800-feet

to the south was upgraded. Armor rock was placed over site rubble or quarry rubble at a 2:1 horizontal to vertical slope to an elevation of +15 feet NAVD 88. A cross section of the revetment is shown in Section "A-1" in **Appendix C**. Repairs and improvements have been made to the revetment at the pier providing protection to the Skates On the Bay. Although no design drawings were found for this section, they appear similar to the improvements shown on the Section "A-1" City drawings. The rock armor at the pedestrian entrance to the Skates On the Bay restaurant has been modified to reduce wave spray nuisance.

- **Shoreline Zone 3 – Marina Basin**: No revetment was built on the shore of the Marina Basin as it is protected by the breakwaters.
- **Shoreline Zone 4 - West Side from Marina Entrance North to Spinnaker Way Roundabout:** Just north of the boat harbor's entrance, a 400-foot long, narrow promontory protects the OCSC Sailing Club's moorings. The existing elevation of the top of the revetment and trail behind it is at a low elevation (approximately +12.5-foot NAVD '88).
- **Shoreline Zone 5 -West Side from Spinnaker Way to the Northwest Corner of the Marina Bay Area:** In 1976, the riprap slopes of most of the landfill area were compacted and covered with 12 inches of impervious filter rock and 3 feet of armor rock with a variable slope. A typical cross section of the improvement is shown in the Waterfront Park - External Seal & Armor Protection Typical Section included in **Appendix C**. Rock has been added to fill in eroded and worn-down areas near the Perimeter Trail on the west side of the landfill. The Perimeter Trail along the back of the revetment along this length is at a high elevation at Spinnaker Way and then falls to a low of about +12 foot NAVD 88 near the northwest corner.
- **Shoreline Zone 6 - North Side and northern 800 feet along East Side of the Marina Bay Area:** The revetment along this stretch is similar to Shoreline Zone 5. The 400-foot length of revetment next to the northeast corner has a lower top elevation than the length to the west. Recent minor repairs have been made to the rip-rap protected slope along the east side. The lowest Perimeter Trail elevation along this stretch of the east side of César E. Chávez Park is +18-foot NAVD 88.
- **Shoreline Zone 7 - East side of the Marina from 800 –feet south of the northeast corner and north side of McLaughlin Eastshore Park:** This shoreline, which is exposed to calmer waters, is protected by revetment of lower standard than the remainder of the Project Area. Along the north side of McLaughlin Park, the top of revetment elevation is about +10-foot NAVD 88. This shoreline just holds back the present-day extreme water surface elevation from serious flooding of the trail at the back of the revetment that is the unpaved extension to Virginia Street.
- **Shoreline Zones 8 and 9 -South Side of Marina Bay Area:** Shoreline Zones 8 and 9 include the eastern portion of south facing revetment south of University Avenue and the San Francisco Bay Trail Spur, the east facing revetment along the continuation of San Francisco Bay Trail Spur, the south facing sheet piled wharf, and the east facing side of the promontory to the south. In the 1970s, the concrete block waste shore protection at the south east corner of the Marina south of University Avenue was upgraded with 12 inches of armor rock placed at a 1.5-2:1 slope as shown in the South Marina Shore Protection As-Built included in **Appendix C**. On the design plans, Section AA shows the south facing protection and Section BB shows the east facing protection at the shoreline return to University Avenue. The beach area that faces southeast is at elevation +10-foot NAVD 88. Along the south side of McLaughlin Park and University Avenue, the existing road surface elevation of University Avenue is at approximately

+12-foot NAVD 88. The San Francisco Trail Spur along the revetment side of University Avenue is at approximately +10-foot NAVD 88 and above. The condition and elevations of the revetment, trail, and playground area along the promontory facing east are similar to the shoreline to the east of the sheet piled wharf.

2.2.2 Breakwater

Two breakwaters were constructed west of the Marina entrance. One, directly parallel to the Marina entrance, is approximately 750-foot long and is rock armored with relatively steep slopes of 1.5 horizontal to 1 vertical, a crest elevation of about +13-foot NAVD 88, and a narrow crest width of 6 feet according to drawing information (**Appendix C**). The breakwater is protected with enough rock armor on the east side to accept some minor overtopping. The second breakwater, to the northwest of the entrance, is approximately 500-feet long and constructed of reinforced concrete with vertical and battered piles. The two detached breakwaters at the entrance to the Marina reduce the wave action within the boat harbor portion by approximately one-foot wave height at the entrance. Because of the breakwaters, the boat harbor is calm with negligible wave action and runup.

A short breakwater that can be submerged at extreme high tide extends south parallel to the west side of the most southern portion of the Project Area and protects the site of the former Hs Lordships restaurant.

2.2.3 Utilities and Buildings

There are approximately 34 buildings in the Project Area. This includes the Skates on the Bay and Hana Japan Steak and Seafood restaurants and five other commercial buildings, six buildings associated with the Doubletree Hotel, five restrooms and 17 outbuildings which serve as storage, maintenance, and utility access. There are electrical, sanitary sewer, water, and fire facilities within the main portion of the Marina around the boat harbor and storm drain facilities and monitoring wells throughout the Area. In addition, there is an existing sanitary sewer pump station in the median of University Avenue near its westerly end. A list of building and utility assets are included in **Appendix B**.

2.2.4 Roadway and Parking

The Project Area includes the terminus of University Avenue as well as Spinnaker Way, Marina Boulevard and Seawall Drive. The roads provide access to the commercial, boating, recreational and natural amenities of the area. There is substantial informal parking provided along the roads. Several road segments have pavement damage due to flooding and some have buckling damage from subsurface settling. The Virginia Street Extension, along the north of McLaughlin State Park is a dirt road and is utilized as a walking path. There are approximately 21 acres of parking within the Project Area.

2.2.5 Boat Facilities

Within the boat harbor, there are 14 docks with slips for over 1,000 boats. A list of the dock assets is included in **Appendix B**. A majority of these are rented out by the City of Berkeley for private watercraft. There are commercial boating facilities including a sailing school, the Berkeley Yacht Club, the Cal Sailing Club, Hornblower Cruises and Events, and small scale ferries and charter boats. There are boat maintenance, dry storage, gas, and repair facilities. A

number of docks for launching personal recreational watercraft including small sail boats, kayaks, and windsurfers are located on the shoreline south of the main boat harbor.

2.2.6 Recreational / Access Assets

The Project Area has 100 acres of park space, 7 miles of trails, picnic areas, a 17-acre off-leash dog area, and bird-watching areas. The San Francisco Bay Trail, a popular 500-mile trail through the Bay, circumnavigates the south water's edge of the area. The varied terrain of the Project Area makes it ideal for viewing and photographing the San Francisco Bay, the San Francisco skyline, and Bay area bridges. Adventure Playground, located south of the boat harbor, is a staffed play space for children that was opened in 1979. The Playground, which is free to the public, encourages unrestricted and creative play and has building materials, a zip line, and painting. The Project site provides exceptional public access for boating and viewing the Bay with its public docks and varied trails near and above the water.

2.2.7 Natural Resources

Identified natural resources in the Project Area include a dedicated "protected natural area" and a western burrowing owl habitat both located in the northeast corner of César E. Chávez Park. South of the boat harbor, there is a shorebird park and nature center with a classroom. There are several large trees throughout the Marina landscaped areas and in César E. Chávez Park.

In addition to the identified resources, the Project Area has the ability to support a varied assemblage of wildlife which may move through the region, migrate seasonally, or reside in the area year round. A wide variety of taxa native to the state of California have low population numbers, limited distributions, or are otherwise vulnerable to extinction or extirpation within the state. Although they may include ecologically significant units and sub-species as well as species, these taxa are collectively referred to as "special status species" (SSS). The following background information was reviewed to identify potential biological resources in the Project Area and are summarized in **Appendix D**:

- *California Natural Diversity Database* (CNDDB). 2018. California Department of Fish and Game, Sacramento, CA. Accessed online.
- California Native Plant Society. 2018. *Inventory of Rare and Endangered Vascular Plants of California* (online edition, v8-01a). Accessed online.
- Information for Planning and Conservation (IPaC). 2018. United States Fish and Wildlife Service. Accessed online.

2.3 Sea Level Rise Estimate

Sea level rise criteria used in this analysis are based on the 2018 update of the California Coastal Commission Sea Level Rise Policy Guidance document (California natural resources Agency, et al, 2018). The document includes scenario projections for sea level rise for 12 sites on the California coast. The appendix to the document includes depths of sea level rise associated with probabilities of occurrence for future decades up to and including 2150. For decades after 2050, low and high emission scenarios are included. Probabilistic projected depths of sea level rise for each decade and each site include:

- Median, with 50% probability
- A range that is likely, with a 66% probability. The upper end of the range is recommended for low risk aversion project sites.

- 1 in 20 chance, or 5% probability
- 1 in 200 chance, or 0.05% probability. This scenario is recommended for medium to high risk aversion project sites.
- Extreme scenario that relates to a worst case estimate of global warming. This scenario is recommended for extreme risk aversion project site.

The Guidance includes "risk decision framework" to identify the risk category to utilize in sea level rise impact analysis for a given site. Factors to consider include the site's capacity to adapt to increased sea levels, economic effects, and the potential impact of sea level rise at the site to communities, infrastructure, and natural systems.

The sea level rise projections for the Project Area are based on the San Francisco gauge location, the closest site to the Project Area. The Guidance document includes sea levels for 2014 as the existing conditions.

2.3.1 Sea Level Rise Scenarios

Because the Berkeley Marina is primarily a recreational facility, the Low Risk Aversion projection with a high chance of exceedance corresponding to the upper limit of the likely range of sea level rise would be a reasonable level to consider in planning. If future buildings are proposed in the Project Area, the Medium-High Risk Aversion projection with a 1 in 200 chance of exceedance would be the more appropriate projection to order to avoid future flooding. A facility that would be classified as a Risk Category III or IV structure according to the California Building Code, such as those used to house emergency treatment facilities or hold large public assembly would need further consideration of flood elevation criteria.

The sea level rise impact can be added to a range of tidal conditions. For this study, we used the 100-year extreme tide taken from the San Francisco Bay Tidal Datums and Extreme Tide Study

2.3.2 Static-Varying Tides

Various tidal elevations were taken from Appendix B-31 of the FEMA/San Francisco Bay Conservation and Development Commission (BCDC) "San Francisco Bay Tidal Datums and Extreme Tides Survey" dated February 2016 based on the Alameda Point 518 Panel 1, the closest point in the Tidal survey to the Project Area. The Tidal survey includes elevations for six normally occurring tidal conditions and projected elevations for the 1-year to 500-year extreme tides.

The tidal datum values in feet at Alameda Point 518 Panel 1 and Appendix B-31 of the FEMA/BCDC document are shown below together with estimated tide levels due to future sea level rise based upon the San Francisco Gage data in the current 2018 California Coastal Commission Sea Level Rise Policy Guidance document (**Appendix E**).

Values in **Table 1** are given in feet relative to NAVD 88 for the upper limit of the "likely range" termed the Low Risk Aversion projection.

Refer to **Appendix F** for background information and additional explanation.

Table 1. Tide Elevations with Low Risk Aversion Sea Level Rise

		Year					
		2016	2030	2050	2070	2100	2150
Mean Higher High Water	MHHW	+6.20	+6.5	+7.1	+7.9	+9.4	+12
Mean High Water	MHW	+5.63	+5.9	+6.5	+7.3	+8.8	+11
Mean Tide Level	MTL	+3.32	+3.6	+4.2	+5.0	+6.5	+9
Mean Sea Level	MSL	+3.31	+3.6	+4.2	+5.0	+6.5	+9
Mean Low Water	MLW	+1.01	+1.3	+1.9	+2.7	+4.2	+7
Mean Lower Low Water	MLLW	-0.07	+0.2	+0.8	+1.6	+3.1	+6

The extreme tide elevation at the entrance of the Berkeley Marina combined with sea level rise projections are given in **Table 2**. The extreme tide values have been obtained from Alameda Point 518 Panel 1 and Appendix B-31 of the FEMA/BCDC "San Francisco Bay Tidal Datums and Extreme Tides Survey" dated February 2016. Future sea level rise values are from the current 2018 California Coastal Commission Sea Level Rise Policy Guidance document. Values are given in feet relative to NAVD '88 for the Low Risk Aversion projection.

Table 2. Tide Elevations with 100-Year Extreme Tide

	Year					
	2016	2030	2050	2070	2100	2150
100-year Extreme Tide + Low Risk Aversion SLR	+9.8	+10.1	+10.7	+11.5	+13	+15

2.3.2 Wave Runup and Storm Surge

The waves impacting different vicinities of the Project Area vary due to fetch (the area in which waves are generated having a near constant direction and speed) irregularity and existing breakwater structures. Because current projections of wind and wave climate change are uncertain, assumptions have been made to arrive at a wave height increase allowance.

The effect of changes in the wind climate associated with sea level rise when considered together with future climate change will likely result in higher wind generated waves that would break on the revetment and shore protection with resulting greater forces acting on the armor rock and higher runup. The greater water depth would allow an increase in the number of larger waves attacking the revetment. Wind generated waves are expected to exceed any ferry wake.

The larger locally generated waves from the west and northwest impacting the west side, north side and the most northern 900-feet of the east side are limited by the low fetch and the protection from the coastal ridge along the shoreline. Waves at the Golden Gate entrance to the San Francisco Bay result in swells that are reduced in magnitude as they approach the Marina.

The maximum wave height for waves acting on the Marina revetment is assessed as 5-foot with an associated wave period of 4 seconds. The depth of the water at the approach to the revetment is sufficient to allow such waves to penetrate to the Marina without reduction of wave height. Shoaling due to the shallow bed at the wave approach from the southwest and from the north or northeast limits the magnitude of the wave height. The water surface at the southerly portion of the east side revetment is sheltered and remains calm when storms are present in the Bay.

Waves attacking the south shore from the southwest are expected to be a maximum of 3 foot high.

Storm surge resulting from sustained storms at the Golden Gate would raise up the water surface. Splashing and spray could occur due to winds approaching from the Bay acting together with larger waves at higher tides. Splash and spray nuisance would increase as sea level rises depending on the elevation and set back of the trails and roads at different areas of the Project Site. Where trails and roads are close to the revetment, notices to users should be posted or sections barricaded off in times of expected storm surge.

Wave runup and overtopping will be of consideration where the site is low in elevation and exposed to greatest wave action. The west side south of the Marina Basin along Seawall Drive at the back of the existing revetment is the area near the Project Area most at risk to unacceptable conditions in the future due to wave runup and overtopping.

The revetment at the existing Skates on the Bay restaurant has been built up to above the road elevation and provides some protection to patrons from overtopping waves and spray.

2.3.3 Water Surface with Sea Level Rise and Extreme Wave Runup

The extreme wave runup elevations for the 100-year storm at the Berkeley Marina are given in the **Tables 3, 4, and 5**. The values are based upon the Mean Higher High Water (MHHW) elevation obtained from Alameda Point 518 Panel 1 and Appendix B-31 of the FEMA/BCDC "San Francisco Bay Tidal Datums and Extreme Tides Survey" dated February 2016 and combined with surge estimated from historical surge values, and future sea level rise values from the current California Coastal Commission Sea Level Rise Policy Guidance document. Values are given in feet relative to NAVD88 (North American Vertical Datum of 1988) for the Low Risk Aversion (upper limit of the "likely range").

Elevations with wave runup are based on an imaginary extension of the revetment at typically 2 horizontal to 1 vertical. Where the revetment slope breaks and the bank extends inland at a lesser slope, the effective runup elevation is reduced to a lower value. Locations with effective runup elevations are identified in the discussion Section 3.3.1 of this report

Table 3 Extreme Wave Runup Elevations with Sea Level Rise – North, West, and Upper East Side

	Year					
	2016	2030	2050	2070	2100	2150
MHHW with Likely Risk Aversion Sea Level Rise + 100-year Extreme Wave Runup + 5-year Surge	+15.3	+15.7	+16.6	+17.8	+20	+24

Table 4. Extreme Wave Runup Elevations with Sea Level Rise – South Side

	Year					
	2016	2030	2050	2070	2100	2150
MHHW with Likely Risk Aversion Sea Level Rise + 100-year Extreme Wave Runup + 5-year Surge	+12.1	+12.5	+13.4	+14.6	+17	+21

Table 5. Extreme Wave Runup Elevations with Sea Level Rise – East Side; Southern 2,000 feet

	Year					
	2016	2030	2050	2070	2100	2150
MHHW with Likely Risk Aversion Sea Level Rise + 100-year Extreme Wave Runup + 5-year Surge	+8.9	+9.3	+10.2	+11.4	+14	+17

2.3.4 Summary of Highest Water Elevations at Various Locations

Table 6 shows the highest water elevations resulting from considering both extreme still water surface elevations from **Tables 1 and 2** and extreme wave runup elevations from **Tables 3, 4, and 5**. Values include sea level rise projections for the Low Risk Aversion and Medium-High Risk Aversion projections as identified. The highest water elevations resulting from wave runup shown are in blue. These values are based on a revetment slope of approximately 2 horizontal to 1 vertical and are subject to reduction where the elevation exceeds the top of revetment elevations and the bank extends back at a lesser slope.

Marina Basin values assume fully effective entrance breakwaters resulting in calm water within the marina.

Table 6. Summary of Highest Water Elevations at Various Locations

	Year					
	2016	2030	2050	2070	2100	2150
North and West Sides & East Side; Northern 900 ft	*+15.3*	*+15.7*	*+16.6*	*+17.7*	*+20*	*+24*
East Side; Southern 2000 ft	+9.8	+10.1	+10.7	+11.5	*+14*	*+17*
South Side	*+12.1*	*+12.5*	*+13.4*	*+14.6*	*+17*	*+21*
Marina Basin	+9.8	+10.1	+10.7	+11.5	+14	+16
Entrance Breakwater	*+15.3*	*+15.7*	*+16.6*	*+17.7*	*+20*	*+24*

2.3.5 Horizontal Spread of Overtopping Waves Without Upgrades

Table 7 gives the approximate horizontal spread by contour elevation for the Low Risk Aversion sea level rise projection for the West Side and South Sides assuming no upgrade or raising of the revetment has been undertaken.

The Marina Basin and the southern portion of the East Side of the Marina Bay Area are not subject to wave overtopping. The still water surface elevations of **Table 1** apply only.

The North Side and the northern portion of the East Side are subject to some overtopping as described in Section 3.1.1.

Table 7. Horizontal Spread of Overtopping by Contour at Various Locations

Sea Level Rise	Year		
	2030	2050	2100
West Side: from South West Corner to Existing Pier	+14	+14	+15
West Side: from Existing Pier to Marina Entrance	+15	+15	+15
West Side: from Marina Entrance to Spinnaker Way Roundabout	+14	+14	+16
West Side: from Spinnaker Way Roundabout to 300 ft Northwards	+16	+16	+18
West Side: 300 ft to 1,000 North of Spinnaker Way Roundabout	+15	+15	+17
West Side: 1,000 from Spinnaker Way Roundabout to Northeast Corner	+16	+17	+19
South Side of McLaughlin Park and University Avenue	+10	+11	+13
South Side: Revetment Facing East and South	+11	+11	+13

2.3.7 Relative Local

AB691 Assessment Criteria includes consideration of the impacts of the relative local sea level. The use of the San Francisco gage for the sea level rise data from the State of California guidance and the tidal information from Appendix B-31 of the FEMA/BCDC “San Francisco Bay Tidal Datums and Extreme Tides Survey” dated February 2016 based on the Alameda Point should address the local sea level.

3.0 2030, 2050, 2100 IMPACTS

3.1 Methods

The likely range, Low Risk Aversion sea level rise projection for the San Francisco, Golden Gate gauge was added to the 100-year extreme tidal sea levels with and without consideration of wave runup. The projected levels were compared to topographic data of the Project Area collected by aerial survey in the summer of 2019.

3.2 Flood Maps

Figures 3.1 to 3.3 show the projected inundation resulting from high tides with 100-year return interval for the 2030, 2050, and 2100 sea level rise scenarios.

3.3 Built Structures

The Berkeley Marina has extensive built structures for both the functioning and support of the Marina and for the protection and stabilization of the Marina and surrounding area. Because the elevation of the site and its facilities are at different elevations, the sea level impacts impact will be variable.

3.3.1 Breakwater and Revetment

The impacts of climate change to the breakwater and revetment of the Berkeley Marina include sea level rise and storm action acting in combination. The higher sea level enables more wave action to occur on the revetment and other shore protection. The other impact of climate change that may affect the Marina area is the change in wind speeds and related changes in wave magnitude.

Increased wave action causes increased instability of the armor rock protecting the revetment. As the wave action increases, the battering of one rock against another increases, and a general deterioration of the armor results. Progressive damage to the rock armor results in displacement of the outer armor rock from its stable interlocked position, movement of the rock down the slope to the toe of the revetment, and exposure of the inner layer of armor and underlayer to wave action. With the underlayer directly exposed to wave action, the slope slumps and falls into a condition where larger rock ends up settled into the bed in a non-interlocked position and the smaller underlayer material is strewn over the bed away from the slope of the now degraded revetment.

Armor rock will degrade over time without wave action. Surge, swell, tidal fluctuations, earthquakes, tsunami runup, and the effect of the climate in general will cause breakage at points of weakness within the rock arising from the effects of nature and quarrying. This deterioration has been estimated and combined with that due to wave action to determine the appropriate ongoing level of repairs and upgrades.

AS shown in **Figures 3.1 to 3.3**, the revetment will become increasingly inundated from 2030 to 2100. The most impacted areas are in the Shoreline Zones 7, 8, and 9, which are also most protected from wave action and runup.

3.3.2 Buildings

The projected inundation of buildings for 2030, 2050, and 2100 sea level rise is shown in **Figure 3.4-3.6**. The buildings in red in these figures have finished floor elevations (FFEs) lower than the projected water surface elevation (WSEL). At 2030, no building will have its FFE inundated, although there will be some inundation surrounding the Double Tree Hotel complex. In 2050, two of the Double Tree Hotel buildings have FFEs lower than the projected WSEL by 0.3 - 0.5 feet. By 2100, the entire hotel complex will be inundated above their FFEs by 0.5 - 3 feet and several outbuildings will be flooded above their FFEs.

3.3.3 Boat Facilities

The inundation of the access base points for the docks within the Marina Basin for 2030, 2050, and 2100 sea level rise is shown in **Figures 3.9-3.9**. No dock base will be flooded in the 2030 WSEL projection. Two dock bases in the northeast section of the Marina Basin will be slightly below water in the 2050 projection and the base of all docks in the Marina Basin will be below water by 0.5 - 3 feet in the 2100 projection.

3.3.4 Roads

With the 2030 Sea Level projection, Marina Boulevard will be impacted with inundation just north of University Avenue and just south of Spinnaker Way and access roads south of Spinnaker Way will be slightly flooded. A parking area parallel to and east of Marina Boulevard and one near the Double Tree Hotel will also be inundated. With the 2050 WSEL projection, there will be more extensive and deeper inundation of Marina Boulevard, most likely making is unpassable. An additional parking area west of the Double Tree Hotel will also be inundated. In the 2100 WSEL projection, much of University Avenue will be inundated, Marina Boulevard will be flooded to a greater and many of the access roads north of the Marina Basin will be inundated. See **Figures 3.10 to 3.12.** As flooding of the roads becomes more frequent, access to the Project Area will become difficult and it will undermine the integrity of the roads and require more frequent repair and maintenance.

3.3.5 Public Access

Figures 3.13-3.15 show the inundation of the walking paths within the Project Area for the 2030, 2050, and 2100 projected sea level rise. Without mitigation, there will be public access issues starting in 2030. Marina Boulevard will be flooded blocking off Spinnaker Way which allows access to the boating and hotel facilities on the north portion of the Marina. The tip of the southern portion of the Marina will be inundated as well, blocking off the walkways and access to H.S Lordship Restaurant. The extension of Virginia Street used as a walking path along the north side of the McLaughlin Eastshore State Seashore is inundated as are a portion of the paths internal to the State Seashore. In 2050, the flooding within Marina Boulevard and the south tip will be more pronounced and the flooding of the paths within the State Seashore is more extensive. Access to the docks on the interior of the Marina will be blocked as well. In 2100, the entrance to the Marina on University Avenue will be completed inundated and the docks on the interior of the Marina will not be accessible. There are several sections

3.4 Non-built

3.4.1 Changes to Shoreline

The major risk of sea level rise to the shoreline is the loss and/or degradation of the revetment. This could jeopardize the landfill of César E. Chávez Park, causing erosion and loss

of landmass. There is a potential erosion and loss of the integrity of both the San Francisco Trail Spur and University Avenue along Shoreline Zone 8 and 9.

3.4.2 Recreation

As mentioned in previous sections, several trails and access to the Marina viewing points and coastal access will be impacted by projected sea level rise. Degradation of the trails will make walking and running less accessible and will also cut off potential for small boat recreation.

3.4.3 Natural Resources

Damage to natural resources include potential damage to the protected natural area within César E. Chávez Park and a western burrowing owl habitat both located in the northeast corner of the park. Because there is significant inundation within the McLaughlin Eastshore State Seashore, any habitat within the grassland will be significantly impacted starting in 2030.

4.0 LOSSES / COSTS

4.1 Financial Impact of Sea Level Rise

Potential financial impacts to the Berkeley Marina caused by projected sea level rise include damage to commercial and public buildings and infrastructure, loss of public resources, loss of habitat and natural resources, and loss of berth rental revenue to the City.

4.1.1 Non-Market Losses

The Berkeley Marina is a valuable public resource enjoyed by tens of thousands of people every week. Temporary loss of this resource due to intermittent flooding or permanent loss due to frequent inundation and/or loss of access will induce non-market losses to the public. Non-market losses for the impacts of sea level rise to the Berkeley Marina were estimated using the Duke Marina Ecosystem Services Partnership guidelines. Non-cost uses of the Marina by the public include use of personal watercraft such as kayaking and windsurfing, hiking, family activities, beach going, and picnicking. To simplify the calculation the typical use was assigned to "Coastal and marine wildlife viewing" which is valued at $6.78 a family visit. Using traffic counts taken for the University Avenue improvement project, there are typically 33,000 cars using the Marina a week for a total value of approximately $225,000. Annual losses using this valuation are shown in **Table 8**. The projected losses for the 2030 sea level rise would be approximately 0-1 week of lack of access to the Project Area increasing to 3-5 weeks by 2050 and potentially a complete annual loss by 2100 due to lack of access.

Table 8: **Projected Non-market Value of Berkeley Marina Visits**

Per University Avenue Improvement Project	Weekday Average	Weekend Average	Weekly Total	Annual Total
University Avenue in - bound traffic count	4570	5865	33,000	1,716,000
Total non-market value	$29,000	$40,000	$225,000	$12,000,000

All costs are based on 2019 cost data and have not been escalated for future years.

4.1.2 Commercial and Public Building Assets

Commercial assets within the Marina vulnerable to sea level rise include the Hilton Doubletree Hotel and various restaurants and businesses. Public buildings include outbuildings, recreation and amenity facilities. The following assumptions were made to calculate the building losses for the 2030, 2050, and 2100 sea level rise scenarios:

- Damage was assessed for one sustained flooding event due to 100-year high tide with sea level rise. Multiple flooding events would incur additional damages.
- Square footage costs were taken for San Francisco from the Turner & Townsend International Construction Market Survey 2019.

- Buildings were categorized to match the Turner & Townsend survey building types.
- Building footprints from the topographic survey were used to determine per floor square footages.
- Google maps was used to verity the number of stories for each building.
- Replacement cost was determined from the building footprint, number of floors, and the 2019 Construction Market Survey (Turner & Townsend, 2019).

A tabulation of building assets and projected losses is included in **Appendix G**. Total losses are shown on **Table 9**.

***Table 9*. Building Losses due to Projected Sea Level Rise**

Type of Building	2030	2050	2100
Commercial	0	$3,000,000	$17,100,000
Park / Public	$0	$0	$580,000

All costs are based on 2019 cost data and have not been escalated for future years.

4.1.3 Roads, Paths, and Parking

Losses to damage of roads, paths and parking were calculated using square footage of inundation and repair values. The following assumptions were made when assessing the potential damage of roads, paths and parking:

- Damage was assessed for one sustained flooding event due to 100-year high tide with sea level rise. Multiple flooding events would incur additional damages.
- Replacements costs are reduced from full replacement cost based on four categories of depth of inundation as shown below:

Depth of Inundation	Percent of Total Replacement Cost
0" < D ≤ 6"	10%
6" < D ≤ 12"	25%
12" < D ≤ 24"	50%
24" < D	100%

- Surfaces evaluated included paved roads, paved parking, dirt/gravel parking, paved trails, and dirt/gravel trails.
- Repair costs of dirt/gravel facilities is assumed to be 75% of the repair cost for AC, assuming gravel is easily damaged from erosion.
- Trails were delineated from aerial photos of Project Area.
- Roadways were delineated as part of the topographical survey.

A tabulation of projected losses due to damage to roads, paths, and parking is included in **Appendix G**. Total losses are shown on **Table 10**.

***Table 10*. Road / Parking / Path Losses due to Projected Sea Level Rise**

Type of Building	2030	2050	2100
Road - AC	$9,000	$22,000	$126,000
Parking - AC	$11,000	$29,000	$149,000
Parking - Dirt / Gravel	$3,000	$12,000	$29,000
Path - PCC / AC	$6,000	$15,000	$63,000
Path - Dirt / Gravel	$12,000	$20,000	$32,000
Total	$41,000	$98,000	$399,000

All costs are based on 2019 cost data and have not been escalated for future years.

5.0 MITIGATION ANALYSIS

5.1 Planned Capital Improvement Projects That Include Mitigation

The new ferry may be located on the south side of the marina entrance between the Skates on the Bay restaurant and the former Hs Lordship's restaurant. Because of the lower standard of the existing construction and the scale and size of equipment needed to repair this portion of the revetment, revetment repairs should be ideally undertaken prior to construction of the ferry terminal, in order to avoid disruption to ferry service.

