FINAL INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT / ENVIRONMENTAL IMPACT REPORT (EIS/EIR)

APPENDIX B: COASTAL ENGINEERING

PORT OF LONG BEACH
DEEP DRAFT NAVIGATION STUDY
Los Angeles County, California

October 2021

US Army Corps of Engineers®

Port of LONG BEACH
THE PORT OF CHOICE

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1 Introduction

Presented herein is the Coastal Engineering Report of the Port of Long Beach (POLB) Deep Draft Navigation Study. The purpose of this appendix is to summarize existing physical conditions and present the results of the engineering investigations and analyses conducted to assist in development of the recommended project improvements for the Approach Channel, Main Channel, West Basin, and Pier J Basin Approach of the study.

1.1 Project Area Description

The POLB is located within San Pedro Bay, Los Angeles County, California approximately 20 miles south of downtown Los Angeles. It lies between the Port of Los Angeles to the West, the Los Angeles River mouth and city of Long Beach to the East, and is protected by the Middle Breakwater (18,500 feet) and Long Beach Breakwater (13,350 feet). A map of the Los Angeles region and POLB location is shown in Figure 1-1. The current federal channel includes the entrance at Queens Gate, extending northward along the west of Pier J and east of Pier F, the Navy Mole, and Pier T, shown in Figure 1-2. Further descriptions of the various POLB improvements evaluated as part of this study are provided in the following paragraphs.

Figure 1-1 Study Area Location Map

Figure 1-2 Port of Long Beach Current Federal Channel

1.1.1 Approach Channel

The Approach Channel (teal, Figure 1-3) is currently authorized to -76 feet mean lower low water (MLLW) by 1200 feet wide, and spans from station 192+00 offshore to inside the breakwaters at station 350+00. The channel is predominantly straight, except for a single bend which occurs to the northwest at station 337+00, shortly after passing through the breakwater. The channel then widens to 1300 feet. The gap between the Middle and Long Beach Breakwaters (Queen's Gate) is 1800 feet wide and serves as the main entrance into the Long Beach Outer Harbor of San Pedro Bay. Construction to the current depth was completed by the US Army Corps of Engineers (USACE) in 2001 (USACE 1998). The Approach Channel is utilized by both container and liquid bulk vessels

1.1.2 Main Channel

The Main Channel (Figure 1-3) is the continuation of the Approach Channel from the Long Beach Outer Harbor to the Middle Harbor. It begins at station 350+00, ends at 517+50, and the channel width varies from a minimum of 400 feet at the Navy Mole/Pier F channel bender to a maximum of 1400 feet at the Pier T Turning Basin. The channel is currently authorized to a depth of -76 feet MLLW. This depth was completed by the Port of Long Beach from the start of the Main Channel to the Navy Mole/Pier F channel bender, and most recently had maintenance dredging performed by USACE in 2014. The authorized depth for the Pier T Turning Basin and Berthing area were completed in 2011 by USACE (USACE 2009). The main channel is utilized by both container and liquid bulk vessels, with liquid bulk vessels docking at Pier T.

1.1.3 West Basin

The West Basin (yellow, Figure 1-3) encompasses the approach from the Main Channel Pier T Turning Basin to the Pier T berthing area. It is bounded on the north by Pier T and the west/south by the Navy Mole. Depths currently vary from -43 feet to -80 feet MLLW. The region is not currently a federal area, and is maintained by the POLB. The deeper portions of the basin are located at a sediment borrow pit utilized by the Port of Long Beach in 2016 for slip fill and land reclamation. The West Basin is utilized by only container vessels.

1.1.4 Pier J Basin Approach

The Pier J Approach (orange, Figure 1-3) will construct a route to the northeast off of the Main and Approach Channels, north of the Queen's Gate, and provides access to the Pier J Basin. Small portions of the area have previously been dredged, near the entrance to the Pier J slip and basin, and natural water depths range from -76 feet at the Main Channel to -49 feet MLLW near the Pier J Basin entrance. The Pier J Approach will be utilized by container vessels only.

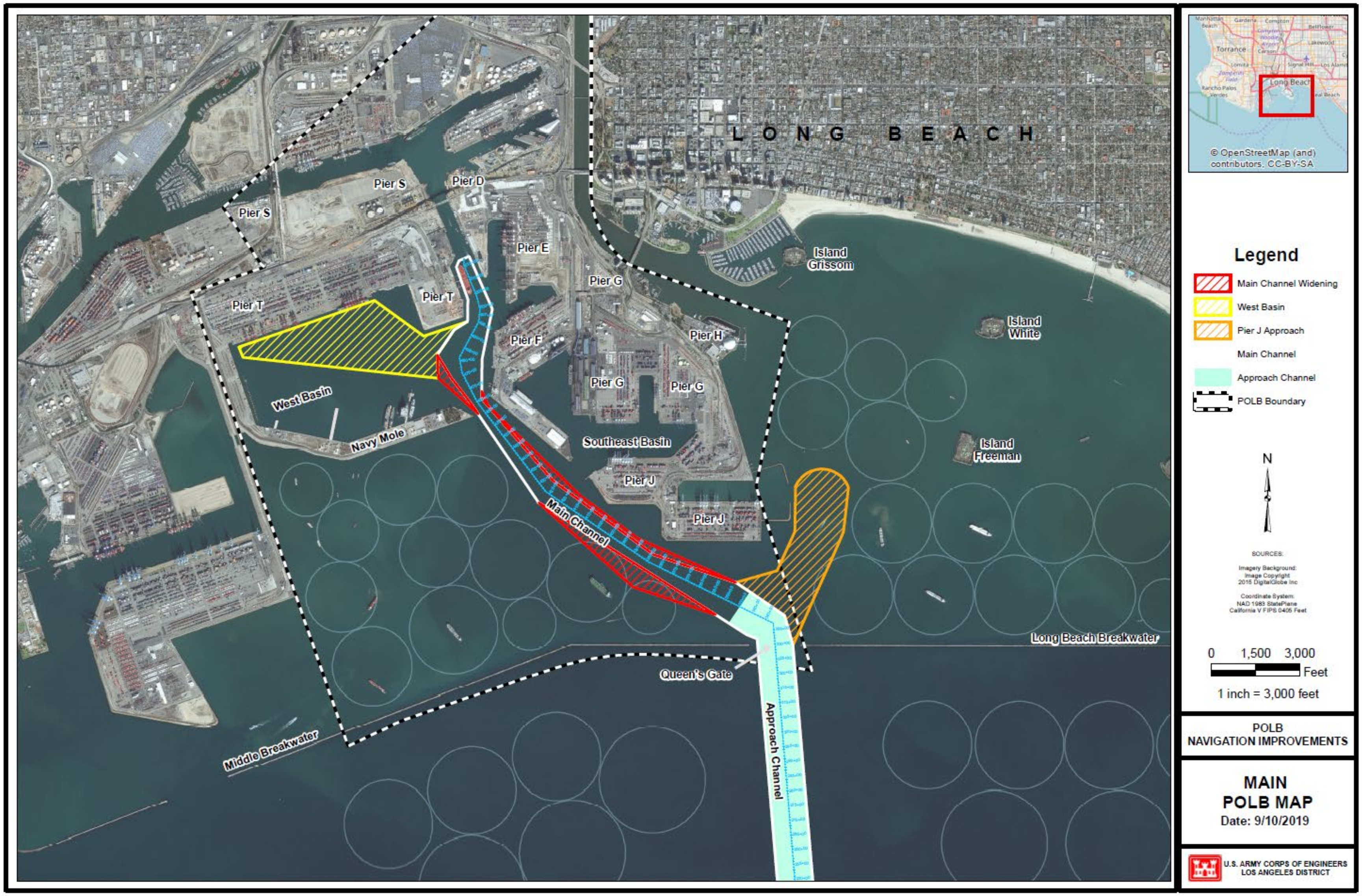

Figure 1-3 Study and Project Area

2 Physical Environment

2.1 Climate

The San Pedro Bay climate is characterized by warm, dry summers and mild winters. Due to Long Beach and San Pedro bays location directly east of the Palos Verdes Peninsula, the area experiences different weather patterns than other nearby coastal communities. Average annual high and low temperatures are 74 degrees and 55 degrees Fahrenheit, with an average temperature of 65 degrees Fahrenheit. Water temperatures in the Port range from 55 – 70 degrees Fahrenheit. Annual precipitation over the port area is 12 inches, the majority of which comes within the winter and early spring months (November to April).

2.2 Winds

The prevailing winds in San Pedro Bay are from the south or west. These are primarily caused by differential heating of water and