Other development may occur with the expectation that marina area revenues will be increased. Coordination of repairs and upgrades with proposed changes in use could be a challenge, unless future development were to be set back from the revetment and appropriate access and laydown area provided for heavy equipment.

5.2 Planned Partnerships

In general, Berkeley is less affected by sea level rise than many other Bay locations. Major effort will be required at airports, at Treasure Island, at ports, and at low lying communities. Such effort will provide experience to marine contractors and will increase knowledge and skills. The demand for rock armor will affect the availability of larger rock, possibly spur development of quarries, will increase the cost of rock armor, and probably lead to the greater use of concrete armor units. Additionally, in the case of natural shorelines, the results of ongoing full-scale experiments around the Bay to enhance protection by marsh development can be expected to reduce the extent of sea level rise protection by rock revetment.

It can be expected that the experience of other local entities in dealing with similar problems will provide useful information through informal contact and by means of the internet.

Reliable information is expected to continue to be provided by the Bay Conservation and Development Commission, The California Coastal Commission, Federal Emergency Management Administration, the US Army Corps of engineers, the National Oceanic and Atmospheric Administration, and the United States Geological Survey.

5.3 Adaption and Mitigation Options

Two options have been explored for capital mitigation measures: revetment repair and upgrade and floodwall construction.

5.3.1 Revetment and Breakwater

One option is to improve the revetment and breakwaters without the addition of floodwalls. The following is a description by Shoreline Zone of possible mitigation actions for the revetment and associated infrastructure within the Marina:

- **Shoreline Zone 1:** this length of revetment is a priority for repair. The repairs could also include a minor raising of the revetment crest. Depending on the extent of future sea level rise, upgrading with an armor overlay and further crest raising would be needed. A crest raising upgrade could be accomplished by placing a 12-foot wide blanket of armor rock over the extent of the existing parking stall area immediately behind the existing revetment. This would greatly reduce the danger and nuisance of overtopping associated with the future sea level rise projections. The rock armor upgrade would be constructed prior to this crest raising upgrade. See **Figures 5.1 and 5.2**. Repairs and

upgrades would need to allow surface drainage westwards and controlled release of drainage into the rock armor to enter the Bay without causing instability. The rock armor upgrade is forecast for the decade beginning 2030 sea level rise and the crest raising forecast for the decade beginning 2050 sea level rise.

- **Shoreline Zone 2:** the narrow two-lane road along the back of the revetment between the restaurant and the marina entrance provides insufficient width to construct a rock blanket at the crest to resist overtopping without narrowing the access road. A narrow road would restrict fire truck access. The addition of a rock armor upgrade with minor raising of the crest would resist overtopping due to the 2030 sea level rise. See **Figure 5.1**. A crest raising and widening upgrade involving reducing traffic to a single lane would resist overtopping due to the 2070 sea level rise. See **Figure 5.2**. Repairs and upgrades would need to allow surface drainage westwards and controlled release of drainage into the rock armor to enter the Bay without causing instability.
- **Shoreline Zone 4:** at the 400-foot long portion nearest the marina entrance where a narrow promontory protects the sailing club moorings, additional protection would be given by a rock berm crest against runup due to a 2030 sea level rise. The 800-foot length of revetment nearest the marina entrance is protected to a degree against runup and overtopping due to the existence of the breakwaters. A transition in revetment crest elevation is possible over this length. Upgrades to this portion of revetment would be like that shown in **Figure 5.3**.
- **Shoreline Zone 5:** crest raising and raising of the top of the revetment, as shown in **Figure 5.2**, would be required for the low risk aversion projections. Low points in the trail could be raised during trail maintenance. Upgrades to the rock armor would be dependent on the deterioration of the rock armor and could be included at some time in the period from 2060 to 2080. The deterioration of the rock armor and the placing of an armor overlay would be a decision required at the ten-year review cycle for repairs and upgrades and based upon inspection and records. Raising of the revetment elevation would be needed for the length of the trail as shown in **Figure 5.4**.
- **Shoreline Zone 6:** raising of the revetment elevation and the installation of rock blanket or equivalent on the far side of the trail would be needed as shown in **Figure 5.4**.
- **Shoreline Zone 7:** revetment raising and adjustment to grading of the Spinnaker Road and the Perimeter Trail are needed for the east side of César E. Chávez Park. The road would need to be raised in stages to provide a 2-foot freeboard above the projected extreme water surface at the forecast end of life of the pavement. The addition of a rock armor overlay would be low priority over much of the length down to within 700 feet of the McLaughlin Park. For the north side of McLaughlin Eastshore Seashore, the extension of Virginia Street trail could be constructed to a higher elevation in a staged process in the future if the trail was considered a useful asset.
- **Shoreline Zone 8:** to avoid inundation of the University Avenue by extreme runup with projected 2050 sea level rise, the revetment would need to be upgraded and potentially the raising of the road. **Figure 5.5** shows a typical revetment improvement.
- **Shoreline Zone 9**: adjustment to avoid inundation by raising the San Francisco Bay Trail spur could be possible. The bank slope between the beach and the trail would be protected from erosion. Because the top of revetment along the east facing promontory is above the 2100 sea level rise elevation, repairs to the existing revetment alone may be adequate and an armor rock overlay would be low priority for this length of shoreline.

- **Submerged Rock Breakwater at South End:** The short stub breakwater providing some protection to the pile supported former Hs Lordship's restaurant could be repaired and upgraded at the same time as the upgrade to the rock breakwater at the marina entrance, unless visual inspections and structure condition surveys showed that an upgrade was needed earlier.
- **Rock Breakwater at the Marina Entrance:** the breakwater will need upgrading to resist 2100 sea level rise and earlier events in order to ensure calm conditions in the Marina Basin. Calm conditions are necessary for marina operations, limitation of damage to boats and moorings, and for reducing the extent of basin submerged slope repair and upgrade. The upgrade of the existing breakwater is shown in **Figure 5.6** – Entrance Breakwater Upgrade. An overlay of armor is placed on the west side of the breakwater and the crest raised a few feet. The combination of concrete unit armor with greater porosity than rock armor together with a wider crest will provide effective wave breaking and limited overtopping although the crest may be slightly submerged at higher extreme wave runup elevations with sea level rise. The 2100 sea level rise would be just slightly below the crest elevation if the armor overlay was 5-foot thick and the top of the crest was set at +16 feet NAVD88. A small amount of overtopping would be possible without conditions within the marina leading to damage of boats and moorings.
- **Concrete Breakwater at Marina Entrance**: no drawings have been reviewed. No visual inspection nor condition survey have been undertaken for this assessment. The adequacy for wave protection against future sea level rise events and the estimate of priority and time at which strengthening, enhancement, replacement, or a combination of these is approximate. The priority and timing of an upgrade is approximate.

5.3.1 Floodwalls

An alternative option for the mitigation of impacts of the projected 2050 and 2100 sea level rise would be the construction of floodwalls around the Berkeley Marina. Floodwall alignments to protect against the most significant damage are shown in **Figures 5.7 and 5.8** for the 2050 and 2100 projected sea level rise, respectively. Associated cross sections are shown in **Figures 5.9 and 5.10**.

5.4 Cost of Measures

5.4.1 Revetment Repair and Upgrade Cost

The revetment repairs and upgrades are required to address the ongoing deterioration of the revetment with age, the climate change effect on winds that cause a change in wave magnitude and armor damage, the greater penetration of wave action at low tide, and the direct effect of sea level rise that raises up the wave action to impact armor rock higher up the slope.

With the expectation that projections of sea level rise and wind level will be more accurate over time as a result of tracking past records and improving the climate models, the crest upgrade is separated from the slope upgrade construction and deferred in the expectation that improved crest elevation estimates can be determined later.

Consideration of deterioration, sea level rise, and wave runup have resulted in estimates of the time for upgrade construction. An approximate allocation of estimated repair and upgrade costs is given in the Forecast of Revetment Repairs and Upgrades included in **Appendix H**. Values for the Low risk Aversion projections are shown. The Forecast has similarities to long-term maintenance plans used by trustees for other major constructed facilities.

The estimated start of the various repairs and upgrades is in effect showing the priorities of the various future actions. If repair and upgrade work is deferred, then the various items can become vulnerabilities and result in increases in cost. The Marina Area has a long length of shoreline protection and breakwaters that are comparable in magnitude to those of a coastal harbor.

5.4.2 Floodwall Cost

A cost estimate was prepared for the floodwall protection for both the 2050 sea level rise mitigation and the 2100 sea level rise mitigation. The cumulative total costs for the 2050 mitigation are approximately $14.3 million and the 2100 mitigation are $31.5 million. The cost estimate is included in **Appendix H**.

5.5 Long Term Maintenance Plan

Without the direct involvement of the US Army Corps of Engineers and without the oversight of a port's harbor maintenance division, an alternative organization to control long term maintenance is advisable, particularly since sea level rise will increase the need for repairs and advance the need for upgrades.

A Board of Trustees, or equivalent organization, could be the appropriate form of responsible body. The Board would be responsible to the City of Berkeley for ensuring that planning, cost estimating, and design of repairs and upgrades are undertaken with the goal of economical repairs and upgrades. This study recommends reevaluating the needs for maintenance and related funding at least every ten years and updating the long-term maintenance plan.

The Board would comprise trustees with design and construction experience of shoreline and breakwaters, and without ties to special interests. The trustees would need experience in cost estimating, the preparation of design and construction documents, and in monitoring construction.

The trustees would be engaged on a limited part time basis and undertake the following:

- Keep informed of the most likely sea level rise projection over the future decades by reviewing updated pertinent published information from the California Coastal Commission, BCDC, USGS, the US Army Corps of Engineers, NOAA, and other sources of reliable information that may arise in the future.
- Watch for local failures and changes to the shoreline protection. Arrange for inspections. Keep records.
- Determine when condition surveys, involving geotechnical and structural evaluations, should be undertaken. Set up construction contract documents and monitor the work. Keep records.
- Ensure that secured records of inspection and condition are kept up to date in the applicable accessible format of the time.
- Determine the lengths of shoreline requiring repairs and prioritize for the short and long term.
- Based on gathered information, update estimates of the extent and the designs of upgrades. Prioritize and schedule.

- Advise the City and check that necessary funding is accumulated consistent with scheduled repairs and upgrades and the associated cash flow needs for engineering, construction, and construction monitoring.
- Monitor the design and construction of repairs and upgrades.

The efforts of the Board of Trustees would be focused on benefitting the City of Berkeley financially by:

- Repairing the existing construction as and when needed.
- Discerning the best use of upgrade funds and prioritizing and scheduling work accordingly.
- Avoiding the spending of funds on non-essential upgrades.
- Reviewing proposals by authorized City developers related to intensive use of a site.

5.6 Adaptation schedule

Trustees of facilities, in general, are familiar with the importance of regular maintenance. Deferred maintenance results in greater future repair costs to correct the condition. It is difficult to accurately assess the increased cost due to lack of regular maintenance. For revetments and breakwaters, the increased cost resulting from deferred repairs and upgrades, could reach on the order of 30 percent over and above the cost of regular repair and upgrades.

The upper layer of armor rock could be removed by the decade 2060 to 2070 for sea level projection if no repairs or upgrades were undertaken.

When the outer layer of rock armor is removed, wave action leaches out the underlayer, the inner layer of rock armor and underlayer deteriorate, and the revetment slope slumps. Slumped material needs to be re-shaped or removed, the underlayer replaced, and armor layers reconstructed

The Repair and Upgrade Plan focusses continual attention on maintenance. A 10-year cycle for review is envisaged with the allocation of repairs and upgrades by decade. An outline of the updating of the repair and upgrade plan procedure is shown in **Figure 5.11** - Updating Repair and Upgrade Plan.

5.7 Monitoring strategies

Inspections include annual inspections together with special inspections following bad storms. Inspection “watch areas” are added to the record of repairs and upgrades on a gridded topographic plan for future reference.

Condition surveys include the excavation of test pits, borings, and geotechnical work prior to repair work. Information gained to assist in repairs can be useful for future upgrades. Key information is added to the gridded topographic plan.

Estimates of the costs of inspections, condition surveys, and updating the repair and upgrade plan every ten years are included against the line item Repair & Upgrade Plan Related Actions, Design and Administration shown in the Forecast of Revetment Repairs and Upgrades included in **Appendix G**. Additional special reviews related to considering future changes in land use, new buildings, or building modifications are included in this item.

6.0 REFERENCES

AECOM, 2016, San Francisco Bay Tidal Datums and Extreme Tides Study, Final Report, February 2016.

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Distribution and Quality Control

DRAFT Berkeley Marina Sea Level Rise AB 691 Assessment Study
Berkeley, California

August 30, 2019

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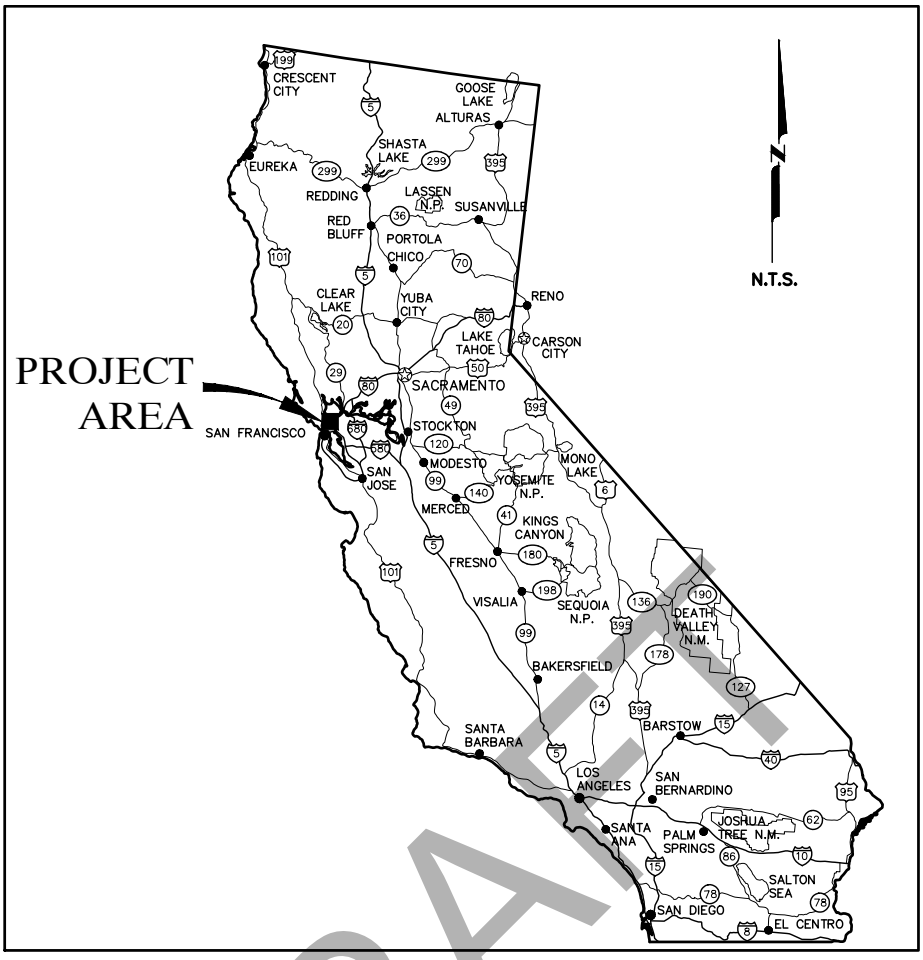
Quality Control Reviewer:

Franz Haidinger, PE
Principal

Figures



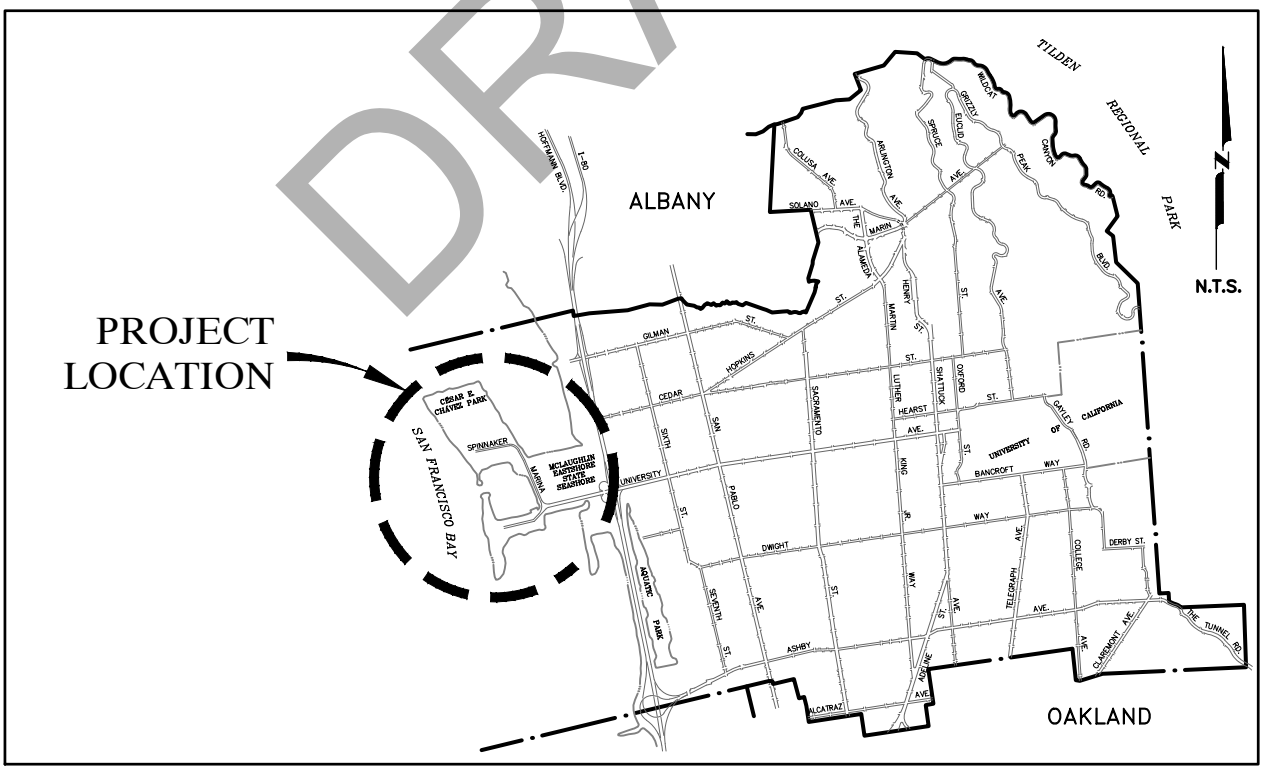


Figure 1.1 - Location and Vicinity Map (not to scale)

Berkeley Marina Sea Level Rise
AB 691 Assessment Study
FEMA Flood Zones

N
1 in. = 1,000 ft.
0 500 1,000 ft.

FIGURE 2.1

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery, FEMA National Flood Hazard Layer	226.24.55	skobs	8/26/2019	8/26/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2.1FEMAFloodZone.mxd

Legend

- Shoreline Zone Boundary
- Shoreline Zone
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9

Berkeley Marina Sea Level Rise AB 691 Assessment Study

Project Area Shoreline Zones

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 2.2

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/26/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2.2ShoreZones.mxd

Legend

Depth

7.0 ft.

Trace

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study
2030 SLR Inundation
100-year Extreme Tide + Low Risk Aversion
(10.1 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.1

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	5/23/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2030-10.1ft\Inundation.mxd

Legend

Depth

7.0 ft.

Trace

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study
2050 SLR Inundation
100-year Extreme Tide + Low Risk Aversion
(10.7 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.2

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	5/23/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2050-10.7ft\Inundation.mxd

Legend

Depth

9.0 ft.

Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study
2100 SLR Inundation
100-year Extreme Tide + Low Risk Aversion
(13 ft. WSEL NAVD'88)

N

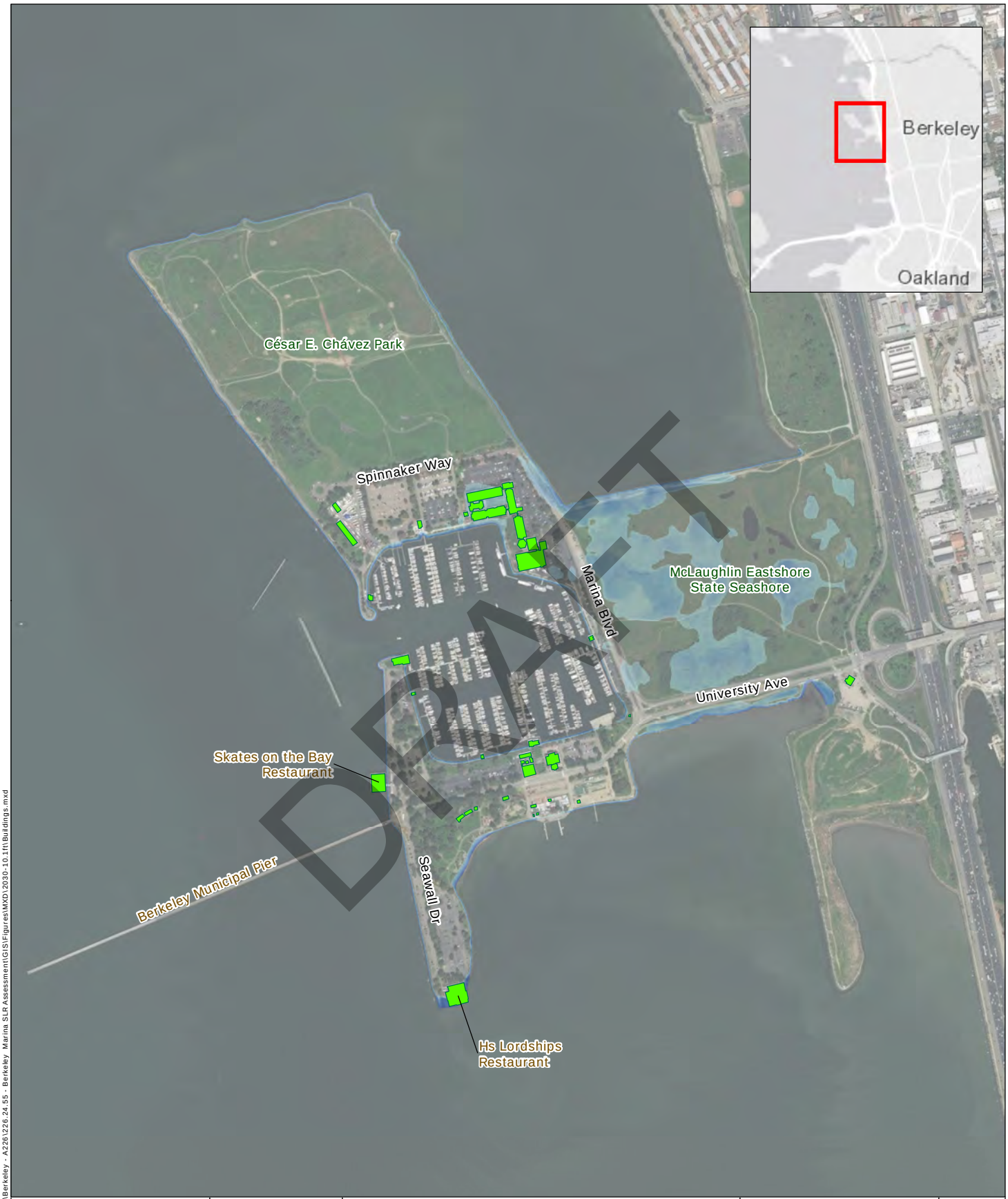
1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.3

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	5/23/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2100-13.0ft\Inundation.mxd



Legend

- Impacted Building
- Unimpacted Building

Depth

- 7.0 ft.
- Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2030 SLR FFE Building Impacts
100-year Extreme Tide + Low Risk Aversion
(10.1 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.4

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	5/23/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2030-10.1ft\Buildings.mxd

Legend
- Impacted Building
- Unimpacted Building

Depth
- 7.0 ft.
- Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2050 SLR FFE Building Impacts
100-year Extreme Tide + Low Risk Aversion
(10.7 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.5

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	5/23/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2050-10.7ft\Buildings.mxd

Legend

- Impacted Building
- Unimpacted Building

Depth

- 9.0 ft.
- Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2100 SLR FFE Building Impacts
100-year Extreme Tide + Low Risk Aversion
(13.0 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.6

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	5/23/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2100-13.0ft\Buildings.mxd

Legend

- Impacted Dock
- Unimpacted Dock

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study
2030 SLR Dock Impacts
100-year Extreme Tide + Low Risk Aversion
(10.1 ft. WSEL NAVD 88)

N

1 in. = 500 ft.

0 250 500 ft.

FIGURE 3.7

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	8/27/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2030-10.1ft\Docks.mxd

Legend

- Impacted Dock
- Unimpacted Dock

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study
2050 SLR Dock Impacts
100-year Extreme Tide + Low Risk Aversion
(10.7 ft. WSEL NAVD 88)

N

1 in. = 500 ft.

0 250 500 ft.

FIGURE 3.8

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	8/27/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2050-10.7ft\Docks.mxd

Legend

- Impacted Dock
- Unimpacted Dock

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study
2100 SLR Dock Impacts
100-year Extreme Tide + Low Risk Aversion
(13.0 ft. WSEL NAVD 88)

N

1 in. = 500 ft.

0 250 500 ft.

FIGURE 3.9

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	8/27/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2100-13.0ft\Docks.mxd

Legend

- Impacted Roadway
- Unimpacted Roadway

Depth

- 7.0 ft.
- Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2030 SLR Roadway Impacts
100-year Extreme Tide + Low Risk Aversion
(10.1 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.10

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2030-10.1ft\Roads.mxd

Legend

- Impacted Roadway
- Unimpacted Roadway

Depth

- 7.0 ft.
- Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2050 SLR Roadway Impacts
100-year Extreme Tide + Low Risk Aversion
(10.7 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.11

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2050-10.7ft\Roads.mxd

Legend

- Impacted Roadway
- Unimpacted Roadway

Depth

- 9.0 ft.
- Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2100 SLR Roadway Impacts
100-year Extreme Tide + Low Risk Aversion
(13.0 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.12

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2100-13.0ft\Roads.mxd

Legend

- Impacted Parking
- Unimpacted Parking

Depth

- 7.0 ft.
- Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2030 SLR Parking Impacts
100-year Extreme Tide + Low Risk Aversion
(10.1 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.13

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2030-10.1ft\Parking.mxd

Legend

- Impacted Parking
- Unimpacted Parking

Depth

- 7.0 ft.
- Trace

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2050 SLR Parking Impacts
100-year Extreme Tide + Low Risk Aversion
(10.7 ft. WSEL (NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.14

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2050-10.7ft\Parking.mxd

Legend

- Impacted Parking
- Unimpacted Parking

Depth

- 9.0 ft.
- Trace

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2100 SLR Parking Impacts
100-year Extreme Tide + Low Risk Aversion
(13.0 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE
3.15

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2100-13.0ft\Parking.mxd

Legend
- Impacted Trail
- Unimpacted Trail

Depth
- 7.0 ft.
- Trace

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2030 SLR Trail Impacts
100-year Extreme Tide + Low Risk Aversion
(10.1 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.16

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

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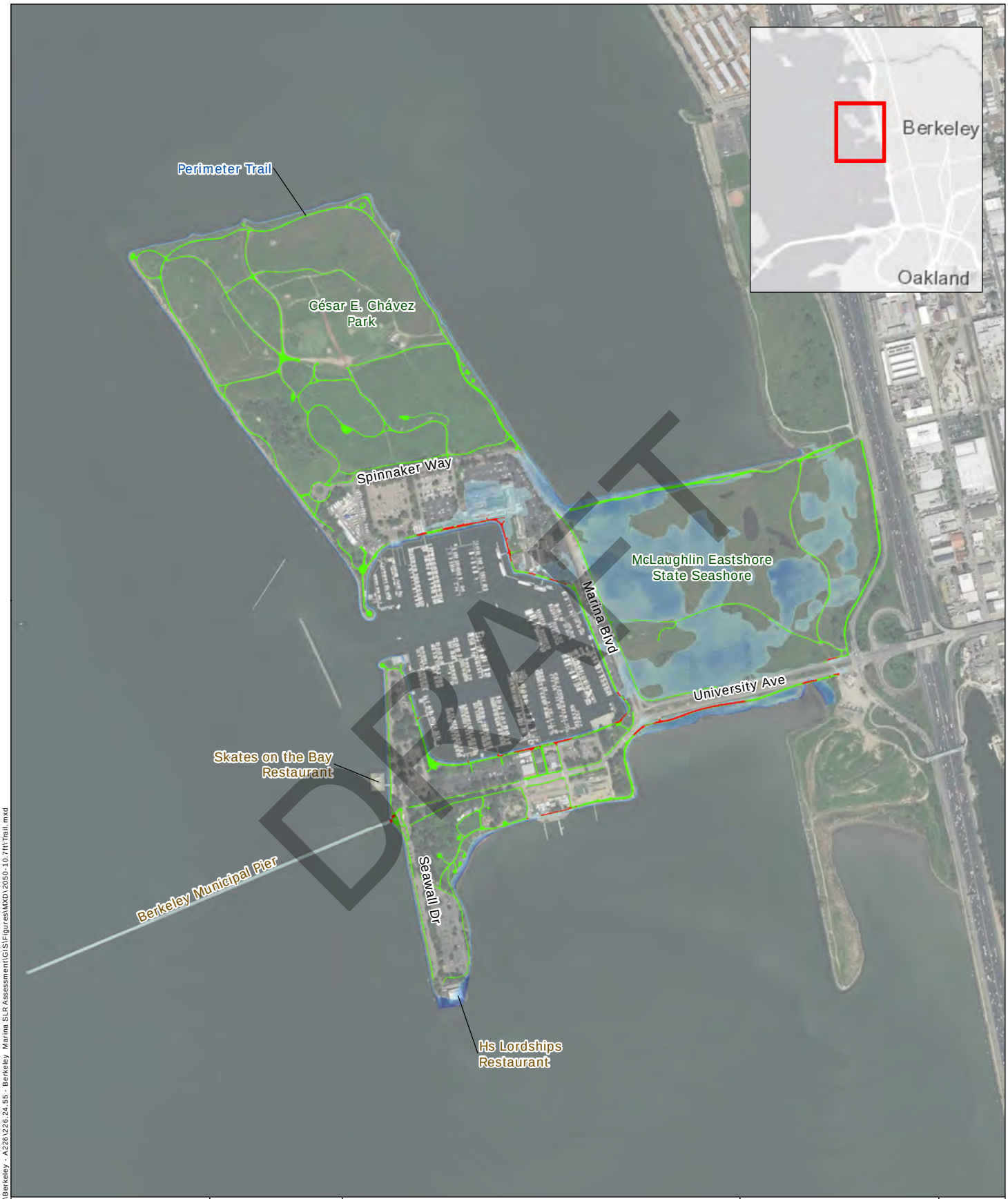


Legend

- Impacted Trail
- Unimpacted Trail

Depth

- 7.0 ft.
- Trace

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2050 SLR Trail Impacts
100-year Extreme Tide + Low Risk Aversion
(10.7 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 3.17

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2050-10.7ft\Trail.mxd

Legend
- Impacted Trail
- Unimpacted Trail

Depth
- 9.0 ft.
- Trace

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2100 SLR Trail Impacts
100-year Extreme Tide + Low Risk Aversion
(13.0 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

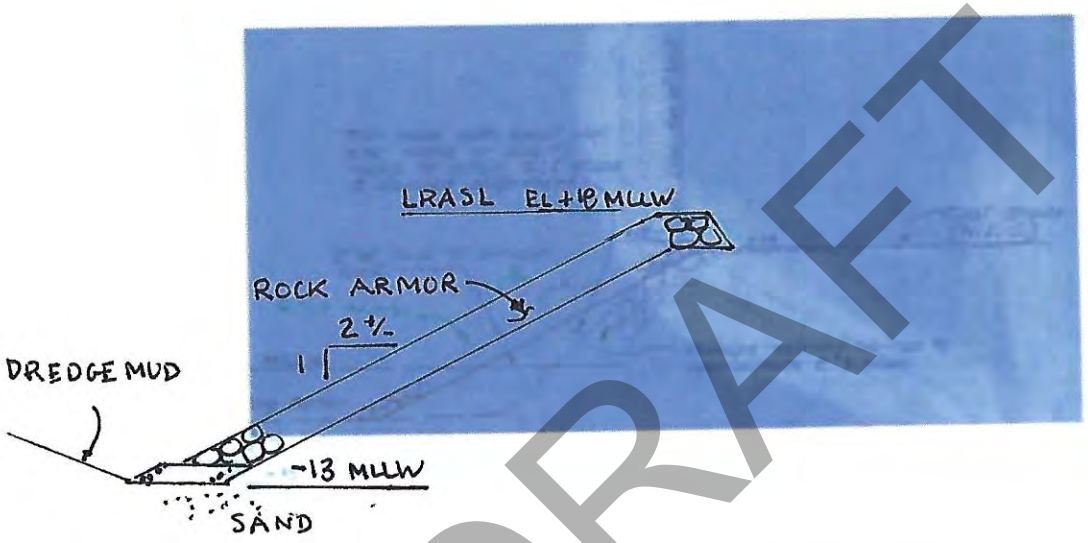
0 500 1,000 ft.