land, and though the shore faces southward, the onshore (prevailing) wind direction occurs due to the Pacific Ocean being oriented to the west. The most common (50% occurrence) wind speeds in the area are around 6-10 miles per hour, and during the summer onshore winds can peak at 20-25 miles per hour. Occasional strong hot winds from the Great Basin area create an offshore wind condition (Santa Ana Winds) out of the north in the fall and winter months. Winds can reach extremes during this time, especially when occurring in tandem with winter storms. Variations in wind speeds can also occur due to a funneling of winds caused by the nearby Palos Verdes peninsula, intensifying winds in the port area. A wind rose from nearby Long Beach Airport is shown in Figure 2-1.

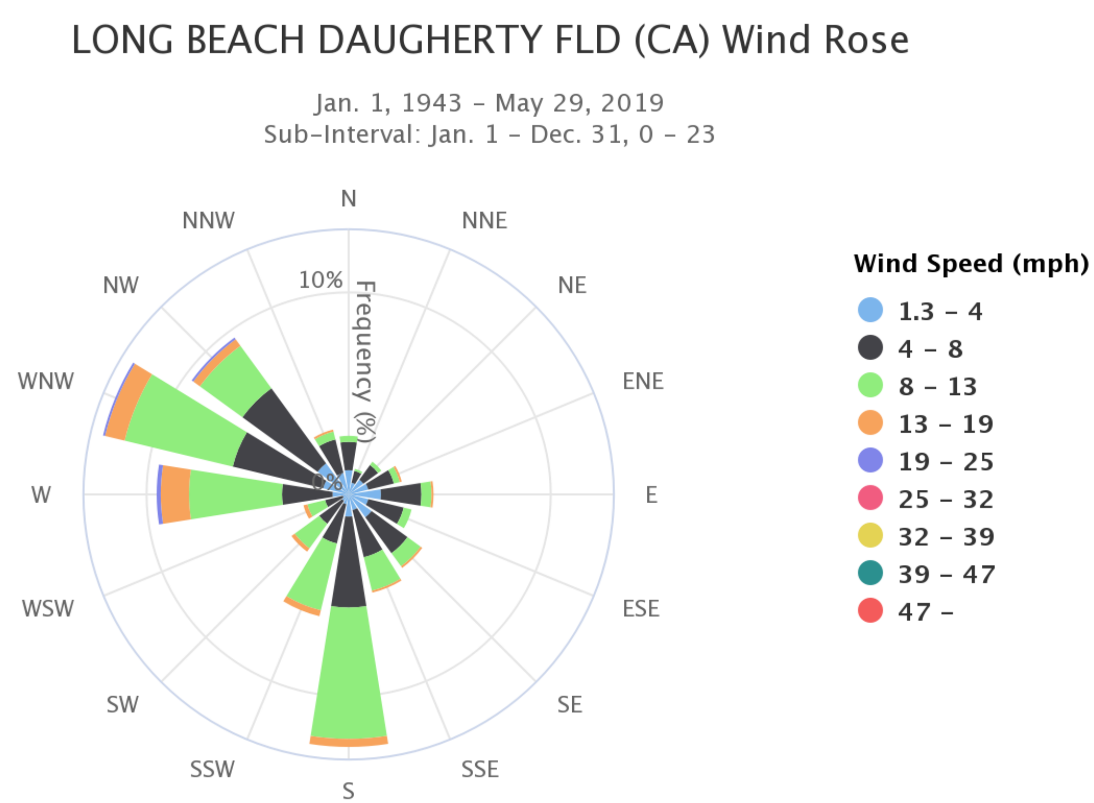

Figure 2-1 Wind Conditions, Long Beach Airport (1943-2019)

2.3 Waves

Due to the sheltering effect of Palos Verdes peninsula, Santa Catalina Island, and San Clemente Island, deepwater waves predominantly approach San Pedro Bay from the west and south. Extratropical storm waves approach from the west, while tropical and pre-frontal sea waves approach from the south. More frequent storm waves from the south occur primarily in the summer, while larger, more threatening storm waves occur less frequently in the winter and originate from the west. The Middle and Long Beach breakwaters provide protection for the port from approaching waves. Outside the breakwaters, waves of 10-12 feet can occur. The typical swell that penetrates into the port has a period upwards of 10 seconds. When wind generated waves occur within the breakwaters they are typically small (< 1 foot wave height), but can reach up to 4 feet with 4 second periods during extreme Santa Ana Winds conditions.

2.4 Tides

Tides along the southern California coastline are of the mixed, semi-diurnal type. Typically, a lunar day (about 25 hours) consists of two unequal high and two unequal low tides. A lower low tide normally follows the higher high tide by approximately seven to eight hours while the time to return to the next higher high tide (through higher low and lower high water levels) is usually approximately 17 hours. Annual tidal peaks typically occur during the summer and winter seasons following a solstice. The increased tidal elevations during the winter season can exacerbate the coastal impacts of winter storms. Tidal datum for the San Pedro Bay are listed in Table 2-1. The mean range of the tide is 3.81 feet, while the great diurnal range is 5.49 feet.

Table 2-1 Tidal Datum at Los Angeles, CA, NOAA Station 9410660

Datum Plane	Elevation, feet, MLLW
Highest Observed Water Level	7.92
Mean Higher High Water (MHHW)	5.49
Mean High Water (MHW)	4.75
Mean Tide Level (MTL)	2.84
Mean Sea Level (MSL)	2.82
Mean Low Water (MLW)	0.94
North American Vertical Datum 1988 (NAVD88)	0.20
Mean Lower Low Water (MLLW)	0.00
Lowest Observed Water Level	-2.73

Source: https://tidesandcurrents.noaa.gov/datums.html?id=9410660

2.5 Currents

Offshore currents, including the California Current, the California Undercurrent, the Davidson Current, and the Southern California Countercurrent (also known as the Southern California Eddy), consist of major large-scale coastal currents, constituting the mean seasonal oceanic circulation with induced tidal and event specific fluctuations on a temporal scale of 3 to 10 days (Hickey 1979).

The California Current is the equator-ward flow of water off the coast of California and is characterized as a wide, sluggish body of water that has relatively low levels of temperature and salinity. Peak currents with a mean speed of approximately 25 to 49 feet per minute occur in summer following several months of persistent northwesterly winds (Schwartzlose and Reid 1972).

The California Undercurrent is a subsurface northward flow that occurs below the main pycnocline and seaward of the continental shelf. The mean speeds are low, on the order of 10 to 20 feet per minute (Schwartzlose and Reid 1972).

The Davidson Current is a northward flowing nearshore current that is associated with winter wind patterns north of Point Conception. The current, which has average velocities between 30 and 60 feet per minute, is typically found off the California coast from mid-November to mid-February, when southerly winds occur along the coast (Schwartzlose and Reid 1972).

The Southern California Countercurrent is the inshore part of a large semi-permanent eddy rotating cyclonically in the Southern California Bight south of Point Conception. Maximum velocities during the winter months have been observed to be as high as 69 to 79 feet per minute (Maloney and Chan 1974).