FIGURE 3.18

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\2100-13.0ft\Trails.mxd

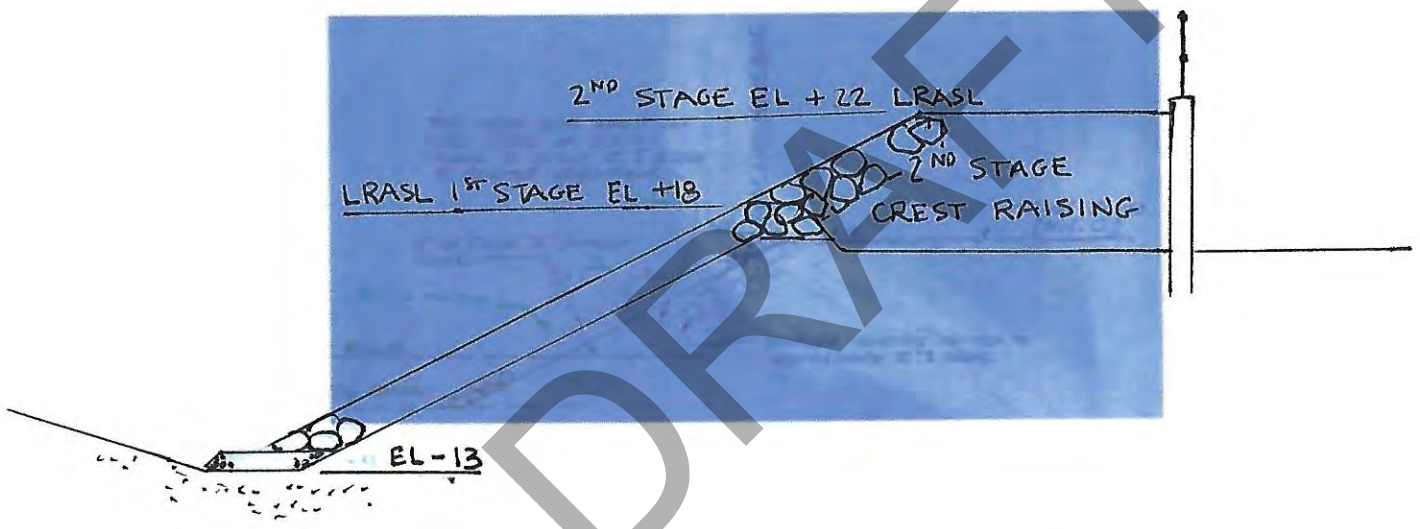
Figure 5.1 - Revetment Upgrade South of Marina Entrance - West Side



REVETMENT CROSS-SECTION

NOT TO SCALE

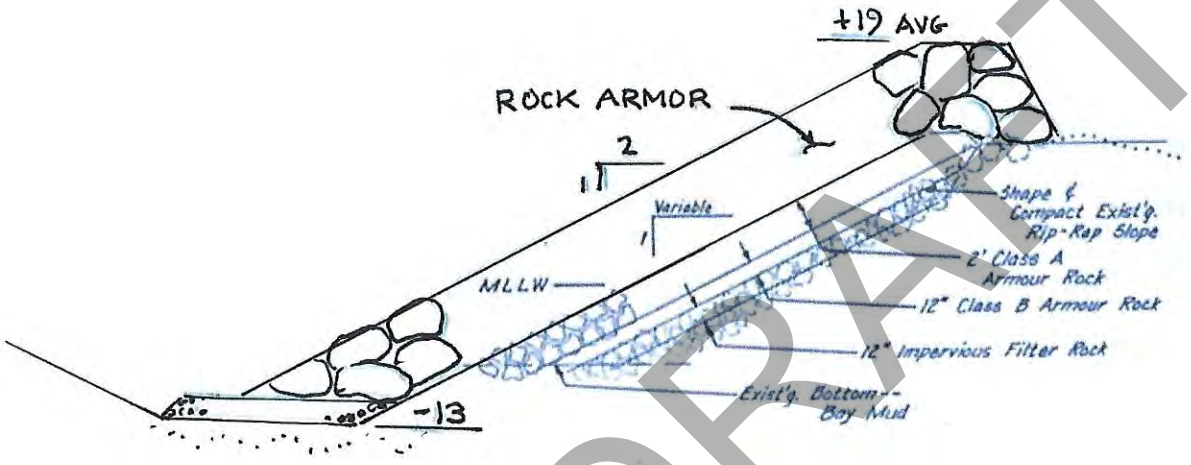
Figure 5.2 - Crest Raising North and South of Marina Entrance - West Side



REVETMENT CROSS-SECTION

NOT TO SCALE

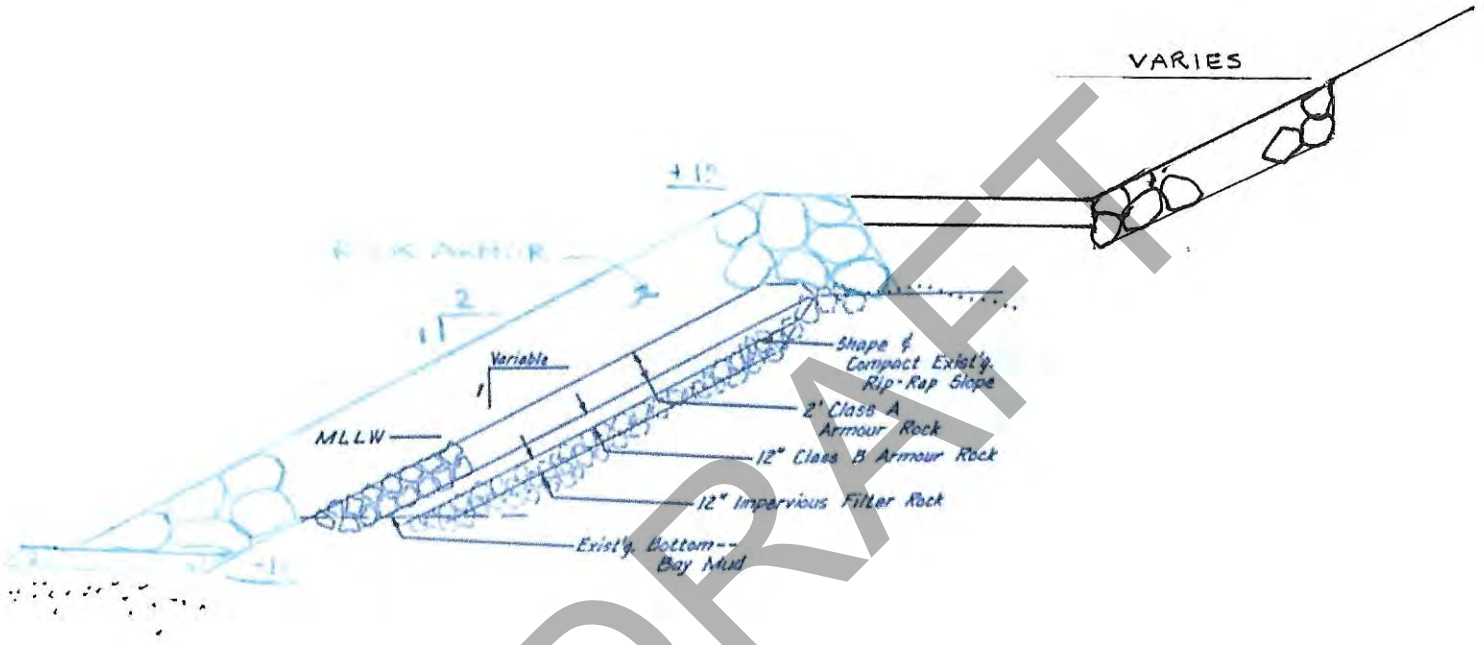
Figure 5.3 - Revetment Upgrade North of Marina - West, North, and East Sides



REVETMENT CROSS-SECTION

NOT TO SCALE

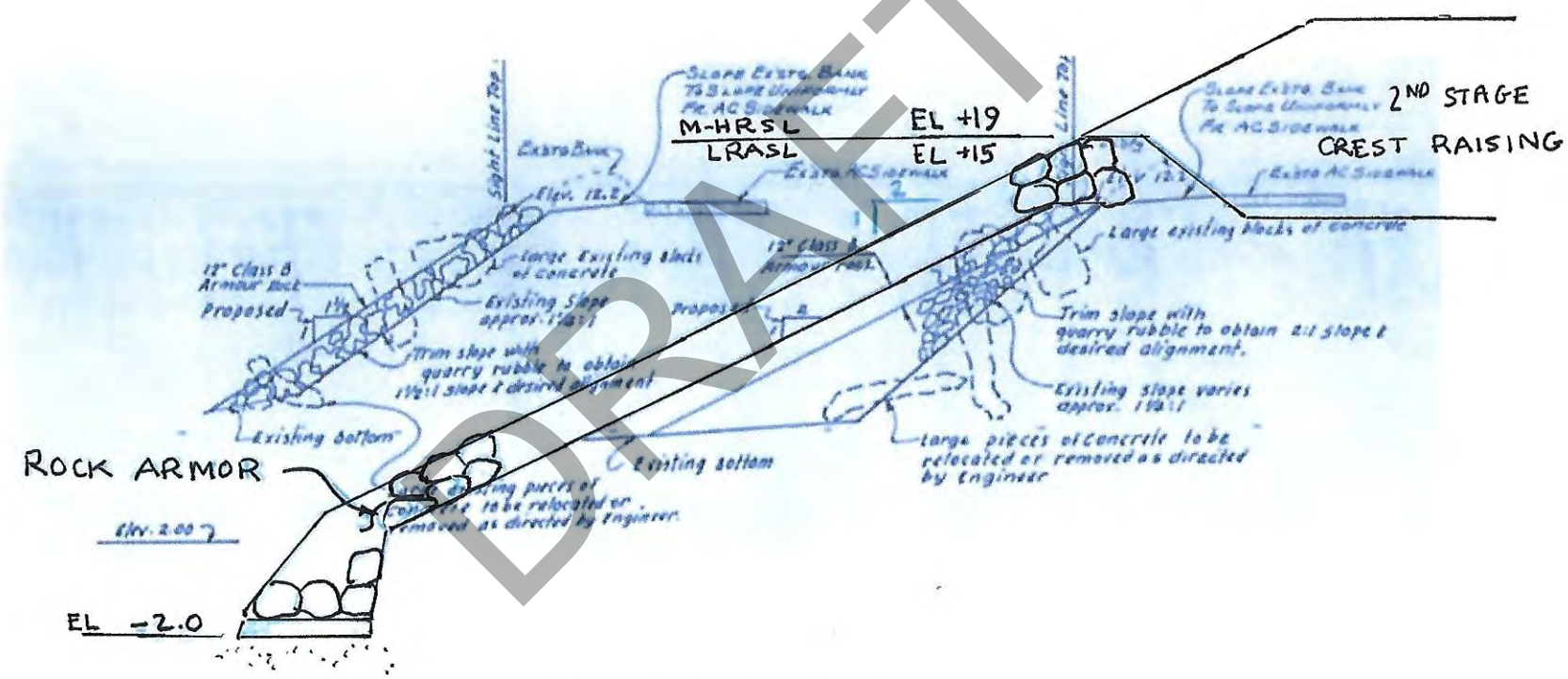
Figure 5.4 Revetment Raising North of Marina - West, North, and East Sides



REVETMENT CROSS-SECTION

NOT TO SCALE

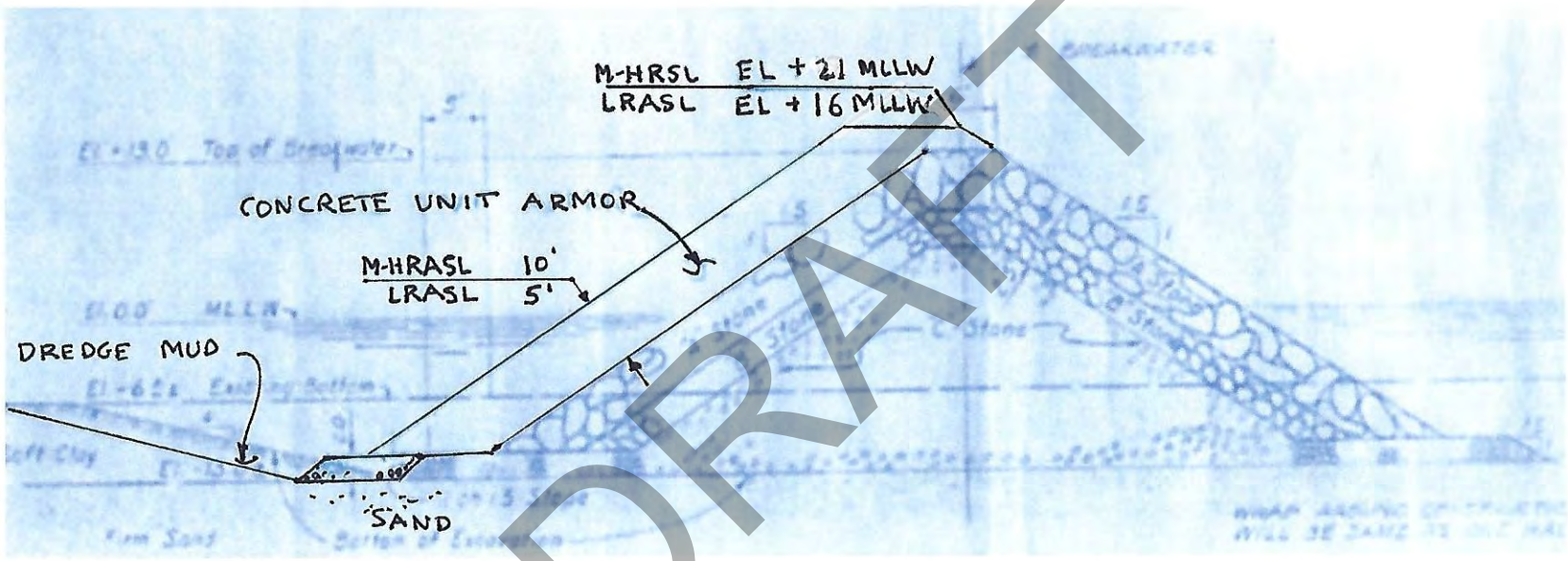
Figure 5.5 - Revetment Upgrade and Crest Raising at South Side



REVETMENT CROSS-SECTION

NOT TO SCALE

Figure 5.6 - Entrance Breakwater Upgrade



BREAKWATER CROSS-SECTION

NOT TO SCALE

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\5.7Seawall-Alt2-2050.mxd

CITY OF BERKELEY

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study

2050 SLR Proposed Floodwalls
100-year Extreme Tide + Low Risk Aversion
(10.7 ft. WSEL NAVD 88)

N

1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 5.7

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	7/15/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\5.8Seawall-Alt2-2100.mxd

CITY OF BERKELEY

NCE

Berkeley Marina Area
Sea Level Rise Assessment

2100 SLR Proposed Floodwalls
100-year Extreme Tide + Low Risk Aversion
(13.0 ft. WSEL NAVD 88)

N

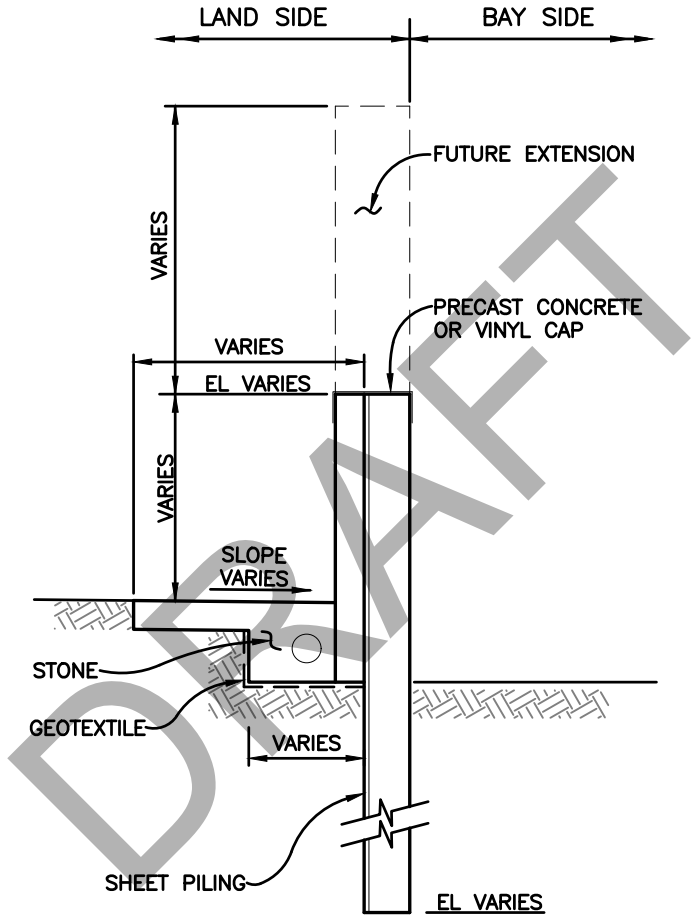
1 in. = 1,000 ft.

0 500 1,000 ft.

FIGURE 5.8

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	5/17/2019	5/23/2019	mhorvath

Figure 5.9 - Floodwall Schematic Alternative A

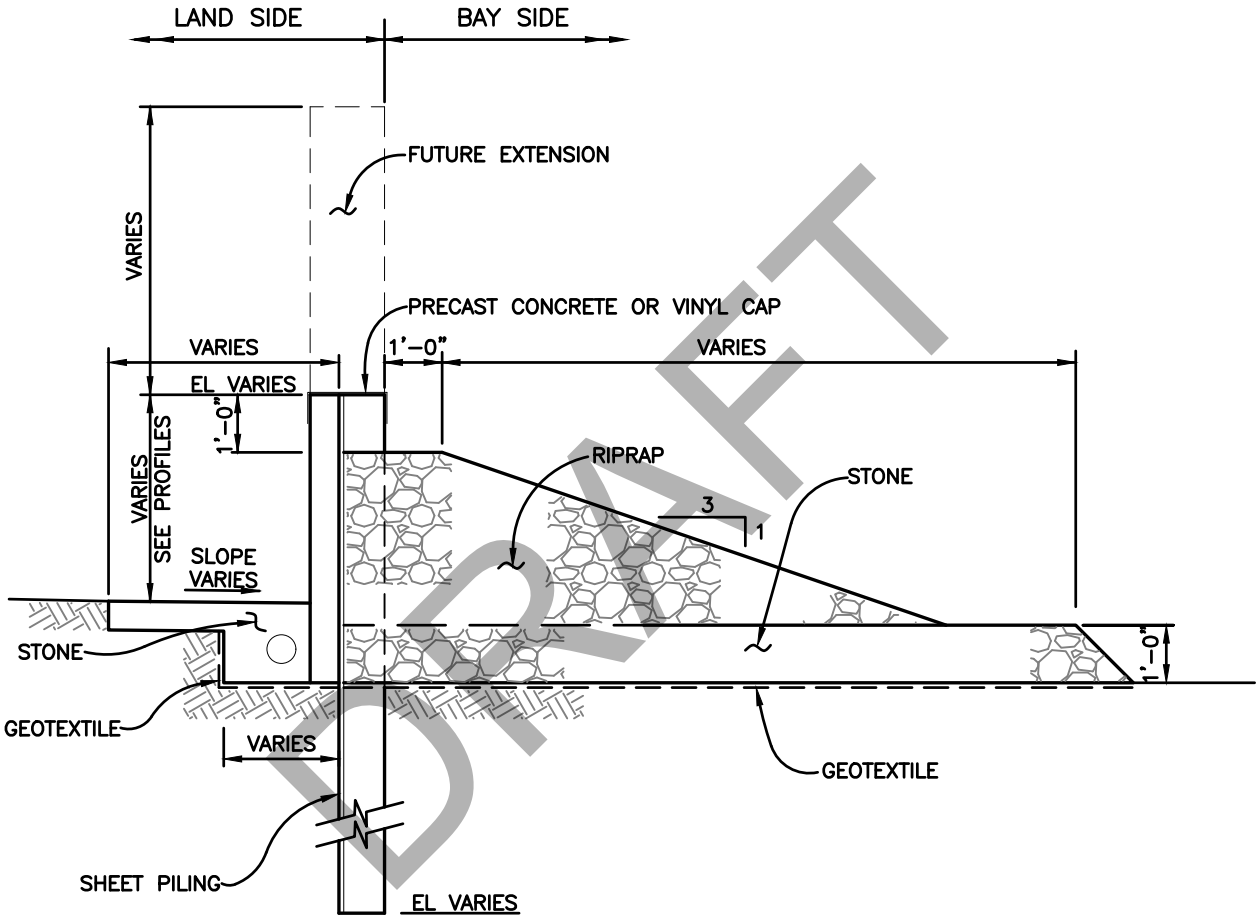


TYPICAL SECTION

ALTERNATIVE A
FLOODWALL SCHEMATIC

CITY OF BERKELEY
BERKELEY MARINA SEA LEVEL RISE AB 691 ASSESSMENT STUDY

Figure 5.10 - Floodwall Schematic Alternative B

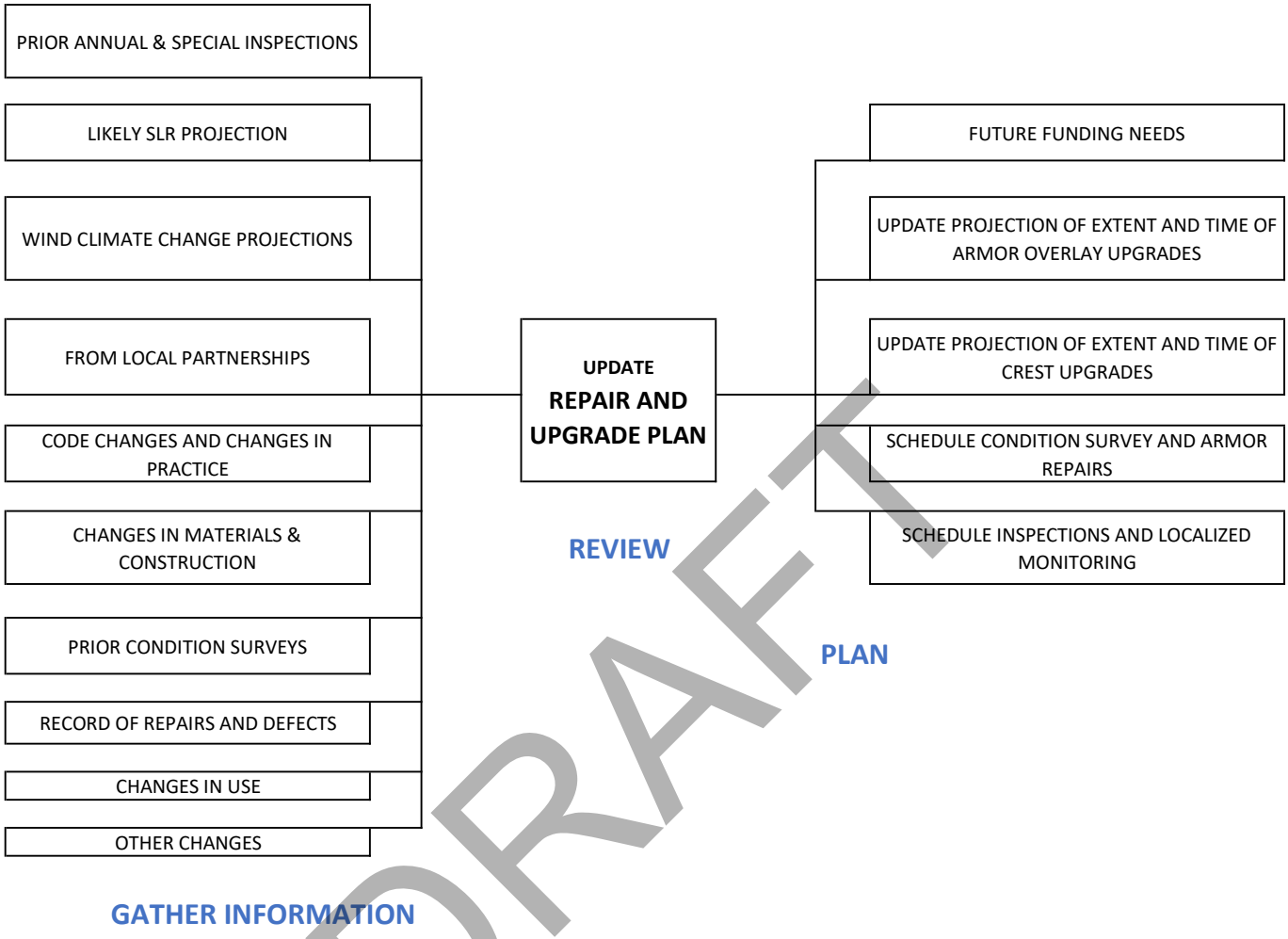


TYPICAL SECTION

ALTERNATIVE B
FLOODWALL SCHEMATIC

CITY OF BERKELEY
BERKELEY MARINA SEA LEVEL RISE AB 691 ASSESSMENT STUDY

Figure 5.10 - Updating Repair and Upgrade Plan

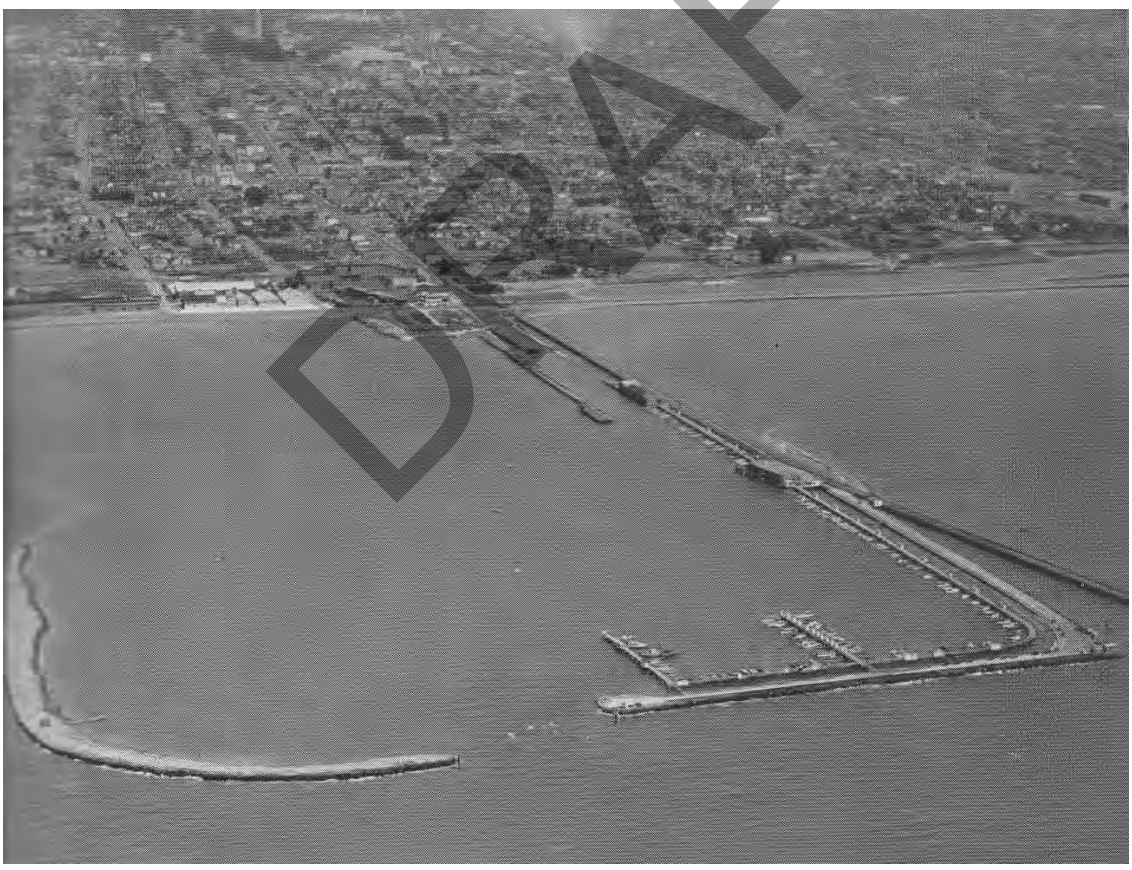


Appendix A

Historic Information

MAP & AERIAL PHOTOGRAPHS FROM INTERNET (March 2019)

PRE WORLD WAR II



PRE WORLD WAR II

Appendix B

Asset Inventory

Legend

Building Footprint

Berkeley Marina Area
Sea Level Rise Assessment

Buildings and
Finished Floor Elevations (FFE)
(NAVD'88)

N

1 in. = 600 ft.