Maximum flood and ebb tidal velocities occur at Queen's Gate, with surface velocities reaching up to 1.1 feet per second. Tidal circulation is generally clockwise within the port, with flows of 0.2 - 0.3 feet per second in inner channels and 0.3 – 1.1 feet per second at the entrance channel near Queen's Gate. Tidal flushing is the primary influence on water quality in the inner port areas.

2.6 Climate Change

2.6.1 Sea Level Change

Sea level change is an uncertainty, potentially increasing the frequency of extreme water levels. Planning guidance in the form of an USACE Engineering Regulation (ER), USACE ER 1100-2-8162 (USACE 2019), incorporates new information, including projections by the Intergovernmental Panel on Climate Change and National Research Council (IPCC 2007, NRC 2012) , and USACE Engineering Pamphlet (EP) 1100-2-1. Planning studies and engineering designs are to evaluate the entire range of possible future rates of sea-level change (SLC), represented by three scenarios of "low," "intermediate," and "high" sea-level change. ER 1100-2-8162 also recommends that a National Oceanic and Atmospheric Administration (NOAA) water level station should be used with a period of record of at least 40 years. The use of sea level change scenarios as opposed to individual scenario probabilities underscores the uncertainty in how local relative sea levels will actually play out into the future. At any location, changes in local relative sea level (LRSL) reflect the integrated effects of global mean sea level (GMSL) change plus local or regional changes of geologic, oceanographic, or atmospheric origin.

- "Low" rate of sea-level change is equal to the historic rate of SLC.
- "Intermediate" rate of sea-level (ISL) change is based on the modified NRC curve I and using the current estimate of 1.7 mm/year for GMSL change, the following equation

  $$E(t) = 0.0017t + bt^2$$

  in which t represents years, starting in 1986, b is a constant, and $E(t)$ is the eustatic sea level change, in meters, as a function of t.

Manipulating the above equation to account for the fact that it was developed for eustatic sea level change starting in 1992, while projects will actually be constructed at some date after 1992, results in equation

$$E(t_2) - E(t_1) = 0.0017(t_2 - t_1) + b(t_2^2 - t_1^2)$$

Where t_1 is the time between the project's construction date and 1992 and t_2 is the time between a future date at which one wants an estimate for sea level change and 1992 (t_2 = t_1 + number of years after construction)

- "High" rate of sea-level change (HSL) is based on the modified NRC curve III and the above equations.

Using the USACE Institute of Water Resources (IWR) Sea Level Change calculator (based on the above equations) and data from Los Angeles, CA NOAA gage 9410660, provides an estimated sea level change of 0.00272 feet per year. Figure 2-2 shows the relative sea level change projections for the three SLC scenarios. As shown in Table 2-2, projecting the three rates of change to the year 2077, which corresponds to a 50 year period of analysis, provides us with predicted low level rise of 0.14 feet, intermediate of 0.67 feet, and high level rise of 2.36 feet. Any rises in sea level are a net positive for deep draft navigation due to a reduction in future dredging needs.