0 300 600 ft.

FIGURE B.1

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	8/26/2019	8/26/2019	na

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\B1-BuildingFFE.mxd

Legend

Berkeley Marina Dock

NCE

Berkeley Marina Sea Level Rise
AB 691 Assessment Study
Berkeley Marina Docks
(NAVD 88)

N

1 in. = 500 ft.

0 250 500 ft.

FIGURE
B.2

SOURCE	JOB NUMBER	DRAWN	DATE	REVISED	APPROVED
ESRI World Imagery basemap	226.24.55	skobs	8/27/2019	8/27/2019	mhorvath

Document Path: P:\Active Projects\Berkeley - A226\226.24.55 - Berkeley Marina SLR Assessment\GIS\Figures\MXD\B2-Docks.mxd

Revetment Asset Inventory

Revetment and Other Shore Protection	LF	Value $
West Side - South of Marina Entrance	2,700	2,700,000
North of Marina - Southern 2,000 LF on East Side	6,050	8,470,000
North of Marina - West Side, North Side & 900 LF on East Side	2,000	1,400,000
Submerged Rock Breakwater at South End	250	500,000
Rock Breakwater at Marine Entrance	750	6,750,000
Structural Concrete Breakwater at Marine Entrance	500	4,000,000
South Shore Protection	2,800	350,000
Revetment and Other Shore Protection Total		24,170,000

Table X - Field Asset Inventory

Location ID	Category	Field Description	Existing Asset Elevation (FT) [NAVD88]	General Geographical Location	Latitude	Longitude
1903110418	Storm Sewer	SDMH and Catchbasin	19.7	West Side	37.869460	-122.319728
1903110431	Monitoring Well	Monitoring Well	14.3	West Side	37.870122	-122.320797
1903110724	Water	Fire Hydrant	12.6	Marina	37.868059	-122.318396
1903110823	Storm Sewer	Grate on Drain Inlet	19.7	West Side	37.869536	-122.319838
1903110830	Storm Sewer	Drain Inlet	14.5	West Side	37.870135	-122.320749
1903110836	Water	Fire Hydrant	19.1	West Side	37.870551	-122.320897
1903110839	Storm Sewer	Drain Inlet	11.8	West Side	37.870966	-122.321612
1903110841	Storm Sewer	Outfall	8.0	West Side	37.870911	-122.321688
1903110844	Storm Sewer	Drain Inlet	12.3	West Side	37.871139	-122.321719
1903110850	Storm Sewer	Two Inlet Pipes in Swale	15.7	West Side	37.871894	-122.322420
1903110852	Storm Sewer	Outfall (Two 12-inch Pipes)	10.7	West Side	37.871843	-122.322537
1903110855	Storm Sewer	Confluence of Concrete swales	17.3	West Side	37.871927	-122.322234
1903110859	Unknown Manhole / Vault	Manhole	20.1	West Side	37.872534	-122.322888
1903110901	Monitoring Well	Monitoring Well	18.0	West Side	37.872985	-122.323331
1903110905	Storm Sewer	Inlet Pipe in swale (2x)	17.6	West Side	37.873133	-122.323411
1903110908	Storm Sewer	Outfall (Two Pipes)	13.9	West Side	37.873086	-122.323513
1903110916	Storm Sewer	Inlet Pipe in Swale	16.5	North Side	37.874547	-122.324353
1903110917	Storm Sewer	Outfall (12-inch)	11.8	North Side	37.874614	-122.324381
1903110922	Storm Sewer	Inlet Pipe in Swale	17.6	North Side	37.874769	-122.323054
1903110924	Storm Sewer	Outfall (12-inch)	9.8	North Side	37.874921	-122.323007
1903110930	Storm Sewer	Two Inlet Pipes in Swale	18.3	North Side	37.875031	-122.321841
1903110933	Storm Sewer	Two outfall pipes (12-in.)	10.3	North Side	37.875162	-122.321888
1903110939	Storm Sewer	Two Inlet Pipes in Swale	15.7	North Side	37.875472	-122.319589
1903110941	Storm Sewer	Two outfall pipes (12-in.)	11.4	North Side	37.875587	-122.319622
1903110945	Storm Sewer	Assumed location of outfall pipe. location approximate.	12.5	North Side	37.875653	-122.319163
1903110952	Storm Sewer	Two Inlet Pipes in Swale	15.7	East Side	37.874693	-122.317873
1903110954	Storm Sewer	Two outfall pipes (12-in.)	14.8	East Side	37.874749	-122.317791
1903110959	Storm Sewer	Inlet Pipe in Swale	11.7	East Side	37.874088	-122.317349
1903111000	Storm Sewer	Outfall (12-inch)	10.3	East Side	37.874124	-122.317253
1903111003	Monitoring Well	Monitoring Well	10.2	East Side	37.873879	-122.317095
1903111008	Storm Sewer	Two outfall pipes (12-in.)	8.2	East Side	37.873414	-122.316655
1903111010	Storm Sewer	Pipe Feature	9.8	East Side	37.873342	-122.316642
1903111014	Storm Sewer	Two Inlet Pipes in Swale	13.6	East Side	37.872879	-122.316478
1903111015	Storm Sewer	Outfall (12-inch)	8.1	East Side	37.872936	-122.316325
1903111017	Water	Fire Hydrant	16.1	East Side	37.872612	-122.316393
1903111019	Electric	PG&E Box	14.6	East Side	37.872628	-122.316338
1903111021	Storm Sewer	Drain Inlet	13.0	East Side	37.872614	-122.316258
1903111032	Monitoring Well	Monitoring Well	12.8	East Side	37.871538	-122.315159
1903111033	Water	Fire Hydrant	15.0	East Side	37.871425	-122.315212
1903111037	Storm Sewer	Drain Inlet	13.5	East Side	37.870745	-122.314660
1903111043	Storm Sewer	Drain Inlet	20.8	Park Interior	37.870494	-122.316414
1903111046	Storm Sewer	Drain Inlet	23.4	Park Interior	37.870344	-122.317103
1903111048	Unknown Utility	Utility Box	25.4	Park Interior	37.870301	-122.317601
1903111105	Sanitary Sewer	SSMH	11.8	Park Interior	37.867600	-122.318468
1903111107	<Null>	Sump with 2 ASTs	10.8	Marina	37.867564	-122.318437
1903111109	Electric	PG&E Box	11.8	Marina	37.867602	-122.318493
1903111115	Electric	Harbor Light	12.2	Marina	37.867058	-122.318288
1903111119	Electric	Electric Junction Box	12.1	Marina	37.867466	-122.318441
1903111122	Sanitary Sewer	SSMH	12.7	Marina	37.868089	-122.318462
1903111132	Storm Sewer	Drain Inlet	12.5	Marina	37.868360	-122.318219
1903111135	Water	Fire Hydrant	13.7	Marina	37.868729	-122.318433
1903111136	Sanitary Sewer	SSMH	13.7	Marina	37.868789	-122.318390
1903111138	Water	Water Box (assumed)	13.7	Marina	37.868782	-122.318375
1903111139	Storm Sewer	Drain Inlet	13.7	Marina	37.868720	-122.318402
1903111143	Storm Sewer	Drain Inlet	13.0	Marina	37.868460	-122.318376
1903111145	Pier/Dock/Ramp	Western edge of crane dock	8.6	Marina	37.868157	-122.317935
1903111147	Pier/Dock/Ramp	Eastern Edge of Crane Dock	8.6	Marina	37.868219	-122.317881
1903111151	Storm Sewer	Stormwater Vault	12.9	Marina	37.868491	-122.318291
1903111155	Sanitary Sewer	SSMH	12.0	Marina	37.868422	-122.318180
1903111158	Storm Sewer	Drain Inlet	12.7	Marina	37.868501	-122.318106
1903111201	Electric	Transformer Box	13.0	Marina	37.868705	-122.317964
1903111203	Pier/Dock/Ramp	Western corner of launch ramp	7.0	Marina	37.868548	-122.317781
1903111205	Pier/Dock/Ramp	Eastern Corner of Launch Ramp	7.3	Marina	37.868595	-122.317517
1903111208	Sanitary Sewer	SSMH	11.9	Marina	37.868728	-122.317409
1903111210	Sanitary Sewer	SSMH	8.9	Marina	37.868820	-122.317021
1903111215	Storm Sewer	Drain Inlet	12.4	Marina	37.869010	-122.317121
1903111217	Water	Fire Hydrant	11.0	Marina	37.868905	-122.316535
1903111219	Storm Sewer	Drain Inlet	10.9	Marina	37.868934	-122.316465
1903111220	Storm Sewer	Drain Inlet	10.0	Marina	37.868988	-122.316316
1903111222	Unknown Utility	Utility Vaut	9.8	Marina	37.868982	-122.316243
1903111223	Storm Sewer	Drain Inlet	10.5	Marina	37.869002	-122.316169
1903111225	Unknown Utility	Utility Boxes	10.7	Marina	37.868981	-122.316056
1903111226	Storm Sewer	Drain Inlet	9.7	Marina	37.869049	-122.315977
1903111229	Pier/Dock/Ramp	End of Dock	6.7	Marina	37.868737	-122.316008
1903111240	Storm Sewer	Drain Inlet	18.5	Park Interior	37.869975	-122.318757
1903111243	Unknown Manhole / Vault	Manhole	18.1	Park Interior	37.869863	-122.318690
1903111244	Water	Fire Hydrant	17.9	Park Interior	37.869808	-122.318646
1903111247	Unknown Manhole / Vault	Manhole	20.7	West Side	37.869737	-122.319386
1903111337	Storm Sewer	Grate on Drain Inlet	8.9	Marina	37.869452	-122.315795
1903111339	Storm Sewer	Grate on Drain Inlet	9.7	Marina	37.869301	-122.315745
1903111340	Unknown Utility	Utility Vaut	9.7	Marina	37.869266	-122.315782
1903111342	Water	Water Valves (above grade)	10.5	Marina	37.869106	-122.315716
1903111345	Water	Water Valves	10.5	Marina	37.869101	-122.315720
1903111346	Unknown Utility	Utility boxes all at same grade	9.7	Marina	37.869044	-122.315690
1903111350	Storm Sewer/Unknown Utility	Grate on Drain Inlet and Utility Boxes	10.5	Marina	37.869223	-122.314712

Location ID	Category	Field Description	Existing Asset Elevation (FT) [NAVD88]	General Geographical Location	Latitude	Longitude
1903111354	Storm Sewer	Grate on Drain Inlet	11.1	Park Interior	37.869939	-122.314634
1903111407	Unknown Utility	Utility Cabinet	9.4	Marina	37.869030	-122.315664
1903111416	Pier/Dock/Ramp	Hornblower Pier	9.9	Marina	37.867940	-122.313788
1903111419	Storm Sewer	Grate on Drain Inlet	9.6	Marina	37.868075	-122.313455
1903111422	Storm Sewer	Grate on Drain Inlet	11.5	Marina	37.868471	-122.313648
1903111426	Storm Sewer	Three grates on drain inlets	12.1	Marina	37.868846	-122.314184
1903111428	Storm Sewer	Grate on Drain Inlet	10.7	Marina	37.869290	-122.314260
1903120727	Water	Fire Hydrant	10.7	Marina	37.869282	-122.314324
1903120729	Electric	Electrical Vault	10.7	Marina	37.869295	-122.314486
1903120731	Storm Sewer	Drain Inlet	10.7	Marina	37.869389	-122.314334
1903120733	Storm Sewer	Drain Inlet	10.4	Marina	37.869496	-122.314389
1903120735	Storm Sewer	Drain Inlet	10.5	Marina	37.869611	-122.314429
1903120736	Storm Sewer	Drain Inlet	10.5	Marina	37.869696	-122.314460
1903120741	Storm Sewer	Drain Inlet	11.4	Marina	37.868510	-122.313399
1903120742	Storm Sewer	Drain Inlet	10.7	Marina	37.868357	-122.313316
1903120744	Storm Sewer	Drain Inlet	9.5	Marina	37.868059	-122.313006
1903120746	Storm Sewer	Drain Inlet	10.5	Marina	37.868116	-122.313189
1903120748	Storm Sewer	Drain Inlet	10.0	Marina	37.867949	-122.313101
1903120810	Storm Sewer	Drain Inlet	11.3	Marina	37.869782	-122.315876
1903120827	Electric	Power Pole	8.7	East Side	37.869910	-122.313868
1903120829	Electric	Power Pole	10.6	East Side	37.870453	-122.314369
1903120833	Electric	Power Pole	9.6	East Side	37.869369	-122.313364
1903120834	Fence	Corner of Fence	11.0	East Side	37.869018	-122.313131
1903120837	Electric	Power Pole	8.2	East Side	37.869436	-122.313001
1903120839	Electric	Power Pole	8.9	East Side	37.869679	-122.311904
1903120842	Electric	Power Pole	8.2	East Side	37.869892	-122.310767
1903120845	Fence	Fenceline	8.0	East Side	37.869923	-122.310063
1903120847	Electric	Power Pole	8.5	East Side	37.870133	-122.309571
1903120851	Electric	Power Pole	11.3	East Side	37.870657	-122.307009
1903120854	NA	Park gate	12.6	East Side	37.870452	-122.307134
1903120857	Electric	Power Pole and Fenceline	12.2	East Side	37.870930	-122.305669
1903120859	Electric	Power Pole	12.8	East Side	37.870890	-122.305601
1903120902	Electric	Power Pole	13.5	East Side	37.869972	-122.305293
1903120905	Electric	Power Pole	11.7	East Side	37.868688	-122.305036
1903120909	Fence	Fenceline	12.3	East Side	37.868451	-122.305169
1903120915	Fence	Fenceline	13.9	South Shore Protected	37.866677	-122.305927
1903120919	Storm Sewer	Drain Inlet	10.6	South Shore Protected	37.866383	-122.306092
1903120923	Fence	Fenceline	10.6	South Shore Protected	37.865972	-122.308117
1903120928	Fence	Fenceline	10.5	South Shore Protected	37.865489	-122.311069
1903120951	Vegetation/Topography	Trees	18.3	South Shore Protected	37.864056	-122.311820
1903120954	Storm Sewer	Drain Inlet	12.4	South Shore Protected	37.864558	-122.311581
1903120957	Storm Sewer	Drain Inlet	12.5	South Shore Protected	37.864085	-122.311991
1903121001	Storm Sewer	Drain Inlet	11.9	South Shore Protected	37.863667	-122.312072
1903121005	Pier/Dock/Ramp	Dock Corner	6.8	South Shore Protected	37.863196	-122.312312
1903121007	Pier/Dock/Ramp	Dock Corner	6.8	South Shore Protected	37.863188	-122.312342
1903121009	Storm Sewer	Drain Inlet	11.8	South Shore Protected	37.863578	-122.312522
1903121013	Storm Sewer	Drain Inlet	12.0	South Shore Protected	37.863506	-122.312883
1903121018	Storm Sewer	Drain Inlet	13.2	South Shore Protected	37.863587	-122.313169
1903121025	Electric	Electrical Box	15.5	South Shore Protected	37.863672	-122.313808
1903121028	Electric	Meter Pedestal	15.4	South Shore Protected	37.863665	-122.313748
1903121029	Sanitary Sewer	SSMH	15.6	South Shore Protected	37.863772	-122.313613
1903121033	Vegetation/Topography	Cypress Trees	16.9	South Shore Protected	37.863352	-122.315027
1903121034	Sanitary Sewer	SSMH	17.2	South Shore Protected	37.863416	-122.315170
1903121037	Water	Water Valves	17.7	South Shore Protected	37.863293	-122.315781
1903121039	Vegetation/Topography	Hilltop Elevation and Cypress Trees	21.0	South Shore Protected	37.863048	-122.316107
1903121045	Pier/Dock/Ramp	Pier	10.1	West Side	37.862871	-122.317616
1903121047	Art	Sundial	11.4	West Side	37.862878	-122.317515
1903121050	Storm Sewer	Drain Inlet	14.6	West Side	37.862667	-122.317204
1903121052	Electric	PG&E Vault	14.6	West Side	37.862654	-122.317145
1903121054	Sanitary Sewer	SSMH	14.5	West Side	37.862257	-122.317064
1903121059	Sanitary Sewer	SSMH	14.7	West Side	37.861455	-122.316839
1903121101	Electric	PG&E Vault	14.6	West Side	37.861297	-122.316789
1903121107	Sanitary Sewer	SSMH	14.4	West Side	37.860626	-122.316614
1903121108	Vegetation/Topography	Landscape Berm	14.7	West Side	37.860615	-122.316460
1903121111	Electric	PG&E Vault	14.8	West Side	37.859893	-122.316392
1903121113	Sanitary Sewer	SSMH	14.7	West Side	37.859840	-122.316419
1903121115	Unknown Manhole / Vault	Manhole	14.6	West Side	37.859788	-122.316324
1903121121	Water	Fire Hydrant	14.4	West Side	37.859763	-122.316435
1903121126	Storm Sewer	Drain Inlet	13.6	South Shore Protected	37.859990	-122.315546
1903121129	Storm Sewer	Outfall	10.8	South Shore Protected	37.859999	-122.315493
1903121135	Storm Sewer	Drain Inlet	15.5	South Shore Protected	37.860788	-122.315769
1903121139	Storm Sewer	Outfall	12.4	South Shore Protected	37.860846	-122.315604
1903121143	Storm Sewer	Drain Inlet	15.0	West Side	37.860713	-122.316273
1903121144	Storm Sewer	Drain Inlet	15.0	South Shore Protected	37.861230	-122.315885
1903121147	Storm Sewer	Outfall	12.3	South Shore Protected	37.861243	-122.315814
1903121204	Storm Sewer	Drain Inlet	16.5	South Shore Protected	37.863215	-122.315161
1903121206	Pier/Dock/Ramp	Elevated Dock Entrance	15.7	South Shore Protected	37.862953	-122.313278
1903121214	Pier/Dock/Ramp	Edge of Dock	11.2	South Shore Protected	37.862888	-122.313632
1903121222	Storm Sewer	Tree Vault	11.2	South Shore Protected	37.863252	-122.312942
1903121332	Storm Sewer	Drain Inlet	17.9	West Side	37.869290	-122.319540
1903121333	Vegetation/Topography	Elevated Area with Trees and Bushes	18.7	West Side	37.869234	-122.319608
1903130318	Storm Sewer	Fire Hydrant	12.2	West Side	37.866383	-122.306094
1903130416	Storm Sewer	Drain Inlet	10.6	West Side	37.866383	-122.306094
1903130605	Storm Sewer	Grate on Drain Inlet	11.3	Marina	37.864189	-122.314287
1903130716	Unknown Utility	Vault	9.6	East Side	37.869446	-122.313581

Location ID	Category	Field Description	Existing Asset Elevation (FT) [NAVD88]	General Geographical Location	Latitude	Longitude
1903130718	Unknown Manhole / Vault	Manhole	10.8	East Side	37.869417	-122.313620
1903130723	Sanitary Sewer	SSMH	11.8	Marina	37.868683	-122.313154
1903130725	Water	Fire Hydrant	10.7	Marina	37.868264	-122.312998
1903130726	Electric	PG&E Vault	10.8	Marina	37.868164	-122.312945
1903130728	Unknown Manhole / Vault	Three Manholes	11.6	Marina	37.867826	-122.312694
1903130730	Electric	Generator	12.1	Marina	37.867763	-122.312775
1903130733	Water	Water Valves	12.3	Marina	37.867398	-122.312543
1903130735	Water	Fire Hydrant	11.3	Marina	37.867260	-122.312483
1903130737	Unknown Manhole / Vault	Manhole	11.8	Marina	37.867037	-122.312273
1903130739	Sanitary Sewer	SSMH	11.3	Marina	37.866845	-122.312149
1903130741	Sanitary Sewer	SSMH	10.7	Marina	37.866730	-122.312105
1903130744	Water	Water Valves	10.1	Marina	37.866555	-122.312108
1903130746	Unknown Manhole / Vault	Two Manholes	11.2	Marina	37.866298	-122.311860
1903130749	Storm Sewer	Drain Inlet	9.6	Marina	37.865723	-122.311476
1903130750	Unknown Manhole / Vault	Manhole	11.3	Marina	37.865444	-122.311416
1903130758	Sanitary Sewer	Two SSMH	12.4	South Shore Protected	37.865840	-122.307104
1903130802	Path/Rec	Pedestrian bridge	5.4	South Shore Protected	37.865908	-122.306803
1903130806	Electric	PG&E Box	10.2	South Shore Protected	37.866074	-122.305963
1903130807	Storm Sewer	Drain Inlet	10.1	South Shore Protected	37.866120	-122.305946
1903130809	Unknown Manhole / Vault	Manhole	11.8	South Shore Protected	37.866149	-122.305588
1903130813	Telephone	Telephone Vault	11.7	South Shore Protected	37.866283	-122.305928
1903130815	Electric	Elecrical Vault and Box	11.7	South Shore Protected	37.866249	-122.306092
1903130825	Unknown Utility	Utility Vaut	13.1	South Shore Protected	37.865511	-122.309399
1903130826	Unknown Utility	Utility Vaut	12.7	South Shore Protected	37.865477	-122.309547
1903130830	Sanitary Sewer	Sewer Transfer Station	13.5	South Shore Protected	37.865321	-122.310402
1903130836	Unknown Utility	Utility Vaut	12.2	Marina	37.865225	-122.311469
1903130839	Water	Fire Hydrant	10.4	Marina	37.865585	-122.311567
1903130841	Electric	Diesel Generator	10.6	Marina	37.865644	-122.311689
1903130845	Sanitary Sewer	SSMH	12.2	Marina	37.866197	-122.312024
1903130846	Unknown Utility	Utility Boxes	11.4	Marina	37.866242	-122.312159
1903130849	Sanitary Sewer	SSMH	11.3	Marina	37.866457	-122.312240
1903130850	Electric	Electrical Box	10.5	Marina	37.866477	-122.312295
1903130856	Unknown Utility	Utility Boxes	10.9	Marina	37.867317	-122.312750
1903130901	Storm Sewer	Outfall	8.0	Marina	37.867710	-122.313043
1903130902	Storm Sewer	Drain Inlet	12.2	Marina	37.867748	-122.312936
1903130919	Storm Sewer	Grate on Drain Inlet	11.7	Marina	37.864664	-122.312296
1903130919	Storm Sewer	Grate on Drain Inlet	11.7	Marina	37.864664	-122.312296
1903130923	Storm Sewer	Grate on Drain Inlet	11.5	Marina	37.864870	-122.311992
1903130924	Electric	Electrical Cabinet	12.1	Marina	37.865002	-122.311853
1903130926	Pier/Dock/Ramp	Slab Pier Corner	9.4	Marina	37.865200	-122.311905
1903130928	Pier/Dock/Ramp	Slab Pier Corner	7.7	Marina	37.865009	-122.312488
1903130929	Pier/Dock/Ramp	Slab Pier Corner	10.6	Marina	37.864796	-122.312395
1903130930	Water	Fire Hydrant	11.6	Marina	37.864699	-122.312354
1903130931	Electric	Electric Cabinet and Telephone Box	11.3	Marina	37.864675	-122.312450
1903130934	Electric	Electric Charging Station	11.0	Marina	37.864601	-122.312918
1903130936	Electric	Electrical Cabinet	9.1	Marina	37.864650	-122.313029
1903130937	Pier/Dock/Ramp	Pier	6.2	Marina	37.864678	-122.313078
1903130938	Storm Sewer	Grate on Drain Inlet	10.7	Marina	37.864469	-122.313324
1903130940	Water	Fire Hydrant	10.6	Marina	37.864521	-122.313263
1903130945	Storm Sewer	Grate on Drain Inlet	14.2	Marina	37.864003	-122.313312
1903130946	Storm Sewer	Grate on Drain Inlet	13.6	Marina	37.864063	-122.313524
1903130948	Art	Art - Calliope Sculpture	12.0	Marina	37.864175	-122.313810
1903130951	Pier/Dock/Ramp	Pier	10.1	Marina	37.864605	-122.313799
1903130954	Sanitary Sewer	Two SSMH and Utility Vault	10.8	Marina	37.864450	-122.313806
1903130957	Building	Utility Boxes and Fire Hydrant	10.7	Marina	37.864363	-122.314028
1903131001	Electric	Electrical Box	15.5	Marina	37.863843	-122.313851
1903131003	Storm Sewer	Grate on Drain Inlet	11.6	Marina	37.864136	-122.314309
1903131005	Storm Sewer	Grate on Drain Inlet	11.4	Marina	37.864216	-122.314158
1903131007	Storm Sewer	Grate on Drain Inlet	11.3	Marina	37.864177	-122.314349
1903131008	Telephone	Telephone Box	10.8	Marina	37.864278	-122.314337
1903131009	Storm Sewer	Grate on Drain Inlet	11.2	Marina	37.864306	-122.314441
1903131011	Storm Sewer	Outfall	6.8	Marina	37.864378	-122.314467
1903131012	Electric	Electrical Cabinet	10.9	Marina	37.864239	-122.314734
1903131015	Unknown Manhole / Vault	Manhole and Utility Boxes	10.7	Marina	37.864232	-122.314801
1903131017	Electric	Electrical Cabinet	9.3	Marina	37.864261	-122.314849
1903131018	Pier/Dock/Ramp	Pier	9.6	Marina	37.864300	-122.314884
1903131020	Sanitary Sewer	SSMH	12.8	Marina	37.864013	-122.314749
1903131021	Storm Sewer	Grate on Drain Inlet	12.8	Marina	37.864025	-122.314913
1903131026	Unknown Manhole / Vault	Manhole	11.2	Marina	37.864142	-122.315269
1903131027	Pier/Dock/Ramp	Pier	10.7	Marina	37.864144	-122.315666
1903131029	Storm Sewer	Grate on Drain Inlet	11.5	Marina	37.864052	-122.315693
1903131031	Storm Sewer	Outfall	6.1	Marina	37.864115	-122.315714
1903131032	Unknown Utility	Utility Vaut	11.6	Marina	37.864029	-122.315739
1903131033	Storm Sewer	Grate on Drain Inlet	14.2	Marina	37.863882	-122.315647
1903131039	Electric	Diesel Generator	17.2	Marina	37.863821	-122.316569
1903131041	Electric	Electrical Cabinet, Fire Hydrant, SSMH, Control Panels	12.3	Marina	37.863956	-122.316505
1903131043	Sanitary Sewer	SSMH, Telephone Boxes	16.1	Marina	37.863905	-122.316633
1903131046	Electric	Electric Box (Ventilated)	12.2	Marina	37.864940	-122.317068
1903131047	Electric	Electrical Pedestal	12.1	Marina	37.864997	-122.317094
1903131048	Sanitary Sewer	SSMH, TelephoneBox	11.9	Marina	37.865034	-122.317088
1903131050	Pier/Dock/Ramp	Pier	10.5	Marina	37.865028	-122.316913
1903131051	Storm Sewer	Grate on Drain Inlet	11.9	Marina	37.865074	-122.317122
1903131056	Electric/Unknown Utility	Electrical Box (Ventilated) and Utility Boxes	11.8	Marina	37.865859	-122.317408
1903131059	Electric	Electrical Cabinet	11.9	Marina	37.865750	-122.317336
1903131101	Electric	Electrical Cabinet	11.2	Marina	37.865879	-122.317362
1903131102	Pier/Dock/Ramp	Pier	11.1	Marina	37.865912	-122.317291

Location ID	Category	Field Description	Existing Asset Elevation (FT) [NAVD88]	General Geographical Location	Latitude	Longitude
1903131103	Water	Fire Hydrant	11.7	Marina	37.865920	-122.317425
1903131108	Unknown Manhole / Vault	Vault and Harbor Light	15.4	Marina	37.866078	-122.317938
1903131122	Storm Sewer	Grate on Drain Inlet	16.1	West Side	37.864309	-122.317447
1903131124	Storm Sewer	Grate on Drain Inlet	14.7	West Side	37.863794	-122.317312
1903131125	Electric	Electrical Box	15.2	West Side	37.863582	-122.317178
1903131126	Electric	Electrical Cabinet, Pedestal, and Control Panel	15.7	West Side	37.863575	-122.317258
1903131128	Unknown Manhole / Vault	Manhole	15.8	West Side	37.863313	-122.317094
1903131134	Sanitary Sewer	Three SSMH	15.6	West Side	37.863432	-122.317507
1903131136	Storm Sewer	Grate on Drain Inlet	14.5	West Side	37.863607	-122.317541
1903131137	Electric	Electrical Vault	13.8	West Side	37.863648	-122.317535
1903131138	Storm Sewer	Grate on Drain Inlet	14.5	West Side	37.863801	-122.317567
1903131140	Sanitary Sewer	SSMH	15.2	West Side	37.863359	-122.317362
1903131141	Unknown Utility	Utility Vaut	15.2	West Side	37.863237	-122.317288
1903131142	Sanitary Sewer	SSMH	14.8	West Side	37.863034	-122.317281
1903131144	Art	Art - Archer Statue	15.7	West Side	37.862992	-122.317168
1903131148	Sanitary Sewer	SSMH	17.9	South Shore Protected	37.863579	-122.314996
1903131203	Storm Sewer	Grate on Drain Inlet	16.7	Park	37.870259	-122.316151

Table B.2 - Building Asset Inventory and Finished Floor Elevation

Building ID	Building Type	Finished Floor Elevation	
		[MLLW]	[NAVD88]
B-1	Commercial Bldg	14.37	14.03
B-2	Out Bldg	13.95	13.61
B-3	Out Bldg	12.77	12.43
B-4	Out Bldg	14.04	13.70
B-5	Out Bldg	12.96	13.30
B-6	Out Bldg	14.18	13.84
B-7	Out Bldg	11.04	10.70
B-8	Commercial Bldg	13.75	13.41
B-8	Commercial Bldg	16.14	15.80
B-9	Out Bldg	12.40	12.06
B-10	Out Bldg	12.27	11.93
B-11	Out Bldg	11.64	11.30
B-12	Out Bldg	11.64	11.30
B-13	Office bldg	15.96	15.62
B-14	Out Bldg	16.54	16.20
B-15	Restroom	17.63	17.29
B-16	Out Bldg	18.48	18.14
B-17	Out Bldg	17.09	16.75
B-18	Commercial Bldg	16.04	15.70
B-19	Restroom	11.85	11.51
B-20	Out Bldg	12.62	12.28
B-21	Commercial Bldg	15.85	15.51
B-22	Restroom	13.04	12.70
B-23	Commercial Bldg	14.28	13.94
B-24	Commercial Bldg	12.79	12.45
B-25	Out Bldg	16.22	15.88
B-26	Out Bldg	17.04	16.70
B-27	Restroom	12.87	12.53
B-28	Out Bldg	16.63	16.29
B-29	Hotel Building	12.38	12.04
B-29	Hotel Building	11.47	11.13
B-29	Hotel Building	12.17	11.83
B-30	Hotel Building	10.71	10.37
B-31	Hotel Building	10.49	10.15
B-31	Hotel Building	11.89	11.55
B-32	Hotel Building	12.57	12.23
B-33	Hotel Building	12.95	12.61
B-33	Hotel Building	12.92	12.58
B-34	Restroom	12.64	12.30

Notes: For building location see Figure B.1

Table B.3 - Building Asset Inventory and Finished Floor Elevation

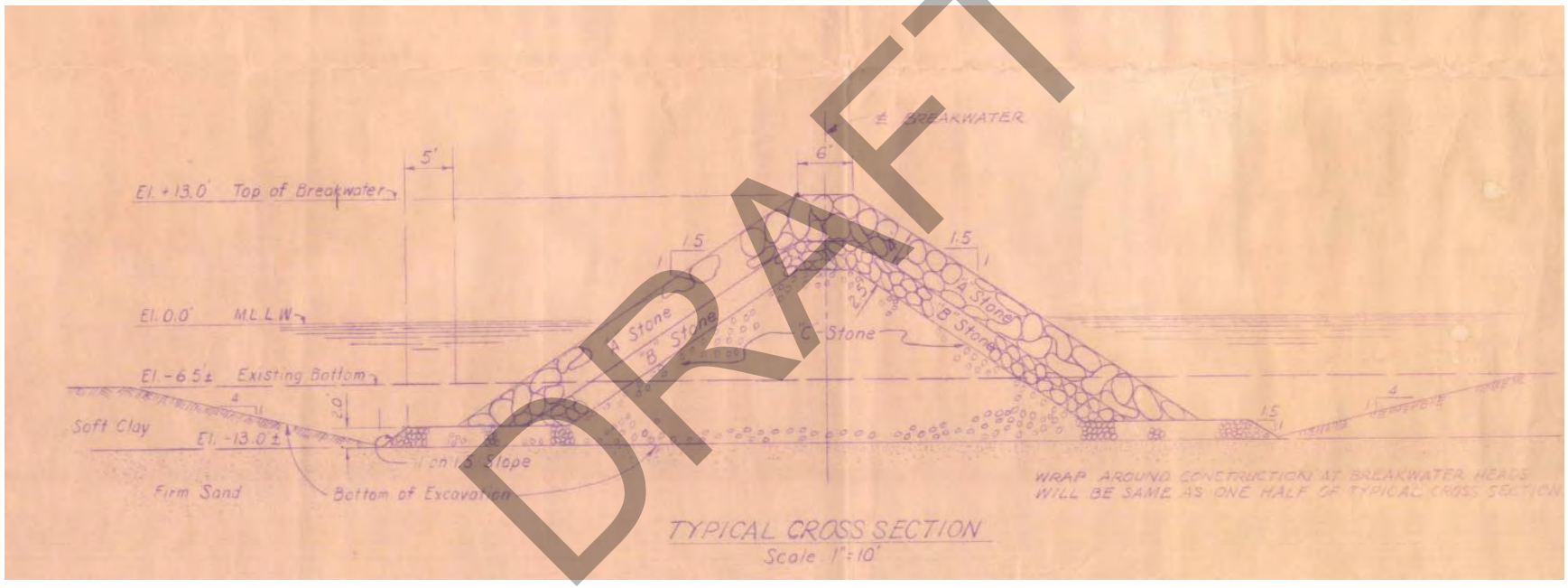
Building ID	Building Type	Dock Elevation	
		[MLLW]	[NAVD88]
D-1	40 Slips	12.50	12.16
D-2	25 Slips	11.30	10.96
D-3	102 Slips	11.60	11.26
D-4	87 Slips	10.50	10.16
D-5	5 Slips (For large Boats/Ships)	10.50	10.16
D-6	118 Slips	11.00	10.66
D-7	61 Slips	11.70	11.36
D-8	157 Slips	11.40	11.06
D-9	49 Slips	11.30	10.96
D-10	93 Slips	11.30	10.96
D-11	105 Slips	11.30	10.96
D-12	26 Slips	11.50	11.16
D-13	177 Slips	11.32	11.66
D-14	6 Slips	12.70	12.36

Notes: For dock location see Figure B.2

Appendix C

Record Drawings of the Revetment

PORTIONS OF DRAWING INFORMATION FROM CITY



ROCK BREAKWATER AT MARINA ENTRANCE

5

1. [illegible] the datum of mean [illegible]

2. [illegible] in accordance with [illegible] Soil Classification [illegible] System.

3. Cards [illegible] laboratory tests and are shown [illegible] soil symbols on logs [illegible], CL, etc. Spaces marked ND indicates no recovery for that interval, and WO defines the word of washing before taking sample.

4. Written descriptions to the right of the logs are field descriptions except those paragraphs and phrases flanked by an asterisk (*) which indicates laboratory descriptions.

5. Spaces marked with numbers (e.g. 28, 40/6", etc.), indicates the number of blows required to advance indicated interval using a 140-pound hammer and 30-inch drop.

6. All samples were taken with 2 3/8-inch pushtubes, two and four feet in length.

7. Foundation borings are labled 2F-1 through 2F-3, and dredging borings are identified 2D-4 through 2D-10.

SYMBOL	DESCRIPTION	DATE	APPROVAL
2	As constructed, no changes made	17 Jun 65	
1	DELETED FOG SIGNAL & LIGHT STRUCTURE	11 AUG 65	

REVISIONS

U. S. ARMY ENGINEER DISTRICT, SAN FRANCISCO
CORPS OF ENGINEERS
SAN FRANCISCO, CALIFORNIA

DRAWN BY:

TRACED BY:

CHECKED BY:

SUBMITTED:

CHIEF, FOUNDATIONS SECTION

APPROVAL RECOMMENDED:

CHIEF OF BRANCH

APPROVED

CHIEF ENGINEERING DIVISION

DATE:

ALAMEDA COUNTY CALIFORNIA

BERKELEY HARBOR
BREAKWATER
LOGS OF BORINGS & TYPICAL SECTION

PREPARED UNDER THE DIRECTION OF

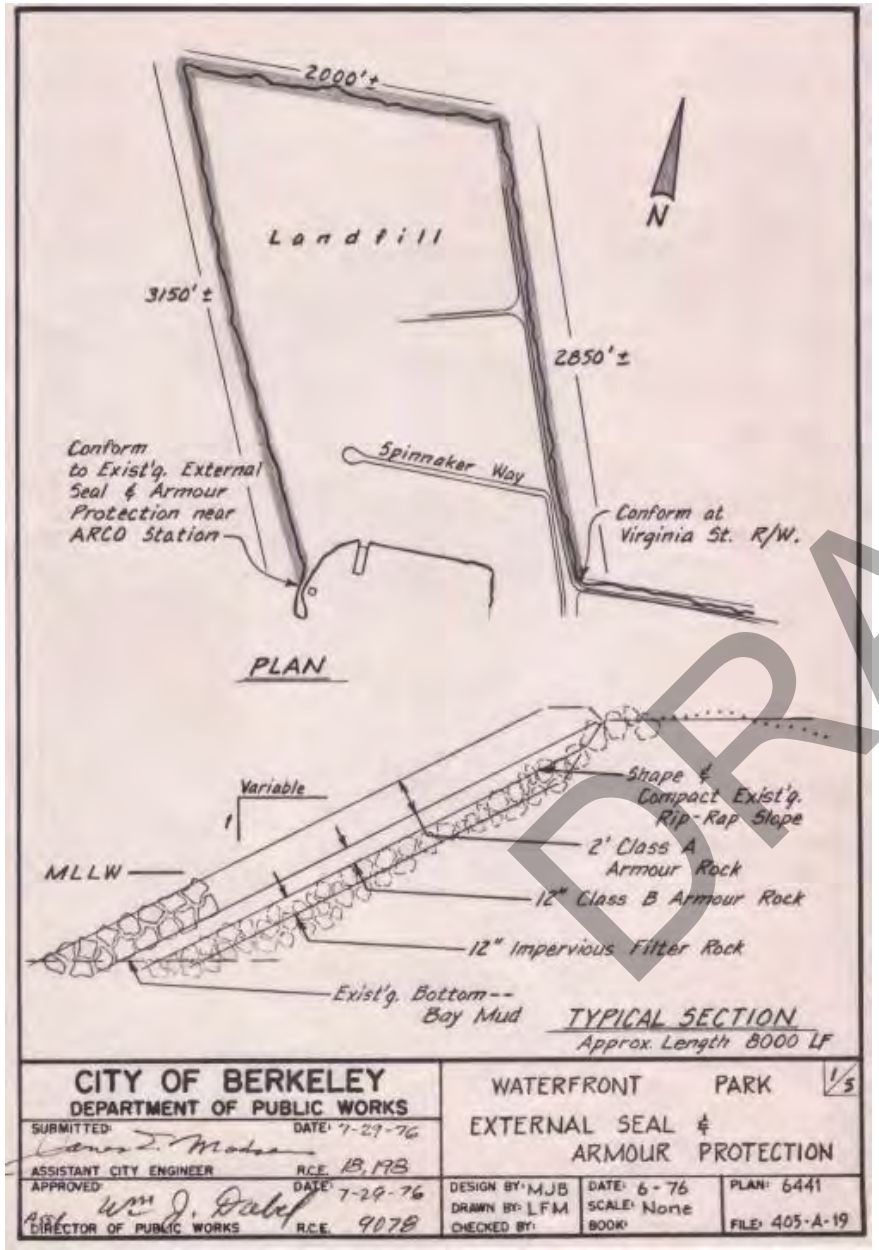
LT COLONEL, C.E., DISTRICT ENGINEER

SCALE

JOB No.

DRAWING NUMBER

SHEET



CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS

WATERFRONT PARK 1/5

EXTERNAL SEAL & ARMOUR PROTECTION

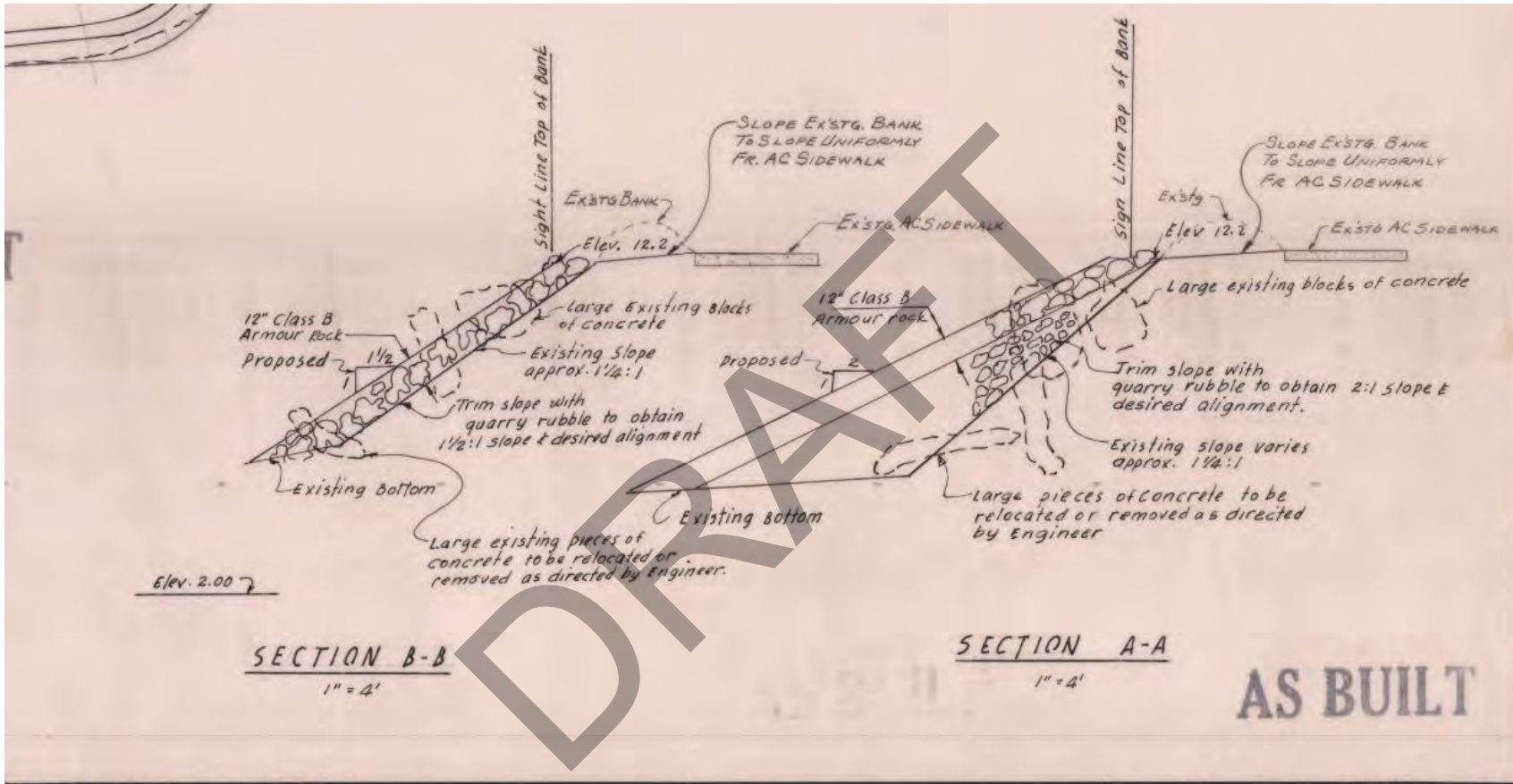
SUBMITTED: James D. Madsen DATE: 7-29-76
ASSISTANT CITY ENGINEER R.C.E. 18,178

APPROVED: Wm J. Dabel DATE: 7-29-76
DIRECTOR OF PUBLIC WORKS R.C.E. 9078

DESIGN BY: MJB
DRAWN BY: LFM
CHECKED BY:

DATE: 6-76
SCALE: None
BOOK:

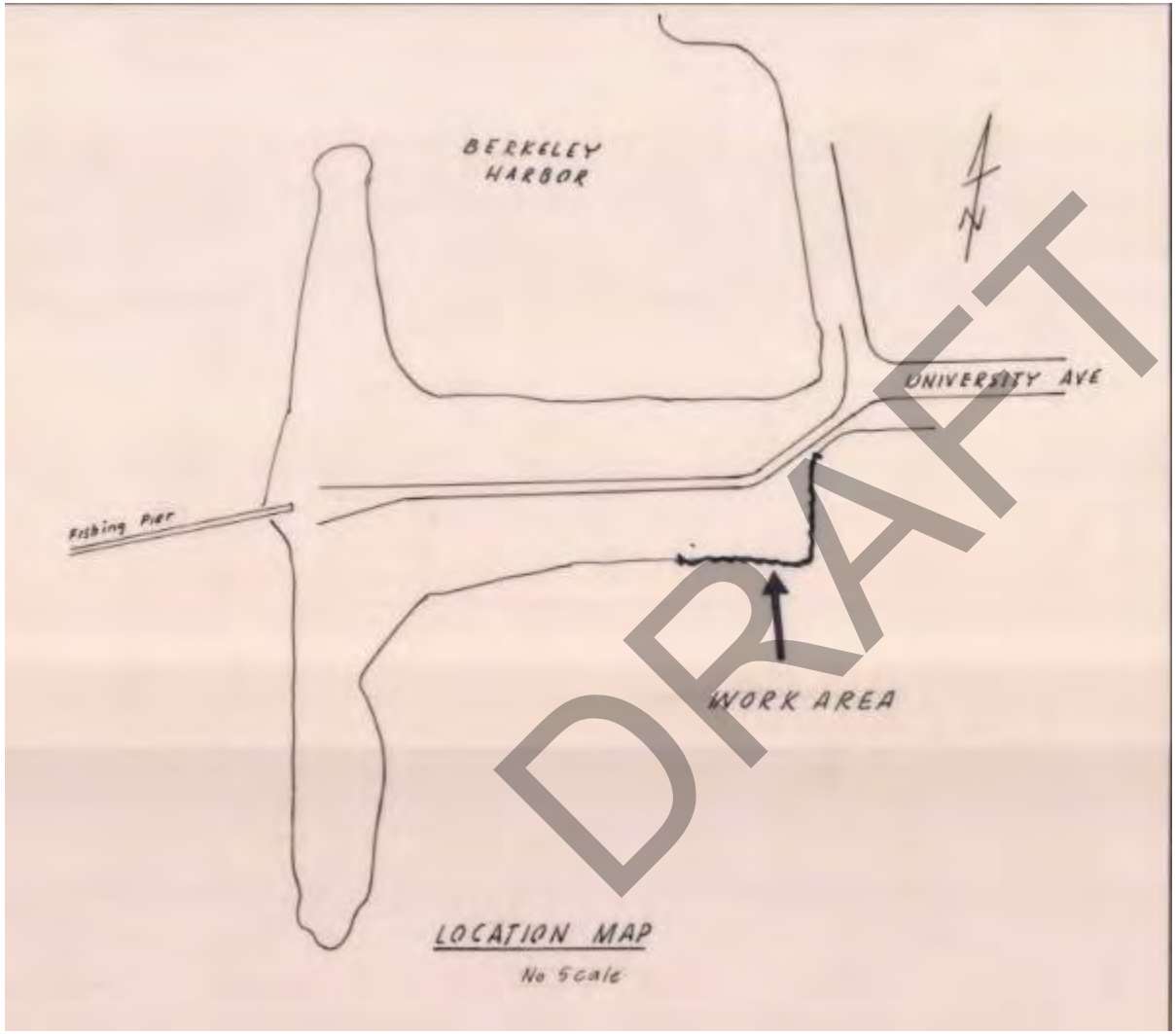
PLAN: 6441
FILE: 405-A-19



AS BUILT

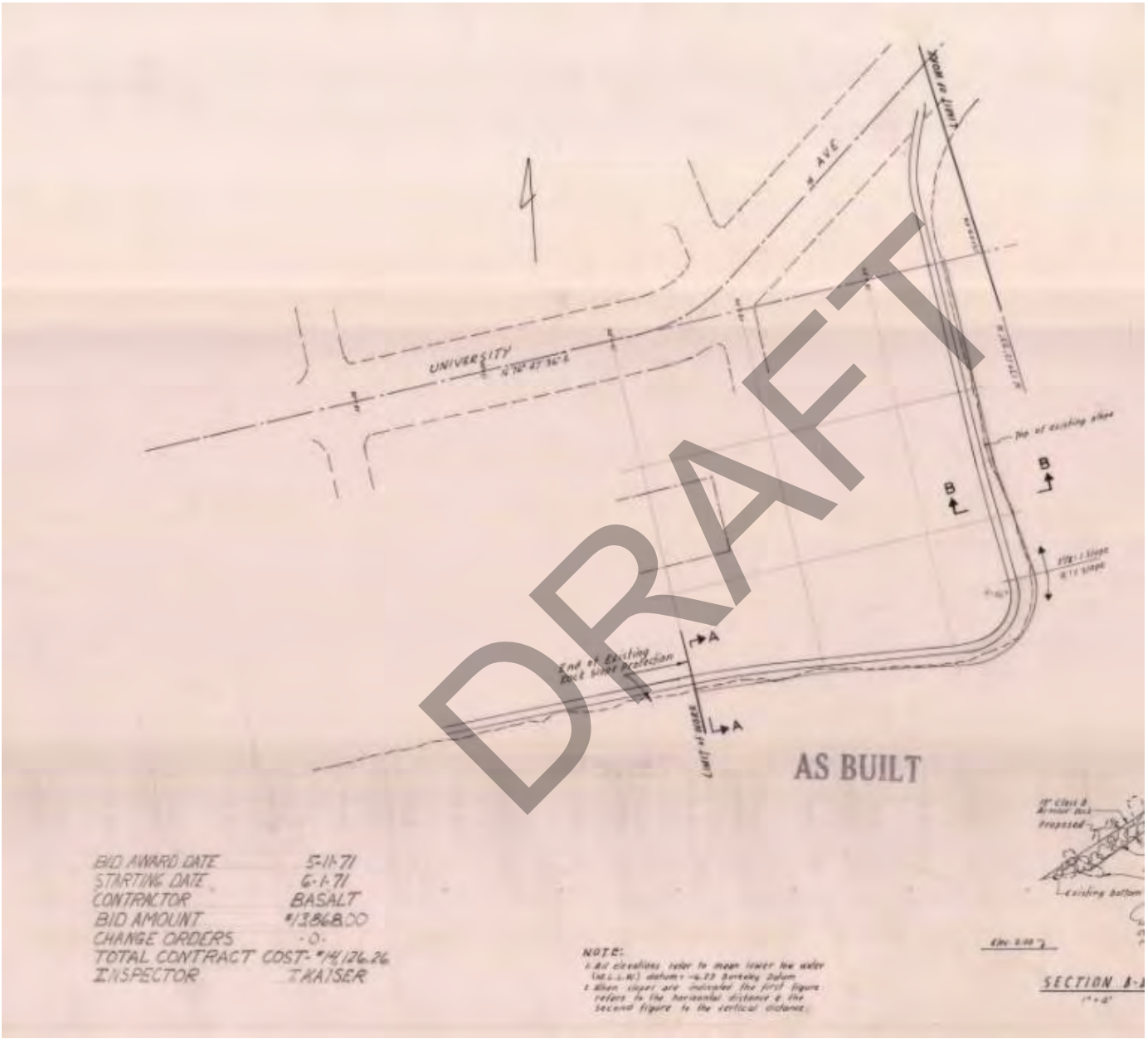
REVISION | MARK | DATE | DESCRIPTION

RECOMMEND APPROVAL: ASSOCIATE CIVIL ENGINEER	DATE 13 Dec. 71 16071 R.C.E.	CITY OF BERKELEY DEPARTMENT OF PUBLIC WORKS	SOUTH MARINA SHORE PROTECTION	DESIGN TK	HORIZ. 1" = 40'	PLAN 5830	
APPROVED: DIRECTOR OF PUBLIC WORKS	DATE 8595 R.C.E.			DRAWN PLT	VERT.	FILE 403-76	
				CHECK	BOOK	SHEET 1 OF 1	
				AS BUILT	DATE DEC. 1970		



LOCATION MAP

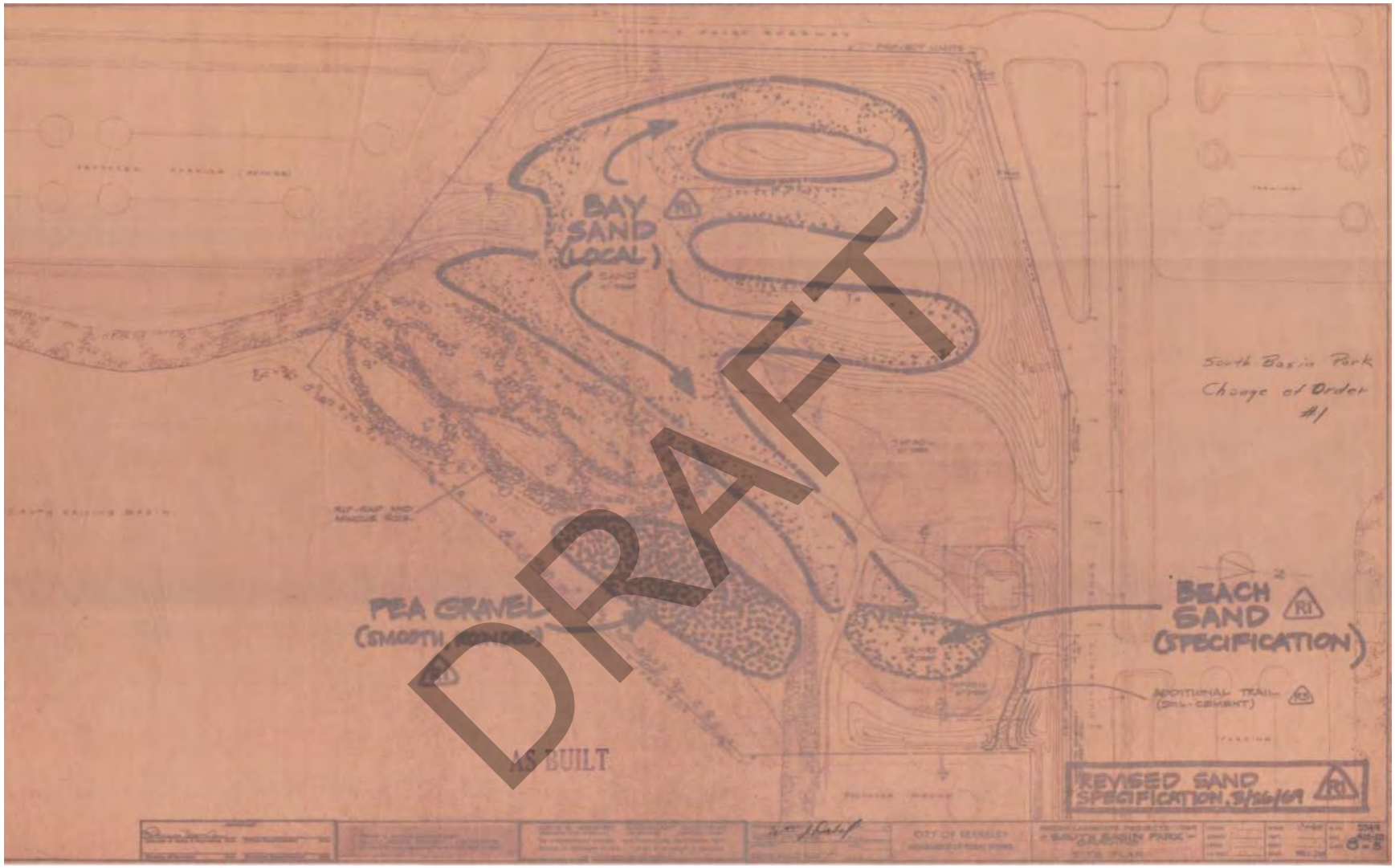
No Scale

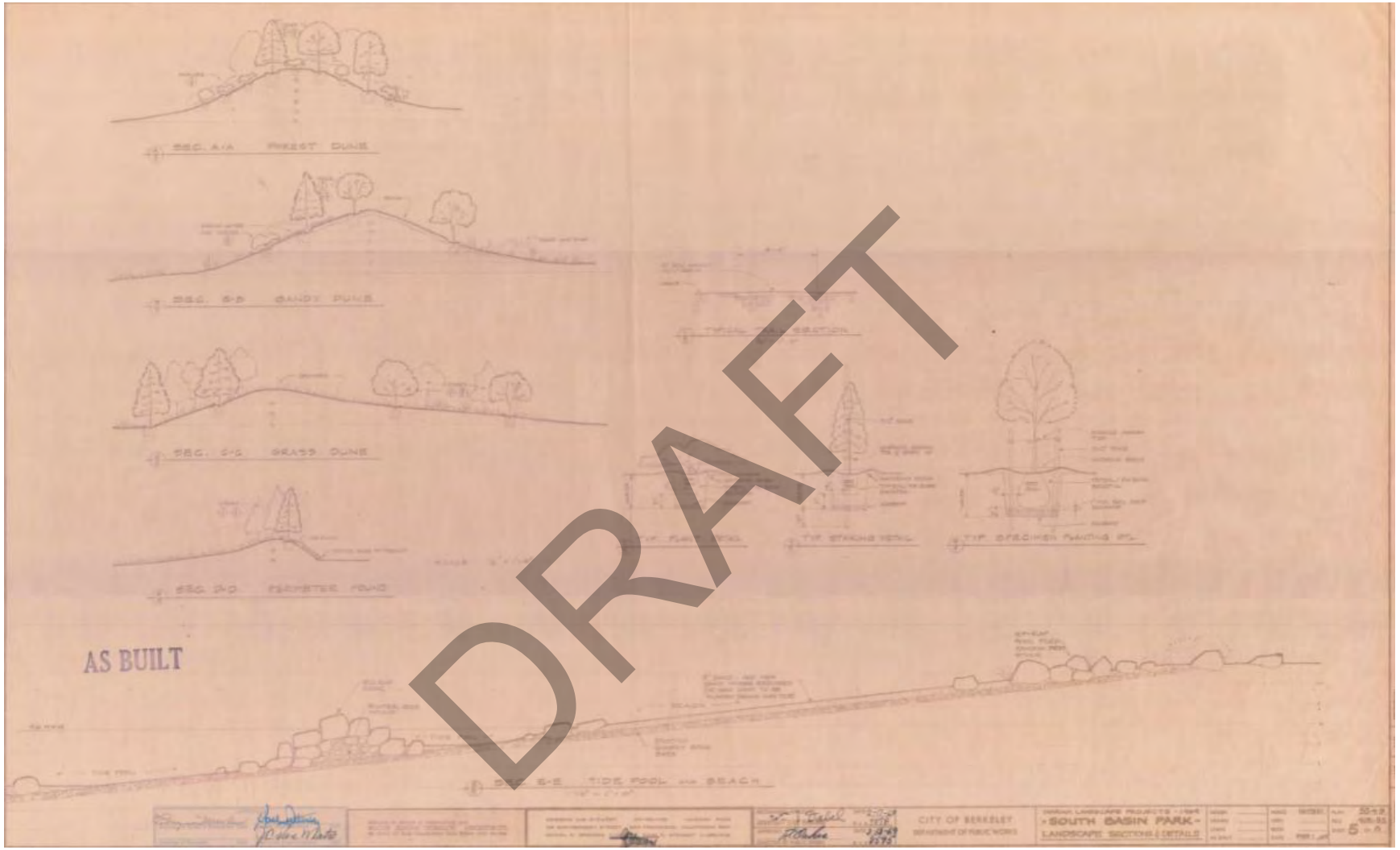


BID AWARD DATE	5-11-71
STARTING DATE	6-1-71
CONTRACTOR	BASALT
BID AMOUNT	$13868.00
CHANGE ORDERS	-0-
TOTAL CONTRACT COST	$14,176.26
INSPECTOR	T. KAISER

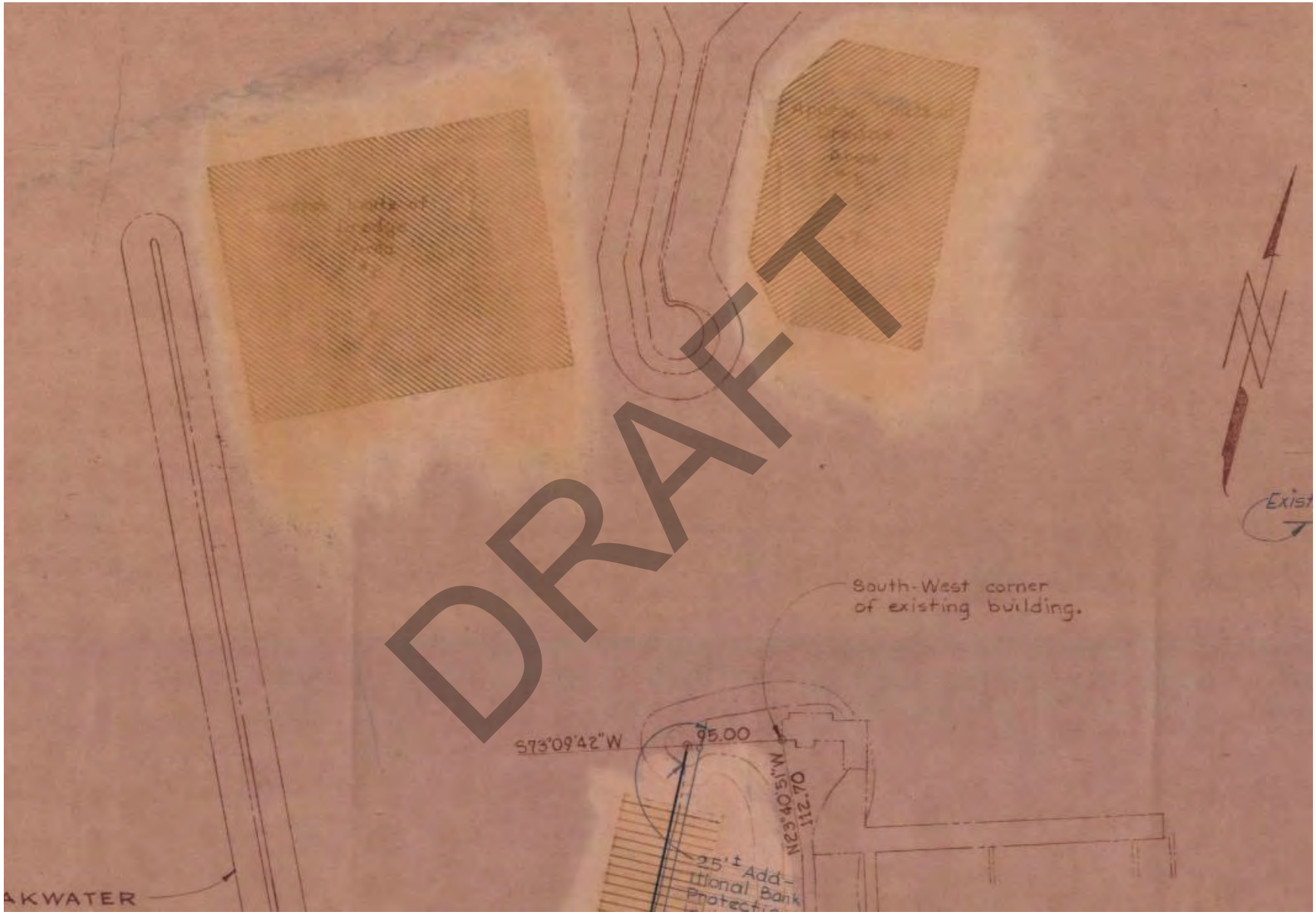
NOTE:
1. All elevations refer to mean lower low water (M.L.L.W.) datum = +4.23 Berkeley Datum
2. When slopes are indicated the first figure refers to the horizontal distance & the second figure to the vertical distance.

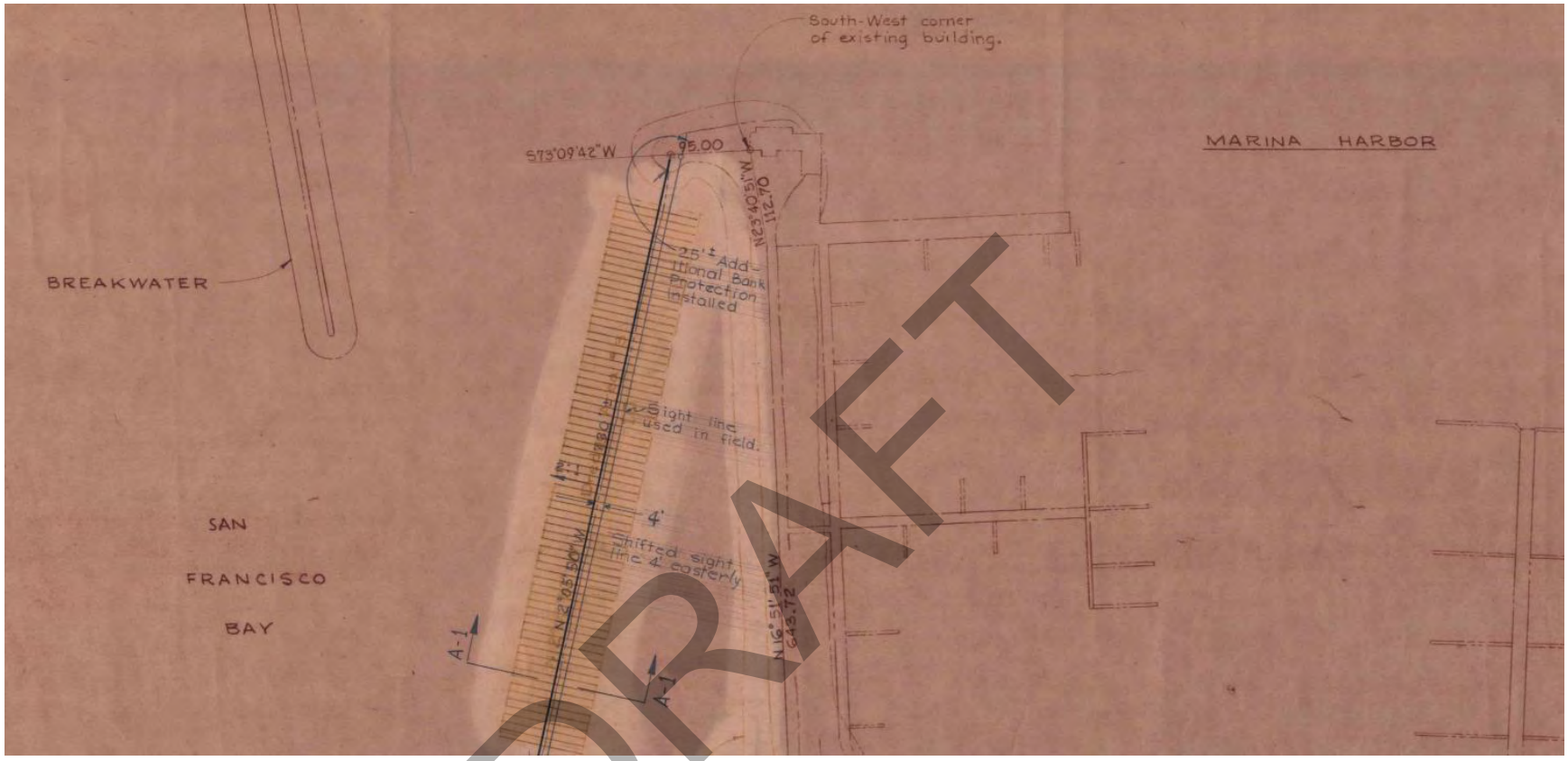
SECTION B-B
(1" = 4')


BAY SAND (LOCAL)
PEA GRAVEL
BEACH SAND (SPECIFICATION)
ADDITIONAL TRAIL (DECOMPOSED GRANITE)
South Basin Park
Change of Order #1
AS BUILT
REVISED SAND SPECIFICATION 3/26/09
DRAFT

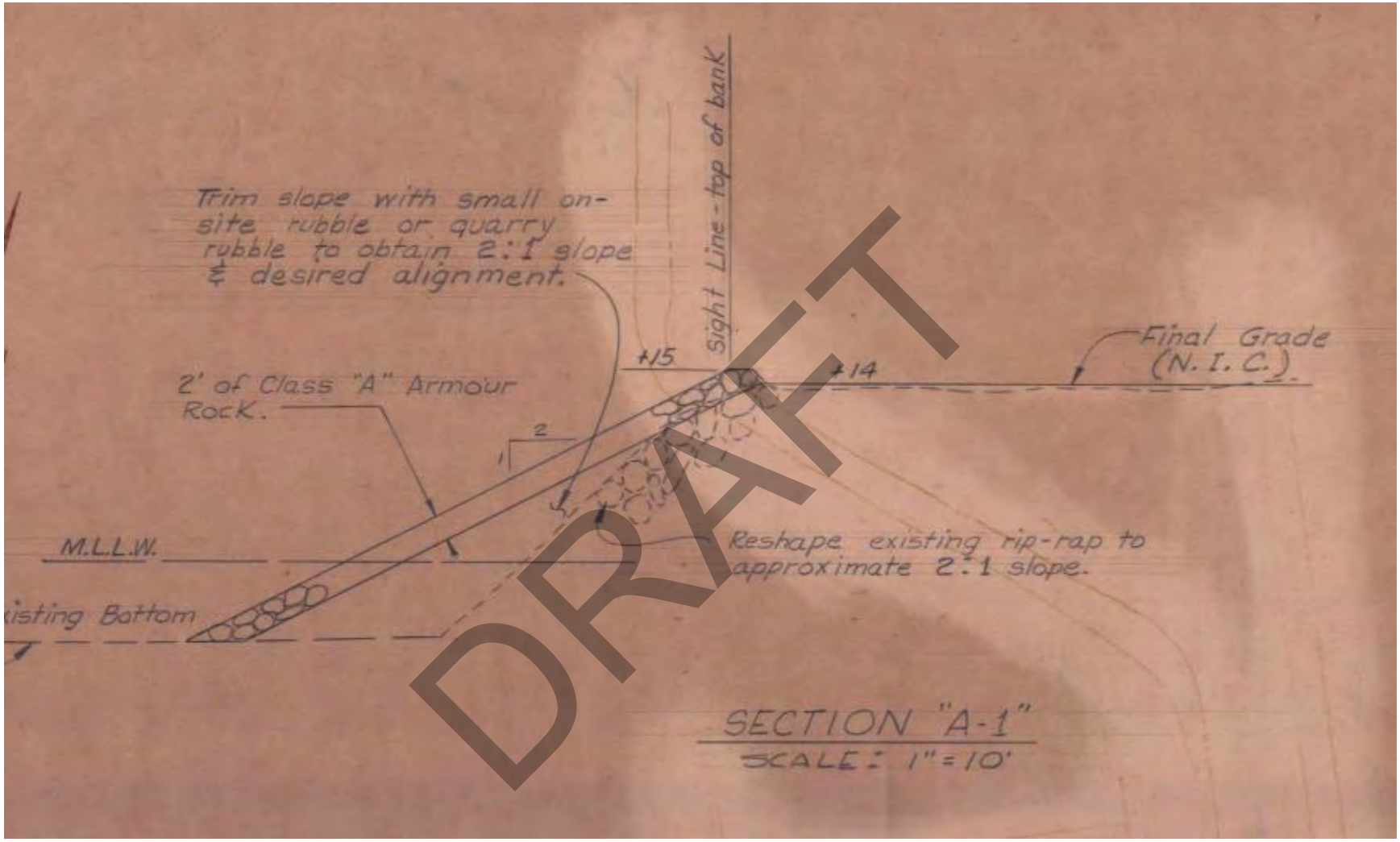

SEC. A-A FOREST DUNE
SEC. B-B SANDY DUNE
SEC. C-C GRASS DUNE
SEC. D-D PERIMETER ROAD
SEC. E-E TIDE POOL AND BEACH
AS BUILT
DRAFT
CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS
- SOUTH BASIN PARK -
LANDSCAPE SECTIONS & DETAILS


SOUTH BASIN PARK
DRAWING INDEX
DRAFT
AS BUILT
CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS
MARINA LANDSCAPE PROJECT-1969
- SOUTH BASIN PARK -
LOCATION PLAN & INDEX

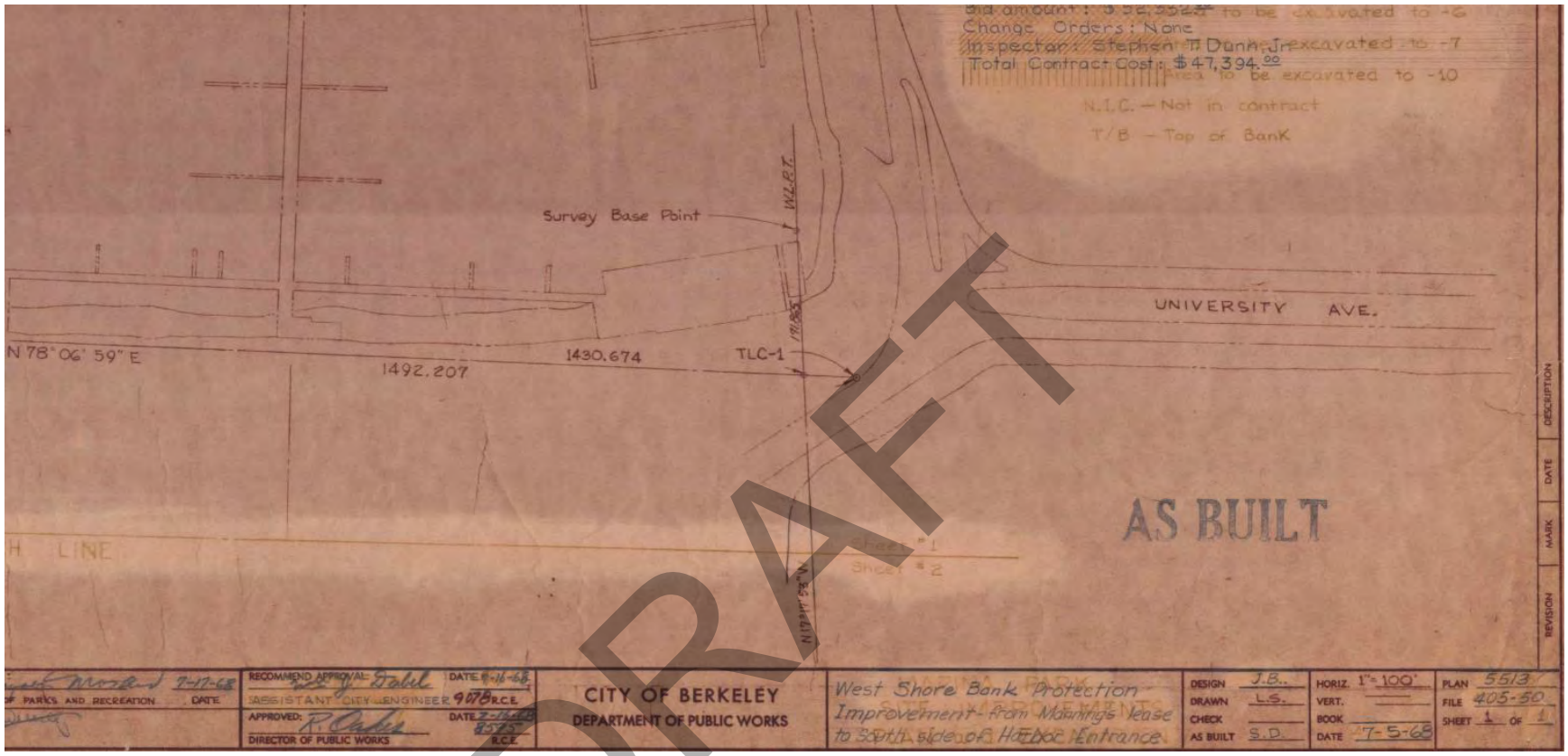

South-West corner
of existing building.
S73°09'42"W
95.00
N23°40'51"W
112.70
25'± Add-
itional Bank
AKWATER
Exist

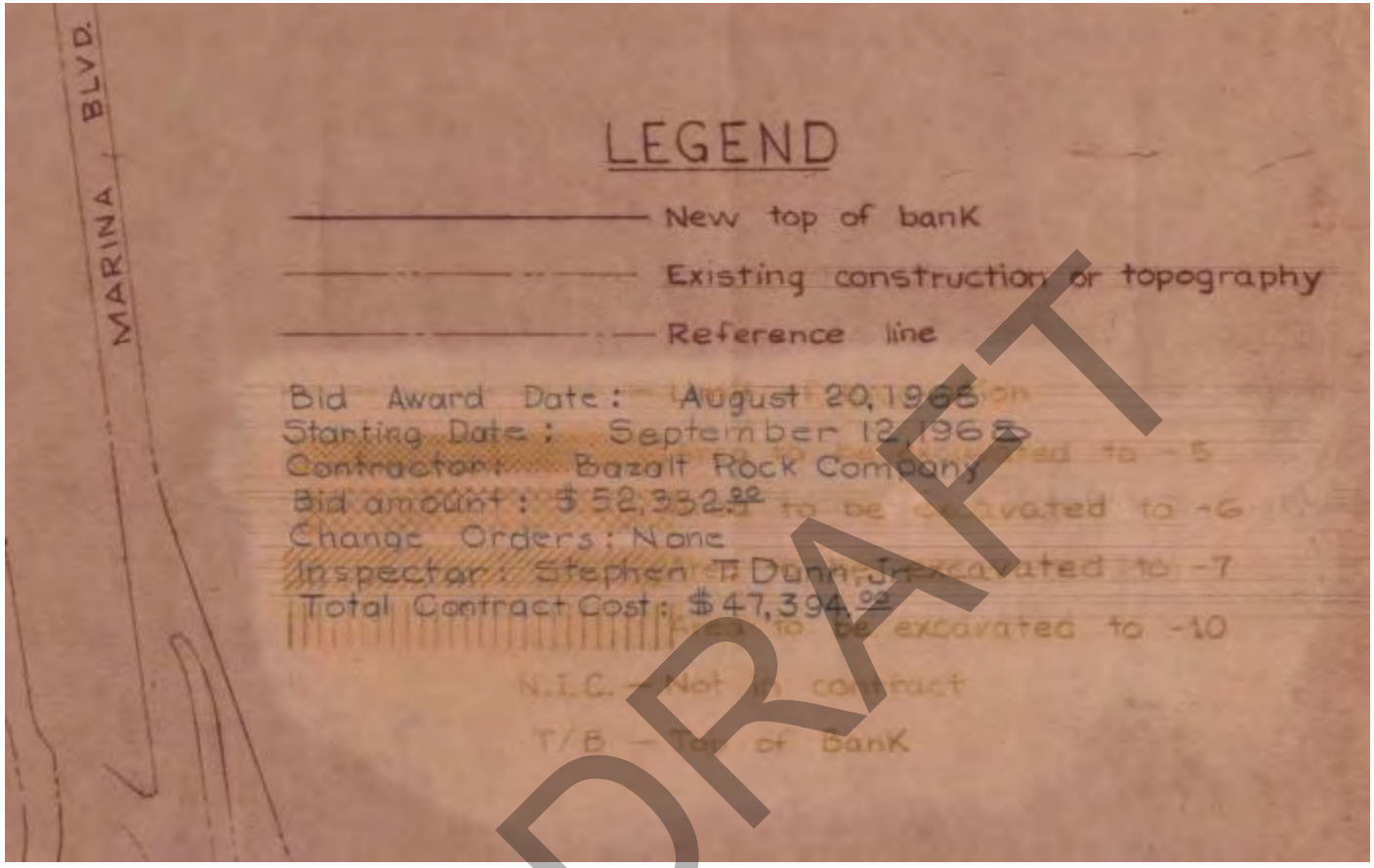

South-West corner
of existing building.
MARINA HARBOR
BREAKWATER
S73°09'42"W
95.00
N25°40'51"W
112.70
25'± Add-
itional Bank
Protection
installed
Sight line
used in field.
4'
Shifted sight
line 4' easterly
N24°05'50"W
388.21
N16°51'51"W
643.72
SAN
FRANCISCO
BAY
A-1
A-1


FRANCISCO
BAY
A-1
A-1
N 16° 51' 51" W
643.72
50'± Additional Bank Protection Installed
Existing Shoreline
Manning's Lease
N 35° 37' 00" W
120.60
N 78° 06' 59" E
USC & GS Mon. "Yacht"
EX. 11.50 (corr 1967)
S 38° 09' 11" W
453.045
A-3
A-3
15.6'
4.8'
MATCH LINE
Sheet # 1
Sheet # 2
76.20
S 67° 10' 24" W
Fishing Pier
"Pier # 1"
See Sheet 2
APPROVED:
DIRECTOR OF PARKS AND RECREATION
DATE
7-17-68
RECOMMEND APPR
ASSISTANT
APPROVED:
DIRECTOR OF PUBL



SECTION "A-1"
SCALE: 1" = 10'

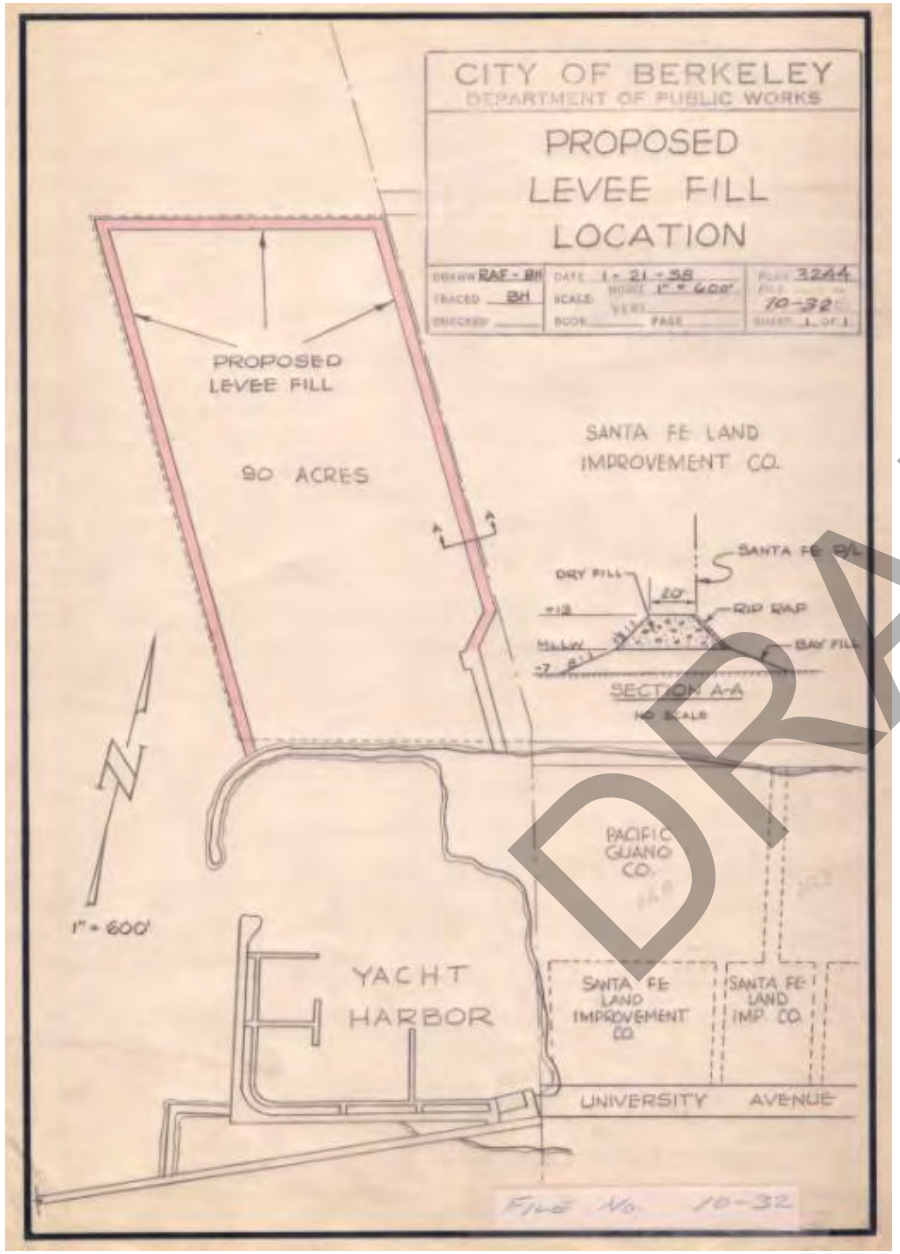

Bid amount: $ 52,952.22 to be excavated to -6
Change Orders: None
Inspector: Stephen T Dunn Jr excavated to -7
Total Contract Cost: $ 47,394.00
to be excavated to -10
N.I.C. — Not in contract
T/B — Top of Bank
Survey Base Point
W.L.B.T.
UNIVERSITY AVE.
N 78° 06' 59" E
1492.207
1430.674
TLC-1
AS BUILT
DRAFT
CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS
West Shore Bank Protection Improvement - from Manning's lease to South side of Harbor Entrance
DESIGN J.B.
DRAWN L.S.
CHECK
AS BUILT S.D.
HORIZ. 1"=100'
VERT.
BOOK
DATE 7-5-68
PLAN 5513
FILE 405-50
SHEET 1 OF 1
RECOMMEND APPROVAL: DATE 9-16-68
ASSISTANT CITY ENGINEER R.C.E.
APPROVED: DATE 9-17-68
DIRECTOR OF PUBLIC WORKS R.C.E.
DATE
DESCRIPTION
DATE
MARK
REVISION

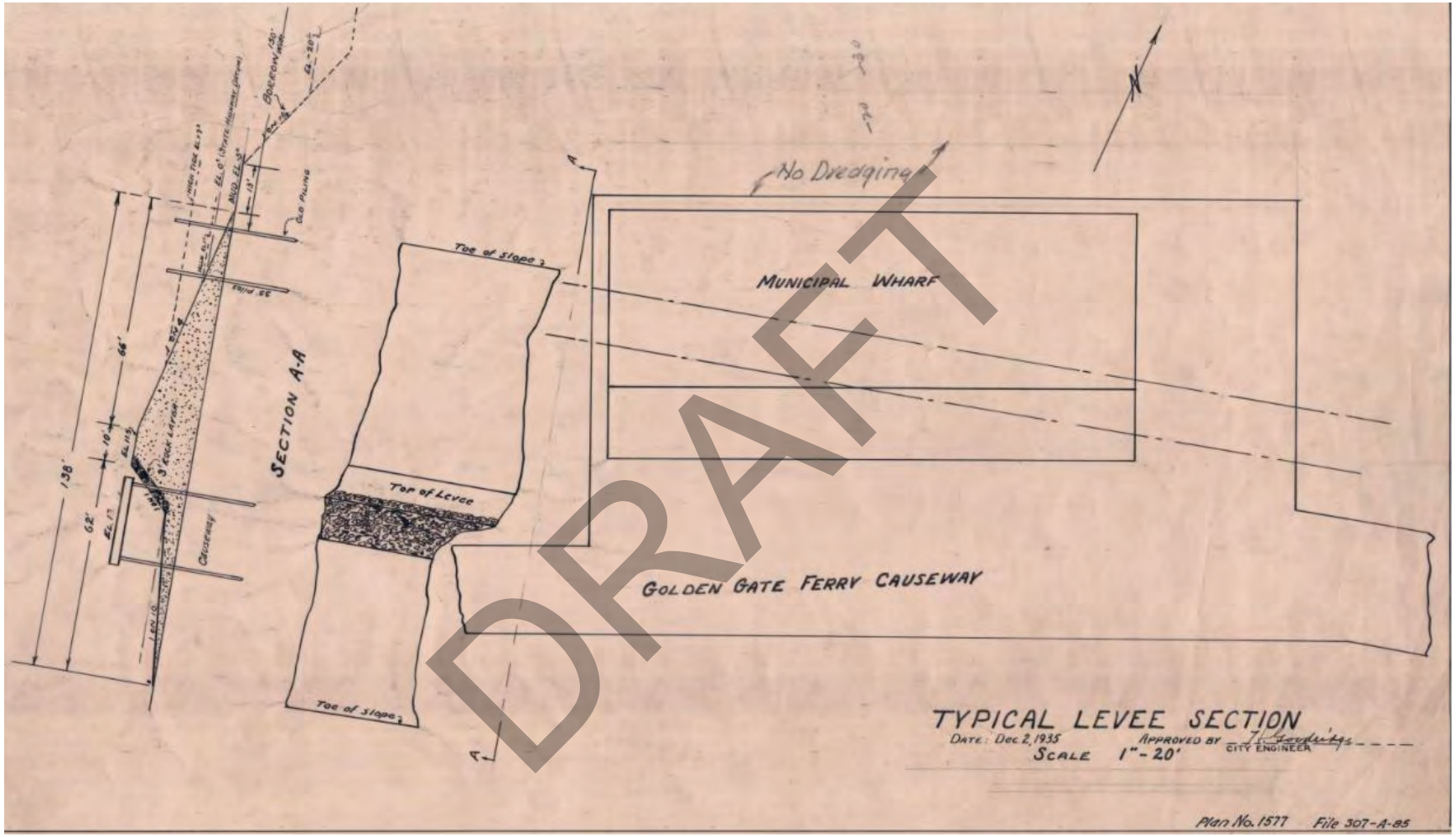

MARINA BLVD.
LEGEND
New top of bank
Existing construction or topography
Reference line
Bid Award Date: August 20, 1965
Starting Date: September 12, 1965
Contractor: Bazalt Rock Company
Bid amount: $52,332.22
Change Orders: None
Inspector: Stephen T. Dunn, Jr.
Total Contract Cost: $47,394.92
N.I.C. - Not in contract
T/B - Top of Bank

INDEX to DRAWINGS	
Sheet No.	Title
1	Plan & Excavation
2	Plan & Excavation
3	Bank Protection
4	Sheet Pile Wall Layout
5	Sheet Pile Wall Details

GENERAL NOTES

1. All horizontal and vertical survey control is based upon U.S.C.&G.S. Mon. "Yacht" and City of Berkeley T.L.C.-1.
2. All elevations refer to mean lower low water (M.L.L.W.) datum - -6.23 Berkeley datum.
3. When slopes are indicated thus ; 2:1 the first figure refers to the horizontal distance and the second figure to the vertical distance.
4. Contour lines designate approximate [illegible] of grading.


CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS
PROPOSED
LEVEE FILL
LOCATION
DRAWN RAF - BH
TRACED BH
CHECKED
DATE 1-21-58
SCALE: HORIZ 1" = 600'
VERT.
BOOK PAGE
FILE 3244
10-32
SHEET 1 OF 1
PROPOSED
LEVEE FILL
90 ACRES
SANTA FE LAND
IMPROVEMENT CO.
SANTA FE R/L
DRY FILL
20'
+12
RIP RAP
MLLW
BAY FILL
-7
SECTION A-A
NO SCALE
N
1" = 600'
PACIFIC
GUANO
CO.
YACHT
HARBOR
SANTA FE
LAND
IMPROVEMENT
CO.
SANTA FE
LAND
IMP. CO.
UNIVERSITY AVENUE
FILE No. 10-32

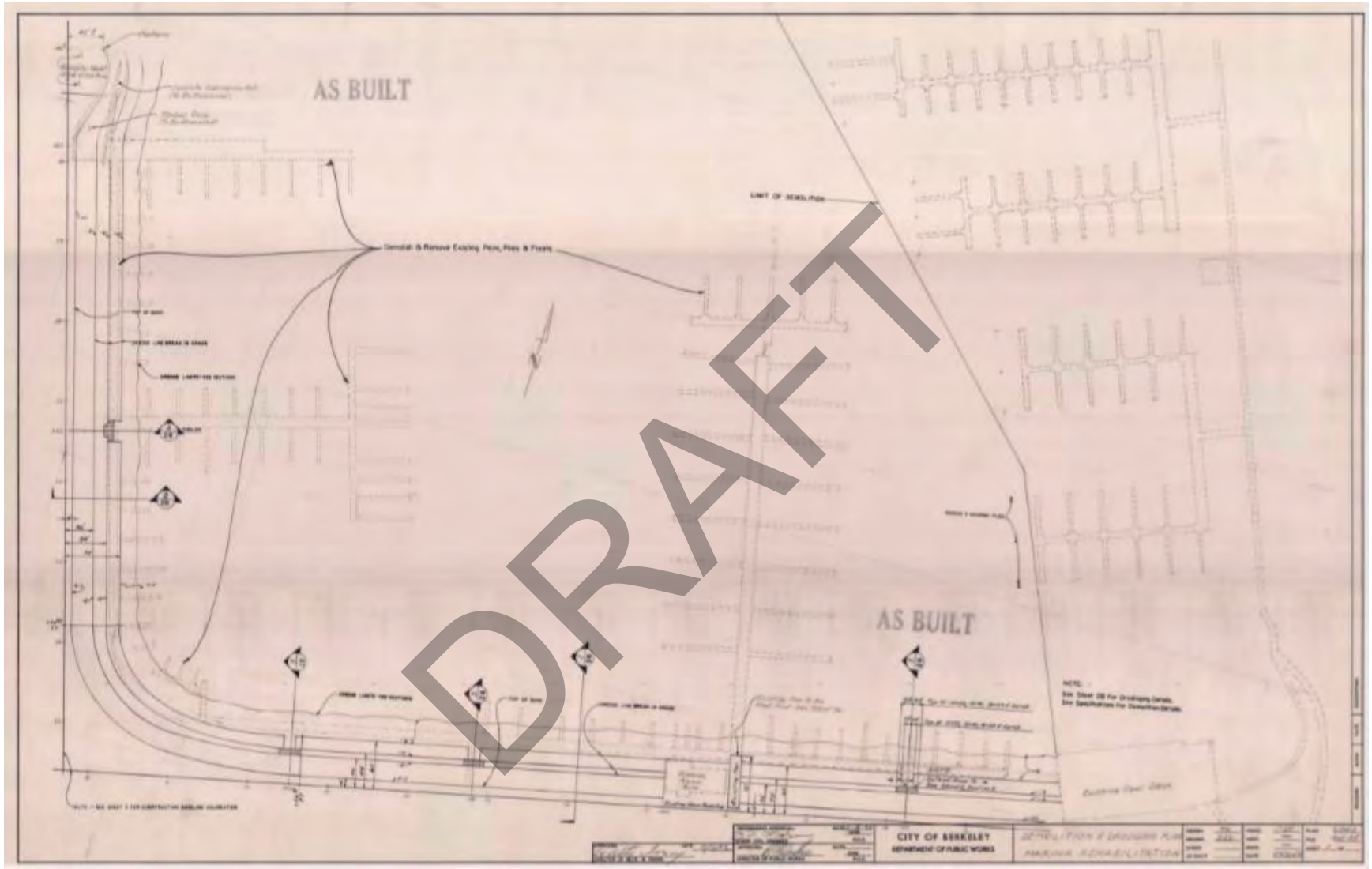


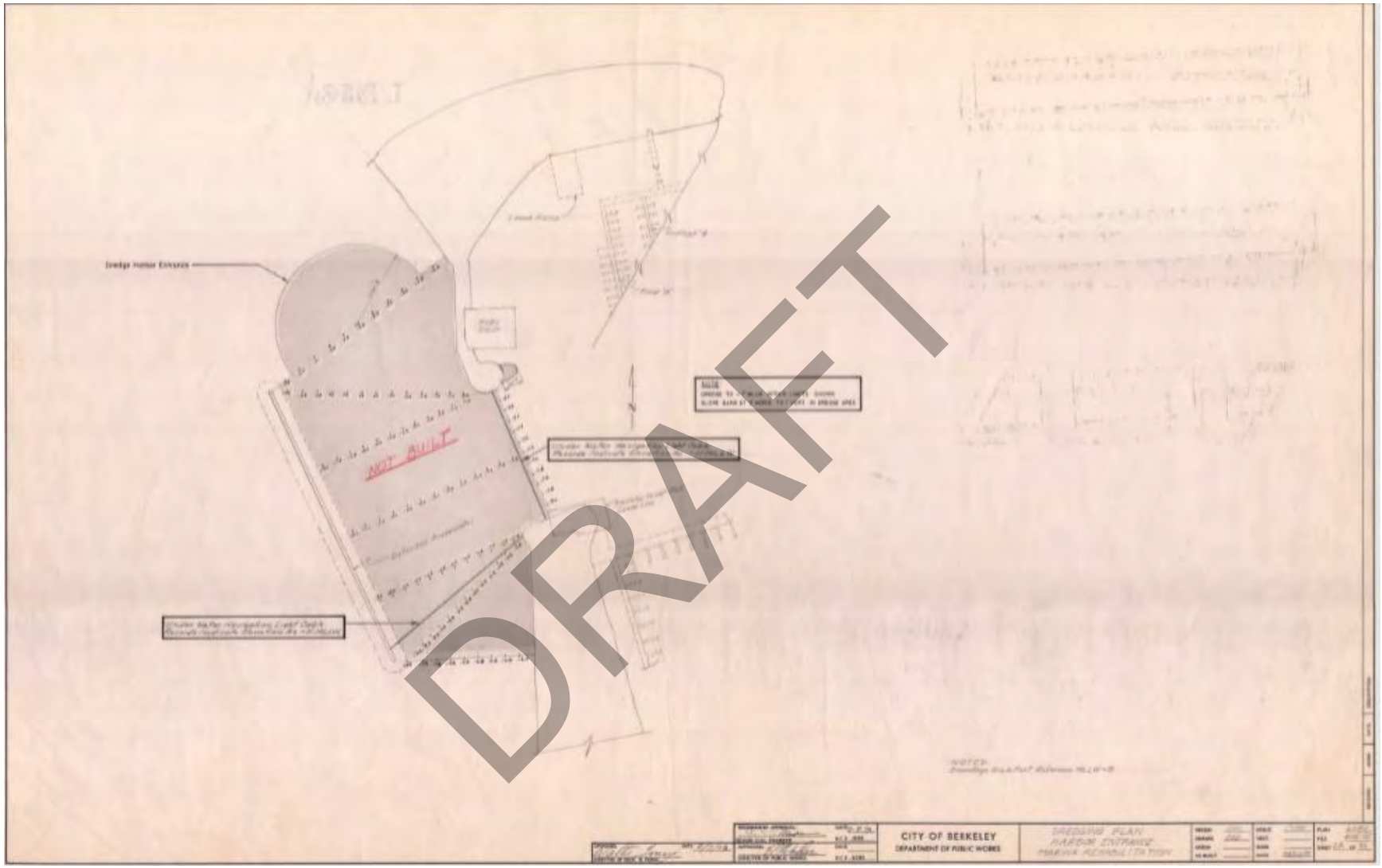
TYPICAL LEVEE SECTION

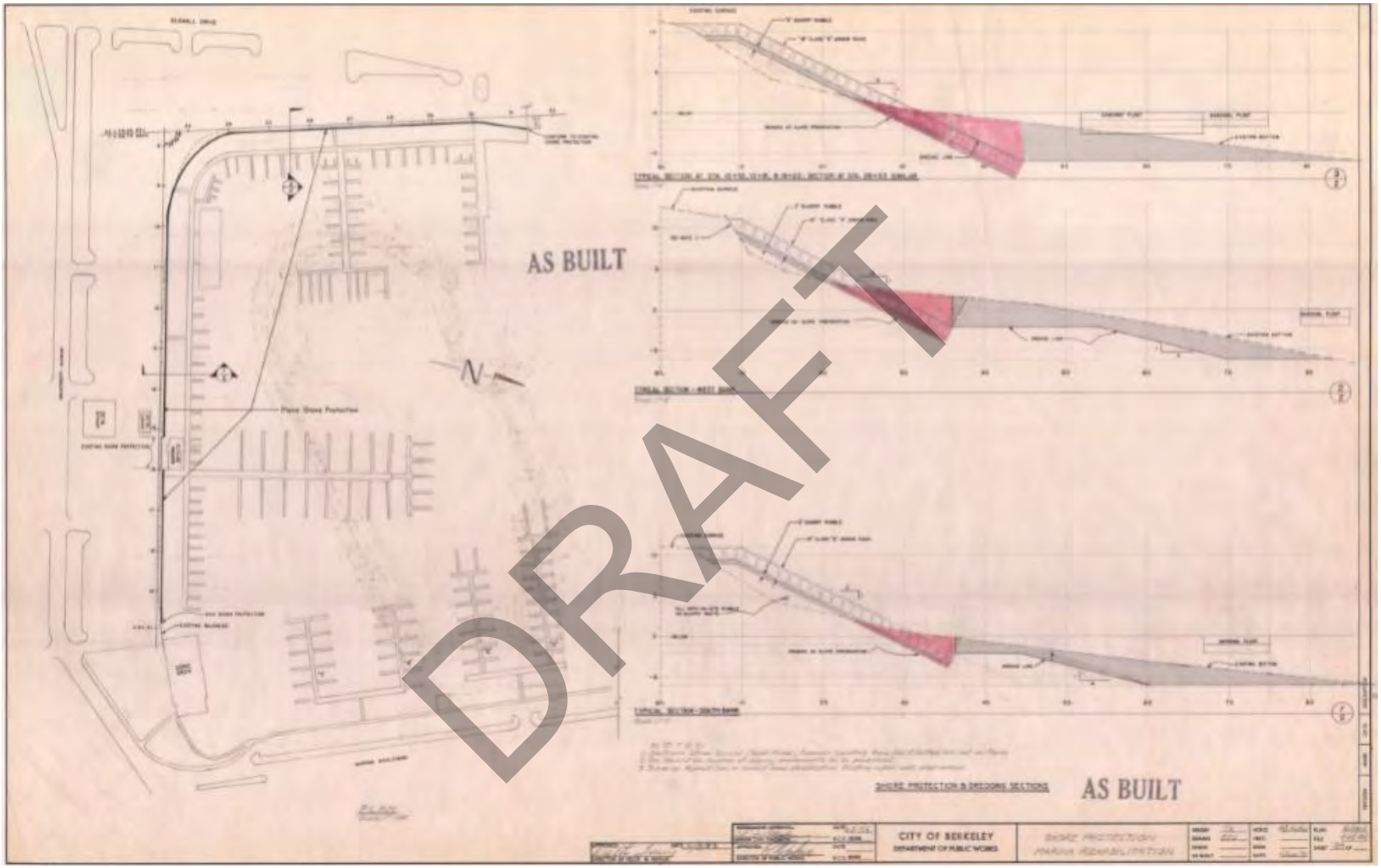
DATE: Dec 2, 1935 APPROVED BY _____ CITY ENGINEER

SCALE 1"-20'

Plan No. 1577 File 307-A-85


AS BUILT
LIMIT OF DEMOLITION
Demolish & Remove Existing Piers, Piles & Floats
AS BUILT
NOTE:
See Sheet 2B For Dredging Details.
See Specifications For Demolition Details.
CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS
DRAFT


NOT BUILT
CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS
DREDGING PLAN
HARBOR ENTRANCE
PIERCE ACQUISITION


AS BUILT
N
Piers Shore Protection
DRAFT
AS BUILT
CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS


DRAFT
NOT BUILT
CITY OF BERKELEY
DEPARTMENT OF PUBLIC WORKS
MARINA REHABILITATION

Appendix D

Natural Resource Database Search Results

List of Special Status Species that may occur within a 1 Mile Buffer of the Project Area

Species	Status	Habitat
Plant Species		
Adobe sanicle (*Sanicula maritima)*	CR, CNPS 1B.2	Chaparral, coastal prairie, meadows and seeps, valley and foothill grassland
Alkali milk-vetch (*Astragalus tener* var. *tener*)	CNPS 1B.2	Valley grassland, alkali sink, freshwater wetlands
Bent-flowered fiddleneck (*Amsinckia lunaris*)	CNPS 1B.2	Coastal bluff scrub, cismontane woodlands, grasslands.
Blue coast gilia (*Gilia capitata* ssp. *chamissonis*)	CNPS 1B.2	Coastal dunes, coastal scrub
California seablite (*Suaeda californica*)	FE, CNPS 1B.1	Marshes and swamps (coastal salt)
Choris' popcornflower (*Plagiobothrys chorisianus* var. *chorisianus*)	CNPS 1B.2	Chaparral, coastal prairie, coastal scrub
Coastal bluff morning-glory (*Calystegia purpurata* ssp. *saxocola*)	CNPS 1B.2	Coastal bluff scrub, coastal dunes, coastal scrub, north coast coniferous forest
Coastal triquetrella (*Triquetrella californica*)	CNPS 1B.2	Coastal bluff scrub, coastal scrub
Diablo helianthella (*Helianthella castanea*)	CNPS 1B.2	Broadleafed upland forest, chaparral, cismontane woodland, coastal scrub, riparian woodland, valley and foothill grassland
Dark-eyed gilia (*Gilia millefoliata*)	CNPS 1B.2	Coastal dunes
Fragrant fritillary (*Fritillaria liliacea*)	CNPS 1B.2	Cismontane woodland, coastal prairie, coastal scrub, valley and foothill grassland
Kellog's horkelia (*Horkelia cuneata* var. *sericea*)	CNPS 1B.1	Closed-cone coniferous forest, maritime chaparral, coastal dunes, coastal scrub
Loma Prieta hoita (*Hoita strobilina*)	CNPS 1B.1	Usually serpentinite, mesic habitats including chaparral, cismontane woodland, and riparian woodland

Species	Status	Habitat
Long-styled sand-spurrey (*Spergularia macrotheca* var. *longistyla*)	CNPS 1B.2	Meadows and seeps, marshes and swamps
Marin Dwarf-flax (*Hesperolinon congestum*)	FT, CT CNPS 1B.1	Serpentine endemic.
Most beautiful jewelflower (*Streptanthus albidus* ssp. *peramoenus*)	CNPS 1B.2	Chaparral, Cismontane woodland, Valley and foothill grassland
Oregon meconella (*Meconella oregana*)	CNPS 1B.1	Coatal prairie, coastal scrub
Oval-leaved viburnum (*Viburnum ellipticum*)	CNPS 2B.3	Chaparral, cismontane woodland, lower montane coniferous forests
Pallid manzanita (*Arctostaphylos pallida*)	FT, CE, CNPS 1B.1	Broadleafed upland forest, closed-cone coniferous forest, chaparral, cismontane woodland, coastal scrub
Point Reyes birds-beak (*Cordylanthus maritimus* ssp. *palutris*)	CNPS 1B.2	Coastal salt marsh, wetland riparian
Saline clover (*Trifolium hydrophilum*)	CNPS 1B.2	Marshed and swamps, valley and foothill grassland (mesic, alkaline), vernal pools
San Francisco Bay spineflower (*Chorizanthe cuspidate* var. *cuspidata*	CNPS 1B.2	Coastal bluff scrub, coastal dunes, coastal prairie, coastal scrub
San Joaquin spearscale (*Extriplex joaquinana*)	CNPS 1B.2	Chenopod scrub, meadows and seeps, playas, valley and foothill grassland
Santa Cruz tarplant (*Holocarpha macradenia*)	CNPS 1B.1	Coastal prairie, coastal scrub, valley and foothill grassland
Suisun marsh aster (*Symphyotrichum lentum*)	CNPS 1B.2	Freshwater wetlands, brackish marsh.
Tiburon buckwheat (*Eriogonum luteolum* var. *caninum*)	CNPS 1B.2	Chaparral, cismontane woodland, coastal prairie, valley and foothill grassland
Tiburon Jewelflower (*Streptanthus glandulosus* ssp. *niger*)	FE, CE, CNPS 1B.1	Serpentine endemic.
Tiburon Mariposa Lily (*Calochortus tiburonensis*)	FT, CNPS 1B.1	Serpentine endemic.

Species	Status	Habitat
Tiburon Paintbrush (*Castilleja affinis* ssp. *Neglecta*)	FE, CNPS 1B.2	Serpentine endemic.
Two-fork clover (*Trifolium amoenum*)	FE, CNPS 1B.1	Coastal bluff scrub, valley and foothill grassland (sometimes serpentine)
Western leatherwood (*Dirca occidentalis*)	CNPS 1B.2	Broadleafed upland forest, closed-cone coniferous forest, chaparral, cismontane woodland, north coast coniferous forest, riparian forest, riparian woodland
White-rayed Pentachaeta (*Pentachaeta bellidiflora*)	FE, CNPS 1B.1	Valley grassland. Affinity for serpentine.
Avian Species		
Alameda song sparrow (*Melospiza molodia pusillula*)	CSC	Tidal salt marshes around San Francisco Bay
California least tern (*Sternula antillarum browni*)	FE, SE, FP	Migratory. Feeds in shallow estuaries or lagoons where small fish are abundant. Breeds in abandoned salt ponds and along estuarine shores in San Francisco Bay. Breeding occurs in areas free of human or predatory disturbance from April-August
California ridgeway's rail (*Rallus obsoletus obsoletus*)	FE, CE, FP	Requires emergent wetlands and tidal sloughs, although occasionally uses transition zone between wetland and adjacent upland habitat. Nesting occurs mid-March to July in lower zones of saline emergent wetlands, where cordgrass (*Spartina* sp.) is abundant and tidal sloughs are nearby
Northern harrier (*Circus cyaneus*)	CSC	Meadows, grasslands, open rangelands, desert sinks, fresh and saltwater emergent wetlands. Prefers open terrain with good ground cover, seldom found in wooded areas.
Western snowy plover (*Charadrius alexandrinus nivosus*)	Ft, CSC, BCC	Sandy beaches, sand spits, dune-backed beaches, sparsely-vegetated dunes, beaches at creek and river mouths, and salt pans at lagoons and estuaries. Breeding occurs March-September in Shallow scrapes or depressions in the sand
White-tailed kite (*Elanus leucurus*)	FP	Yearlong resident in coastal and valley lowlands, generally found near agricultural areas. Inhabits herbaceous and open stakes of most habitats mostly in cismontane areas of California.

Species	Status	Habitat
Mammal Species		
Big free-tailed bat (*Nyctinomops macrotis*)	CSC	Roosts in cliffs, caves or buildings.
Salt marsh harvest mouse (*Reithrodontomys raviventris*)	FE, CSC, FP	Salt and brackish marshes with dense cover and a high percentage of pickleweed
Herptile Species		
Alameda whipsnake (*Masticophis lateralis euryxanthus*)	FT, CT	Common in scrublands broken by scattered grassy patches, rocky hillsides, gullies, canyons, or stream courses
California red-legged frog (*Rana draytonii*)	FT, CSC	A pond frog that inhabits humid forests, woodlands, grasslands, and streamsides; however, frequents otherwise permanent sources of water. Breeds January-April and can be found in damp woods during non-breeding periods
Fish Species		
Delta smelt (*Hypomesus transpacificus*)	FT, CE	Estuary of Sacramento River. Brackish and fresh water
Longfin smelt (*Spirinchus thaleichthys*)	FC, CT, CSC	Coastal lagoons, bays, estuaries, sloughs, tidal freshwater streams and offshore
Tidewater goby (*Eucyclogobius newberryi*)	FE	Lagoons formed by streams running into the sea. The tidewater goby prefers salinities of less than 10 ppt.
Invertebrate Species		
San Bruno elfin butterfly (*Callophrys mossii bayensis*)	FE	Rocky outcrops and cliffs in coastal scrub, in the fogbelt of steep north facing slopes that receive little direct sunlight. Host plant is broadleaf stonecrop (*Sedum spathulifolium*)

Sources: CNDDB 2018, USFWS 2018, and CNPS 2018.

STATUS CODES
FE: Federally Endangered
FT: Federally Threatened
FPE: Federally Endangered (Proposed)
FC: Federal Candidate

BEPA: Bald Eagle Protection Act

CE: California Endangered
CT: California Threatened
CR: California Rare
CP: California Protected
CSC: California Species of Special Concern
WL: California Watch List
FP: California Fully Protected

BCC: USFWS Birds of Conservation Concern

California Native Plant Society Listing (CNPS)
1A: Plants Presumed Extinct in California

1B: Plants Rare, Threatened, or Endangered in California and elsewhere
2: Plants Rare, Threatened, or Endangered in California, but more common elsewhere
3: Plants about which we need more information – a review list
4: Plants of limited distribution – a watch list
A2: Locally Rare in Alameda and Contra Costa Counties
.1: Seriously threatened in California
.2: Moderately threatened in California
.3: Not very threatened in California

Appendix E

Excerpts from the Sea-Level Rise Guidance 2018 Update

State of California Sea-Level Rise Guidance

2018 UPDATE

TABLE 13: Projected Sea-Level Rise (in feet) for San Francisco

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					*H++ scenario (Sweet et al. 2017) *Single scenario*
		MEDIAN	**LIKELY RANGE**		**1-IN-20 CHANCE**	**1-IN-200 CHANCE**	
		50% probability sea-level rise meets or exceeds...	*66% probability sea-level rise is between...*		*5% probability sea-level rise meets or exceeds...*	*0.5% probability sea-level rise meets or exceeds...*	
				Low Risk Aversion		**Medium - High Risk Aversion**	**Extreme Risk Aversion**
High emissions	2030	0.4	0.3 -	0.5	0.6	0.8	1.0
	2040	0.6	0.5 -	0.8	1.0	1.3	1.8
	2050	0.9	0.6 -	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6 -	1.3	1.6	2.4	
High emissions	2060	1.1	0.8 -	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8 -	1.5	1.9	3.1	
High emissions	2070	1.4	1.0 -	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 -	1.8	2.3	3.9	
High emissions	2080	1.7	1.2 -	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0 -	2.1	2.8	4.7	
High emissions	2090	2.1	1.4 -	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0 -	2.4	3.2	5.7	
High emissions	2100	2.5	1.6 -	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2 -	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9 -	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2 -	2.8	3.9	7.4	
High emissions	2120	3	2.2 -	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3 -	3.1	4.4	8.5	
High emissions	2130	3.3	2.4 -	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3 -	3.4	4.9	9.7	
High emissions	2140	3.7	2.6 -	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3 -	3.8	5.5	11.0	
High emissions	2150	4.1	2.8 -	5.8	7.7	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

TABLE 14: Probability that Sea-Level Rise will meet or exceed a particular height (in feet) in San Francisco

Estimated probabilities that sea-level rise will meet or exceed a particular height are based on Kopp et al. 2014. All heights are with respect to a 1991 – 2009 baseline; values refer to a 19-year average centered on the specified year. Areas shaded in grey have less than a 0.1% probability of occurrence. Values below are based on probabilistic projections; for low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050; ***the H++ scenario is not included in this table.***

SAN FRANCISCO - High emissions (RCP 8.5)

	Probability that sea-level rise will meet or exceed... (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2030	0.1%									
2040	3.3%									
2050	31%	0.4%								
2060	65%	3%	0.2%	0.1%						
2070	84%	13%	1.2%	0.2%	0.1%					
2080	93%	34%	5%	0.9%	0.3%	0.1%	0.1%			
2090	96%	55%	14%	3%	0.9%	0.3%	0.2%	0.1%	0.1%	
2100	96%	70%	28%	8%	3%	1%	0.5%	0.3%	0.2%	0.1%
2150	100%	96%	79%	52%	28%	15%	8%	4%	3%	2%

SAN FRANCISCO - Low emissions (RCP 2.6)

	Probability that sea-level rise will meet or exceed... (excludes H++)									
	1 FT.	2 FT.	3 FT.	4 FT.	5 FT.	6 FT.	7 FT.	8 FT.	9 FT.	10 FT.
2060	43%	1.4%	0.2%							
2070	62%	4%	0.6%	0.2%						
2080	74%	11%	2%	0.4%	0.2%	0.1%				
2090	80%	20%	3%	1.0%	0.4%	0.2%	0.1%	0.1%		
2100	84%	31%	7%	2%	0.8%	0.4%	0.2%	0.1%	0.1%	
2150	93%	62%	31%	14%	7%	4%	2%	2%	1%	1%

TABLE 15: Projected Average Rate of Sea-Level Rise (mm/year) for San Francisco

Probabilistic projections for the rates of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column.) Values are presented in this table as mm/yr, as opposed to feet as in the previous two tables, to avoid reporting values in fractions of an inch. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. For low emissions (RCP 2.6) the starting year is 2060 as we are currently on a high emissions (RCP 8.5) trajectory through 2050.

		Probabilistic Projections (mm/yr) (based on Kopp et al. 2014)				H++ scenario (Sweet et al. 2017) *Single scenario
		MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE	
		50% probability sea-level rise meets or exceeds...	66% probability sea-level rise is between...	5% probability sea-level rise meets or exceeds...	0.5% probability sea-level rise meets or exceeds...	
High emissions	2030 – 2050	6.7	4.5 - 9.3	12	17	26
Low emissions	2060 - 2080	5.3	3.1 - 8.2	12	22	
High emissions	2060 - 2080	9.5	6.4 - 13	17	28	42
Low emissions	2080 – 2100	5.2	2.3 - 9.1	14	28	
High emissions	2080 – 2100	11	6.0 - 16	22	37	55

San Francisco Bay Tidal Datums and Extreme Tides Study

Final Report • February 2016

AECOM

Location		Coordinates (UTM Zone 10N - Meters)		Tidal Datum						Extreme Tide Elevation							
				FEET-NAVD88						FEET-NAVD88							
County	Point ID	Easting	Northing	MLLW	MLW	MSL	MTL	MHW	MHHW	1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
Alameda	511	6038838.283	2147091.080	-0.07	1.01	3.31	3.32	5.63	6.20	7.42	7.75	8.16	8.47	8.93	9.32	9.75	10.96
Alameda	512	6039057.344	2145337.934	-0.08	1.01	3.31	3.32	5.63	6.20	7.42	7.75	8.16	8.47	8.93	9.32	9.75	10.96
Alameda	513	6038135.463	2146327.892	-0.08	1.01	3.31	3.32	5.63	6.20	7.42	7.75	8.16	8.47	8.93	9.32	9.75	10.96
Alameda	514	6036767.782	2147446.361	-0.07	1.01	3.31	3.32	5.63	6.20	7.42	7.75	8.16	8.48	8.93	9.32	9.76	10.97
Alameda	515	6035173.297	2146940.161	-0.07	1.01	3.31	3.32	5.63	6.20	7.42	7.75	8.16	8.47	8.93	9.32	9.76	10.97
Alameda	516	6033896.167	2145859.619	-0.07	1.01	3.31	3.32	5.63	6.19	7.42	7.75	8.15	8.47	8.93	9.31	9.75	10.95
Alameda	517	6034689.538	2144423.795	-0.07	1.01	3.31	3.32	5.63	6.20	7.42	7.75	8.15	8.47	8.92	9.31	9.74	10.93
Alameda	518	6035770.081	2143146.698	-0.07	1.01	3.31	3.32	5.63	6.20	7.43	7.75	8.16	8.47	8.92	9.30	9.73	10.91
Alameda	519	6035989.142	2141393.519	-0.07	1.01	3.31	3.32	5.63	6.20	7.43	7.75	8.16	8.47	8.92	9.30	9.72	10.90
Alameda	520	6036495.342	2139799.067	-0.08	1.00	3.30	3.32	5.64	6.21	7.44	7.75	8.16	8.47	8.92	9.30	9.72	10.88
Alameda	521	6038120.010	2139572.263	-0.08	1.00	3.31	3.32	5.64	6.21	7.44	7.76	8.16	8.47	8.92	9.30	9.72	10.88
Alameda	522	6039238.446	2140939.977	-0.08	1.00	3.31	3.32	5.64	6.21	7.44	7.76	8.17	8.48	8.93	9.31	9.73	10.90
Alameda	523	6040606.160	2139821.508	-0.08	1.00	3.31	3.32	5.64	6.21	7.44	7.76	8.17	8.48	8.93	9.30	9.72	10.89
Alameda	524	6040825.221	2138068.362	-0.08	1.00	3.31	3.32	5.64	6.21	7.44	7.76	8.16	8.47	8.92	9.30	9.71	10.87
Alameda	525	6040757.111	2136156.522	-0.08	1.00	3.31	3.32	5.64	6.21	7.44	7.76	8.16	8.47	8.91	9.29	9.70	10.86
Alameda	526	6041550.482	2134720.731	-0.08	1.00	3.31	3.32	5.65	6.22	7.45	7.76	8.16	8.47	8.91	9.29	9.70	10.85
Alameda	527	6040689.001	2134244.714	-0.08	1.00	3.31	3.32	5.64	6.22	7.44	7.76	8.16	8.47	8.91	9.28	9.70	10.85

Appendix F

Background Information and Additional Explanation of Sea Level Rise

Background Information on Sea Level Rise Tables

Sea Level Rise Values

The sea level datum values are obtained from Alameda Point 518 Panel 1 and Appendix B-31 of the FEMA/BCDC "San Francisco Bay Tidal Datums and Extreme Tides Survey" dated February 2016. The values used are those at the entrance to the Berkeley Marina.

Future sea level rise values are from the current California Coastal Commission Sea Level Rise Policy Guidance document. Values in the Guidance document are given in feet relative to NAVD88 (North American Vertical Datum of 1988) for the Low Risk Aversion projection (upper limit of the "likely range" with 17 percent probability of exceedance), the Medium-High Risk Aversion (1 in 200 chance or 0.5 percent probability of exceedance), and the Extreme Risk Aversion (no associated probability given but comparable with Dutch coastal protection at about 0.1 percent probability of exceedance). Values used are those for San Francisco.

The future sea level rise values in the Guidance document are given relative to a baseline year of 2000. The values are adjusted to a baseline year 2016 to correspond to the sea level datum values, as shown in the table below.

Adjustment of Sea Level Rise for a 2016 Baseline							
	2000	2016	2030	2050	2070	2100	2150
Extreme Risk Aversion							
Values in feet to 2000 Baseline	0	0.4	1.0	2.7	5.2	10.2	21.9
Values in feet to 2016 Baseline		0	0.6	2.3	4.8	9.8	21.5
Medium-High Risk Aversion							
Values in feet to 2000 Baseline	0	0.3	0.8	1.9	3.5	6.9	13.0
Values in feet to 2016 Baseline		0	0.5	1.6	3.2	6.6	12.7
Low Risk Aversion							
Values in feet to 2000 Baseline	0	0.2	0.5	1.1	1.9	3.4	5.8
Values in feet to 2016 Baseline		0	0.3	0.9	1.7	3.2	5.6

Extreme Still Water Surface Elevations with Sea Level Rise

The extreme still water surface elevations with sea level rise are the 100-year extreme tide elevations for 2016 as given for Alameda Point 518 Panel 1 and Appendix B-31 of the FEMA/BCDC "San Francisco Bay Tidal Datums and Extreme Tides Survey" dated February 2016, increased by the sea level rise beyond 2016. The values used are those at the entrance to the Berkeley Marina.

The values are given in Table 2 for the Guidance document Low Risk Aversion and Medium-High Risk Aversion sea level rise projections, and for the extreme risk aversion scenario.

The extreme tide elevation values in Table 2 have been obtained from the Alameda Point 518 Panel 1 and Appendix B-31 of the FEMA/BCDC "San Francisco Bay Tidal Datums and Extreme Tides Survey" dated February 2016. The preparers of this Survey would no doubt have included the appropriately correlated values for surge. The surge values would be much less in magnitude than a 100-year surge value.

Section 2.3.2 of the "San Francisco Bay Tidal Datums and Extreme Tides Survey" describes "extreme tides" as being temporary short increases above astronomical tide elevations. "Extreme tides" include storm surge and El Nino events, but do not include waves. Therefore, extreme wave runup elevations with sea level rise are separately estimated for the purposes of evaluating runup and overtopping on revetments and breakwaters.

Extreme Wave Runup Elevations with Sea Level Rise

The tabulated extreme wave runup elevations are combined from the MHHW elevation adjusted for future sea level rise, the runup on a 2 horizontal to 1 vertical rock armored slope due to the estimated 100-year extreme wave at the revetment location with an allowance for an increase in wave height associated with increasing sea level rise, and a 5-year storm surge value for the San Francisco Bay.

The extreme wave runup with sea level rise values are given in Table 3a, 3b, and 3c for different locations around the Berkeley Marina Area.

In arriving at estimates of the extreme wave runup elevations given in Tables 3a, 3b, and 3c, this assessment used a 1 in 5-year surge event with a value of 1.0 foot for the Berkeley Marina Area location. The extreme wave runup elevations are a combination of MHHW (MHW is sometimes used; which would be 0.6 foot lower), a maximum wave height (5.0 foot on the North and West sides; 3.0 foot on the South Side) multiplied by 1.6 for an estimate of vertical runup on the 2 horizontal to 1 vertical rock armored slopes, and the 1.0 foot surge value. The maximum wave heights are increased in magnitude over time by a small proportion of the projected sea level rise. The MHHW elevation is increased by the value of sea level rise projection.

Wave runup elevations are based on an imaginary extension of the revetment at 2 horizontal to 1 vertical. Where the revetment slope breaks and the bank continues inland at a lesser slope, the runup elevation is reduced to a lower value. Locations with adjusted runup elevations are identified in the discussion under "Vulnerability, Mitigation, and Adaptation Measures by Location."

Overtopping magnitudes can be approximately estimated from wave runup information. The degree of overtopping helps assessment of whether upgrades can be delayed by using temporary closures of affected revetment areas. This can be useful when assessing maximum life expectancy of an existing repaired revetment and setting the time for future upgrades to revetments and breakwaters.

Relationship between MLLW and NAVD88 Datums

The FEMA/BCDC "San Francisco Bay Tidal Datums and Extreme Tides Survey" dated February 2016 gives elevations with respect to NAVD88.

NAVD88 elevations are very close to Mean Lower Low Water (MLLW) elevations. See Tables 1a and 1b. The City of Berkeley Datum is based upon a different value of MLLW that varies by a few inches.

For the purpose of sea level rise assessments, considering the approximations made, elevations given to NAVD88 and to MLLW could be taken as being the same in value.

Appendix G

Loss Information

Year	NAVD88	Impact Category	Lower Limit	Upper Limit	% Impact
2030	10.1	I	0.0	6.0	0.2
2050	10.7	II	6.0	24.0	0.5
2100	13.0	III	24.0		1.0

	Total Cost	Rounded Cost
Full Replacement Cost	$ -	$ -
2030Cost	$ -	$ -
2050Cost	$ 3,018,822.16	$ 3,019,000.00
2100Cost	$ 17,094,451.63	$ 17,094,000.00

FID	Stories	AREA	ELEVATION	LAYER	Replacement Cost / SF	Label	FFE_MLLW	FFE_NAVD88	2030 FFE-WSE	2050 FFE-WSE	2100 FFE-WSE	2030Impact	2050Ipact	2100Impact	2019 Full Replacement Cost	2030Cost	2050Cost	2100Cost
0	1	3156	13.4	Commercial Bld	$ 300.00	B-1	14.37	14.03	0.0	0.0	0.0	0%	0%	0%	$ 946,893.96	$ -	$ -	$ -
1	1	176	14	Out Bldg	$ 122.00	B-2	13.95	13.61	0.0	0.0	0.0	0%	0%	0%	$ 21,431.29	$ -	$ -	$ -
2	1	511	12.2	Out Bldg	$ 122.00	B-3	12.77	12.43	0.0	0.0	-6.8	0%	0%	50%	$ 62,316.02	$ -	$ -	$ 31,158.01
3	1	370	14	Out Bldg	$ 122.00	B-4	14.04	13.7	0.0	0.0	0.0	0%	0%	0%	$ 45,151.87	$ -	$ -	$ -
4	1	802	13.6	Out Bldg	$ 122.00	B-5	12.96	13.3	0.0	0.0	0.0	0%	0%	0%	$ 97,812.11	$ -	$ -	$ -
5	1	263	11	Out Bldg	$ 122.00	B-6	14.18	13.84	0.0	0.0	0.0	0%	0%	0%	$ 32,096.50	$ -	$ -	$ -
6	1	169	11	Out Bldg	$ 122.00	B-7	11.04	10.7	0.0	0.0	-27.6	0%	0%	100%	$ 20,560.87	$ -	$ -	$ 20,560.87
7	2	6975	12.5	Commercial Bld	$ 300.00	B-8	13.75	13.41	0.0	0.0	0.0	0%	0%	0%	$ 4,185,122.79	$ -	$ -	$ -
8	1	2475	11.1	Out Bldg	$ 122.00	B-9	12.4	12.06	0.0	0.0	-11.3	0%	0%	50%	$ 301,965.58	$ -	$ -	$ 150,982.79
9	1	723	11.6	Out Bldg	$ 122.00	B-10	12.27	11.93	0.0	0.0	-12.8	0%	0%	50%	$ 88,193.03	$ -	$ -	$ 44,096.52
10	1	436	11.6	Out Bldg	$ 122.00	B-11	11.64	11.3	0.0	0.0	-20.4	0%	0%	50%	$ 53,242.55	$ -	$ -	$ 26,621.27
11	1	798	11.6	Out Bldg	$ 122.00	B-12	11.64	11.3	0.0	0.0	-20.4	0%	0%	50%	$ 97,360.70	$ -	$ -	$ 48,680.35
12	2	7243	13	Office bldg	$ 300.00	B-13	15.96	15.62	0.0	0.0	0.0	0%	0%	0%	$ 4,345,959.81	$ -	$ -	$ -
13	1	1084	16.5	Out Bldg	$ 122.00	B-14	16.54	16.2	0.0	0.0	0.0	0%	0%	0%	$ 132,241.75	$ -	$ -	$ -
14	1	599	17	Restroom	$ 122.00	B-15	17.63	17.29	0.0	0.0	0.0	0%	0%	0%	$ 73,112.23	$ -	$ -	$ -
15	1	1492	17	Out Bldg	$ 122.00	B-16	18.48	18.14	0.0	0.0	0.0	0%	0%	0%	$ 182,052.61	$ -	$ -	$ -
16	1	1725	16	Out Bldg	$ 122.00	B-17	17.09	16.75	0.0	0.0	0.0	0%	0%	0%	$ 210,469.45	$ -	$ -	$ -
17	2	22172	5	Commercial Bld	$ 300.00	B-18	16.04	15.7	0.0	0.0	0.0	0%	0%	0%	$ 13,303,024.75	$ -	$ -	$ -
18	1	668	5	Restroom	$ 122.00	B-19	11.85	11.51	0.0	0.0	-17.9	0%	0%	50%	$ 81,439.28	$ -	$ -	$ 40,719.64
19	1	2727	10	Out Bldg	$ 122.00	B-20	12.62	12.28	0.0	0.0	-8.6	0%	0%	50%	$ 332,680.22	$ -	$ -	$ 166,340.11
20	1	13716	15.3	Commercial Bld	$ 300.00	B-21	15.85	15.51	0.0	0.0	0.0	0%	0%	0%	$ 4,114,839.00	$ -	$ -	$ -
21	1	656	5	Restroom	$ 122.00	B-22	13.04	12.7	0.0	0.0	-3.6	0%	0%	20%	$ 80,077.35	$ -	$ -	$ 16,015.47
22	1	7384	5	Commercial Bld	$ 300.00	B-23	14.28	13.94	0.0	0.0	0.0	0%	0%	0%	$ 2,215,276.71	$ -	$ -	$ -
23	1	1345	5	Commercial Bld	$ 300.00	B-24	12.79	12.45	0.0	0.0	-6.6	0%	0%	50%	$ 403,510.61	$ -	$ -	$ 201,755.31
24	1	8130	14	Out Bldg	$ 122.00	B-25	16.22	15.88	0.0	0.0	0.0	0%	0%	0%	$ 991,818.84	$ -	$ -	$ -
25	1	2103	17	Out Bldg	$ 122.00	B-26	17.04	16.7	0.0	0.0	0.0	0%	0%	0%	$ 256,622.60	$ -	$ -	$ -
26	1	1562	12	Restroom	$ 122.00	B-27	12.87	12.53	0.0	0.0	-5.6	0%	0%	20%	$ 190,527.73	$ -	$ -	$ 38,105.55
27	1	968	10	Out Bldg	$ 122.00	B-28	16.63	16.29	0.0	0.0	0.0	0%	0%	0%	$ 118,142.66	$ -	$ -	$ -
28	3	12205	10	Hotel Building	$ 300.00	B-29	12.38	12.04	0.0	0.0	-11.5	0%	0%	50%	$ 10,984,367.91	$ -	$ -	$ 1,830,727.98
29	1	5319	9.5	Hotel Building	$ 300.00	B-30	10.71	10.37	0.0	-4.0	-31.6	0%	20%	100%	$ 1,595,767.42	$ -	$ 319,153.48	$ 1,595,767.42
30	4	17998	10	Hotel Building	$ 300.00	B-31	10.49	10.15	0.0	-6.6	-34.2	0%	50%	100%	$ 21,597,349.43	$ -	$ 2,699,668.68	$ 5,399,337.36
31	1	3440	12	Hotel Building	$ 300.00	B-32	12.57	12.23	0.0	0.0	-9.2	0%	0%	50%	$ 1,031,918.16	$ -	$ -	$ 515,959.08
32	2	29148	10.3	Hotel Building	$ 300.00	B-33	12.95	12.61	0.0	0.0	-4.7	0%	0%	20%	$ 17,488,866.19	$ -	$ -	$ 1,748,886.62
33	1	963	5	Restroom	$ 122.00	B-34	12.64	12.3	0.0	0.0	-8.4	0%	0%	50%	$ 117,519.27	$ -	$ -	$ 58,759.64
34	2	1921	12.5	Commercial Bld	$ 300.00	B-8	16.14	15.8	0.0	0.0	0.0	0%	0%	0%	$ 1,152,523.83	$ -	$ -	$ -
35	3	16966	10	Hotel Building	$ 300.00	B-29	11.47	11.13	0.0	0.0	-22.4	0%	0%	50%	$ 15,269,069.45	$ -	$ -	$ 2,544,844.91
36	3	11359	10	Hotel Building	$ 300.00	B-29	12.17	11.83	0.0	0.0	-14.0	0%	0%	50%	$ 10,223,257.64	$ -	$ -	$ 1,703,876.27
37	4	3412	10	Hotel Building	$ 300.00	B-31	11.89	11.55	0.0	0.0	-17.4	0%	0%	50%	$ 4,094,397.15	$ -	$ -	$ 511,799.64
38	2	6658	10.3	Hotel Building	$ 300.00	B-33	12.92	12.58	0.0	0.0	-5.0	0%	0%	20%	$ 3,994,568.30	$ -	$ -	$ 399,456.83
														Total	$ 120,534,000	$ -	$ 3,019,000	$ 17,094,000
														Commercial		$ -	$ 3,019,000	$ 16,517,000

Facility	2030Cost	2050Cost	2100Cost
Road - AC	$ 9,004.44	$ 22,055.11	$ 126,424.89
Parking - AC	$ 10,636.44	$ 29,002.67	$ 149,187.56
Parking - Dirt/Gravel	$ 3,329.78	$ 12,268.44	$ 29,315.56
Path - PCC/AC	$ 5,793.78	$ 15,091.56	$ 62,869.33
Path - Dirt/Gravel	$ 12,378.67	$ 19,792.00	$ 32,071.11

Digits	Value		Definition	% Cost / Cost	
100	1##	=	0" < D ≤ 6"	10%	
200	2##	=	6" < D ≤ 12"	25%	
300	3##	=	12" < D ≤ 24"	50%	
400	4##	=	24" < D	100%	
1	##1	=	Road - AC	$ 4.44	Pavement falue repair was $40/SY from Contra Costa County Local Road Preservation bid tab
2	##2	=	Parking - AC	$ 4.44	Pavement falue repair was $40/SY from Contra Costa County Local Road Preservation bid tab
3	##3	=	Parking - Dirt/Gravel	$ 3.50	
4	##4	=	Path - PCC/AC	$ 4.44	Pavement falue repair was $40/SY from Contra Costa County Local Road Preservation bid tab
5	##5	=	Path - Dirt/Gravel	$ 3.50	

VALUE	Class	Depth Flooded	Surface	2030-Area	2050-Area	2100-Area	%	Cost	2030Cost	2050Cost	2100Cost
101	I	0" < D ≤ 6"	Road - AC	10896	26576	45184	10%	$ 4.44	$ 4,842.67	$ 11,811.56	$ 20,081.78
102	I	0" < D ≤ 6"	Parking - AC	17916	37704	65832	10%	$ 4.44	$ 7,962.67	$ 16,757.33	$ 29,258.67
103	I	0" < D ≤ 6"	Parking - Dirt/Gravel	6596	19328	0	10%	$ 3.50	$ 2,931.56	$ 8,590.22	$ -
104	I	0" < D ≤ 6"	Path - PCC/AC	8632	18880	19328	10%	$ 4.44	$ 3,836.44	$ 8,391.11	$ 8,590.22
105	I	0" < D ≤ 6"	Path - Dirt/Gravel	8504	15332	2148	10%	$ 3.50	$ 3,779.56	$ 6,814.22	$ 954.67
201	II	6" < D ≤ 12"	Road - AC	4988	11812	45020	25%	$ 4.44	$ 2,216.89	$ 5,249.78	$ 20,008.89
202	II	6" < D ≤ 12"	Parking - AC	5364	15056	62640	25%	$ 4.44	$ 2,384.00	$ 6,691.56	$ 27,840.00
203	II	6" < D ≤ 12"	Parking - Dirt/Gravel	896	3504	0	25%	$ 3.50	$ 398.22	$ 1,557.33	$ -
204	II	6" < D ≤ 12"	Path - PCC/AC	2012	8820	20832	25%	$ 4.44	$ 894.22	$ 3,920.00	$ 9,258.67
205	II	6" < D ≤ 12"	Path - Dirt/Gravel	4680	6548	1652	25%	$ 3.50	$ 2,080.00	$ 2,910.22	$ 734.22
301	III	12" < D ≤ 24"	Road - AC	4352	10424	116208	50%	$ 4.44	$ 1,934.22	$ 4,632.89	$ 51,648.00
302	III	12" < D ≤ 24"	Parking - AC	652	12496	112544	50%	$ 4.44	$ 289.78	$ 5,553.78	$ 50,019.56
303	III	12" < D ≤ 24"	Parking - Dirt/Gravel	0	4772	21316	50%	$ 3.50	$ -	$ 2,120.89	$ 9,473.78
304	III	12" < D ≤ 24"	Path - PCC/AC	724	4196	53308	50%	$ 4.44	$ 321.78	$ 1,864.89	$ 23,692.44
305	III	12" < D ≤ 24"	Path - Dirt/Gravel	8312	10628	15368	50%	$ 3.50	$ 3,694.22	$ 4,723.56	$ 6,830.22
401	IIII	24" < D	Road - AC	24	812	78044	100%	$ 4.44	$ 10.67	$ 360.89	$ 34,686.22
402	IIII	24" < D	Parking - AC	0	0	94656	100%	$ 4.44	$ -	$ -	$ 42,069.33
403	IIII	24" < D	Parking - Dirt/Gravel	0	0	44644	100%	$ 3.50	$ -	$ -	$ 19,841.78
404	IIII	24" < D	Path - PCC/AC	1668	2060	47988	100%	$ 4.44	$ 741.33	$ 915.56	$ 21,328.00
405	IIII	24" < D	Path - Dirt/Gravel	6356	12024	52992	100%	$ 3.50	$ 2,824.89	$ 5,344.00	$ 23,552.00

Appendix H

Mitigation Costs

Forecast of Revetment Repairs, and Upgrades

Costs are based on repairing and upgrading the revetment, breakwaters, and other shoreline protection to the current condition; suitable for recreational use. In the event of a change of use, the shoreline protection would need enhancement to meet the required standards for safety. Such increases in cost would be associated with the future development.

Low Risk Aversion

SLR at Upper Limit of "likely range" (83% likely to be below this limit)

Start of Decade	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**
End of Decade	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
Revetment Repairs $	1,000,000	1,000,000	1,000,000	1,200,000	1,200,000	200,000	200,000	200,000
Armor Overlay $						6,480,000	4,305,000	4,200,000
						West Side South of Entrance	planned 2,000 foot max per decade	
Crest Raising - West Side, South of Marina Entrance $							6,210,000	
Crest Raising - West Side, North of Marina Entrance $								2,990,000
Revetment Raising North of Marina - West, North & East Sides $							1,296,000	1,269,000
							planned 2,000 foot max per decade	
Breakwater at West Side - South End - 250 LF Rock $				375,000				
Breakwater at Marina Entrance - 750 LF Rock $				4,125,000				
Breakwater at Marine Entrance - 500 LF Structural Concrete $				2,500,000				2,500,000
Repair, Upgrade & Raising of South Shore Protection $	1,600,000					800,000		
Repair & Upgrade Plan Related Actions, Design & Construction Administration $	690,000	50,000	50,000	2,850,000	50,000	2,962,000	4,774,400	4,433,600
Total Cost per Decade $	**3,290,000**	**1,050,000**	**1,050,000**	**11,050,000**	**1,250,000**	**10,442,000**	**16,785,400**	**15,592,600**

Medium-High Risk Aversion

SLR at 1 in 200 chance of exceedance (99.5% likely to be below this limit)

Start of Decade	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**
End of Decade	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
Revetment Repairs $	1,000,000	1,000,000	1,000,000	200,000	200,000	200,000	200,000	400,000
Armor Overlay $			13,500,000	8,815,000	8,600,000	8,600,000	4,200,000	
			West Side South of Entrance	planned 2,000 foot max cumulative lengths each decade				
Crest Raising - West Side, South of Marina Entrance $			15,120,000					
Crest Raising - West Side, North of Marina Entrance $				7,280,000				
Revetment Raising North of Marina - West, North & East Sides $				3,120,000	3,055,000	1,200,000		
				planned 2,000 foot max cum lengths each decade				
Breakwater at West Side - South End - 250 LF Rock $		375,000						
Breakwater at Marina Entrance - 750 LF Rock $		9,000,000						
Breakwater at Marine Entrance - 500 LF Structural Concrete $				3,000,000		5,500,000		
Repair, Upgrade & Raising of South Shore Protection $	2,400,000			800,000		3,700,000		
Repair & Upgrade Plan Related Actions, Design & Construction Administration $	1,010,000	3,800,000	11,498,000	9,256,000	4,712,000	7,650,000	1,730,000	50,000
Total Cost per Decade $	**4,410,000**	**14,175,000**	**41,118,000**	**32,471,000**	**16,567,000**	**26,850,000**	**6,130,000**	**450,000**

Floodwall Mitigation for 2050 Sea Level Rise Approximate Cost Estimate

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	COST
	NORTH SHORE PROTECTION				
1	Mobilization	1	LS	$ 426,190	$ 426,190
2	Steel Sheet Piling	54,890	SF	$ 50	$ 2,744,500
3	Cap (Precast Concrete)	2,529	LF	$ 100	$ 252,900
4	Concrete Facing	2,529	LF	$ 300	$ 758,700
5	Drainage System	2,529	LF	$ 200	$ 505,800
				NORTH SHORE PROTECTION SUBTOTAL:	**$ 4,688,090**
	SOUTH SHORE PROTECTION				
6	Mobilization	1	LS	$ 291,180	$ 291,180
7	Steel Sheet Piling	37,500	SF	$ 50	$ 1,875,000
8	Cap (Precast Concrete)	1,728	LF	$ 100	$ 172,800
9	Concrete Facing	1,728	LF	$ 300	$ 518,400
10	Drainage System	1,728	LF	$ 200	$ 345,600
				SOUTH SHORE PROTECTION SUBTOTAL:	**$ 3,202,980**
	MARINA PROTECTION				
11	Mobilization	1	LS	$ 319,595	$ 319,595
12	Temporary Access	1	LS	$ 20,000	$ 20,000
13	Steel Sheet Piling	40,131	SF	$ 50	$ 2,006,550
14	Cap (Precast Concrete)	1,849	LF	$ 100	$ 184,900
15	Concrete Facing	1,849	LF	$ 300	$ 554,700
16	Drainage System	1,849	LF	$ 200	$ 369,800
17	Stairways	2	EA	$ 5,000	$ 10,000
18	Dock Removal & Replacement	2	EA	$ 25,000	$ 50,000
				MARINA PROTECTION SUBTOTAL:	**$ 3,515,545**
				TOTAL:	**$ 11,406,615**
				25% CONTINGENCY:	**$ 2,851,654**
				GRAND TOTAL:	**$ 14,258,269**
				ROUNDED TOTAL:	**$ 14,300,000**

Note: The construction cost estimates do not include any cost for utility relocations, permanent or temporary construction easements, environmental studies, permitting, or engineering design services.

Floodwall Mitigation for 2100 Sea Level Rise Approximate Cost Estimate

ITEM NO.	ITEM DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT COST	COST
	NORTH SHORE PROTECTION				
1	Mobilization	1	LS	$ 478,985	$ 478,985
2	Steel Sheet Piling	63,865	SF	$ 50	$ 3,193,250
3	Cap (Precast Concrete)	2,661	LF	$ 100	$ 266,100
4	Concrete Facing	2,661	LF	$ 300	$ 798,300
5	Drainage System	2,661	LF	$ 200	$ 532,200
				NORTH SHORE PROTECTION SUBTOTAL:	**$ 5,268,835**
	SOUTH SHORE PROTECTION				
6	Mobilization	1	LS	$ 682,310	$ 682,310
7	Temporary Access	1	LS	$ 30,000	$ 30,000
8	Steel Sheet Piling	89,374	SF	$ 50	$ 4,468,700
9	Cap (Precast Concrete)	3,724	LF	$ 100	$ 372,400
10	Concrete Facing	3,724	LF	$ 300	$ 1,117,200
11	Drainage System	3,724	LF	$ 200	$ 744,800
12	Stairways	3	EA	$ 5,000	$ 15,000
13	Dock Removal & Replacement	3	EA	$ 25,000	$ 75,000
				SOUTH SHORE PROTECTION SUBTOTAL:	**$ 7,505,410**
	MARINA PROTECTION				
14	Mobilization	1	LS	$ 1,127,445	$ 1,127,445
15	Temporary Access	1	LS	$ 100,000	$ 100,000
16	Steel Sheet Piling	141,793	SF	$ 50	$ 7,089,650
17	Cap (Precast Concrete)	5,908	LF	$ 100	$ 590,800
18	Concrete Facing	5,908	LF	$ 300	$ 1,772,400
19	Drainage System	5,908	LF	$ 200	$ 1,181,600
20	Stairways	18	EA	$ 5,000	$ 90,000
21	Dock Removal & Replacement	18	EA	$ 25,000	$ 450,000
				MARINA PROTECTION SUBTOTAL:	**$ 12,401,895**
				TOTAL:	**$ 25,176,140**
				25% CONTINGENCY:	**$ 6,294,035**
				GRAND TOTAL:	**$ 31,470,175**
				ROUNDED TOTAL:	**$ 31,500,000**

Note: The construction cost estimates do not include any cost for utility relocations, permanent or temporary construction easements, environmental studies, permitting, or engineering design services.