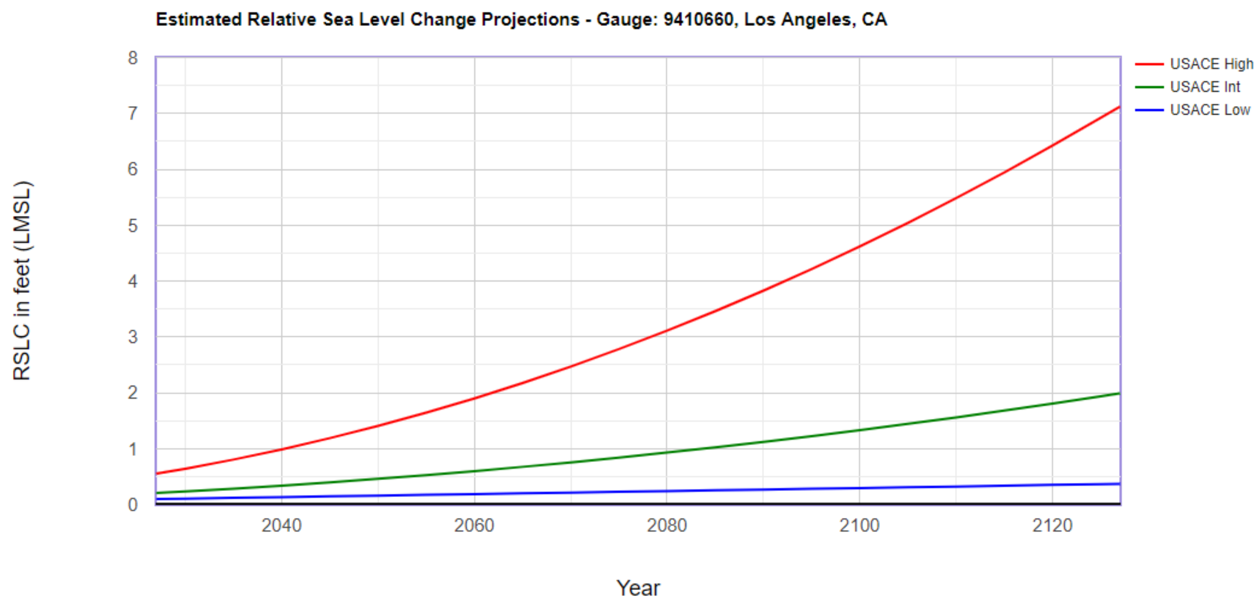

Figure 2-2 Relative Sea Level Rise Projections, Los Angeles, CA, NOAA gage 9410660

Table 2-2 Predicted Relative Sea Level Change, Los Angeles, CA, NOAA gage 9410660

9410660, Los Angeles, CA
NOAA's 2006 Published Rate: 0.00272 feet/yr
All values are expressed in feet relative to LMSL

Year	USACE Low	USACE Int	USACE High
2027	0.10	0.20	0.55
2030	0.10	0.23	0.64
2035	0.12	0.28	0.80
2040	0.13	0.34	0.99
2045	0.14	0.39	1.19
2050	0.16	0.46	1.41
2055	0.17	0.52	1.64
2060	0.19	0.60	1.90
2065	0.20	0.67	2.17
2070	0.21	0.75	2.47
2075	0.23	0.84	2.78

Year	USACE Low	USACE Int	USACE High
2080	0.24	0.93	3.11
2085	0.25	1.02	3.46
2090	0.27	1.12	3.83
2095	0.28	1.22	4.21
2100	0.29	1.33	4.62
2105	0.31	1.44	5.04
2110	0.32	1.56	5.48
2115	0.34	1.68	5.94
2120	0.35	1.81	6.42
2125	0.36	1.94	6.92
2127	0.37	1.99	7.12

2.6.2 Impact on Local Service Facilities

The POLB has an extensive Climate Adaptation and Coastal Resiliency Plan (CACRP) (POLB 2016) in accordance with California Assembly Bill 691 (2014) to manage the direct and indirect risks associated with climate change and coastal hazards. This plan identifies strategies for adaptation to climate change impacts throughout the Port's Harbor District. Port guidelines and policies for future planning studies are influenced by adding sea level rise analysis to all future harbor development permits. The POLB CACRP has analyzed the impact from SLR to all Local Service Facilities (LSF) through the year 2100, which includes inundation modeling for a sea level rise of 55" (4.6') in conjunction with a 100-year storm event. Presently, there are no POLB facilities that will be impacted within the planning horizon of this project (50 years) for any of the USACE SLR curves. LSFs are similarly not at risk through the adaptation horizon of the project (2077-2127) for the low or intermediate SLR curves, however the risk is uncertain beyond 2100 for the high SLR curve.

The POLB CACRP addresses the port's plans to address future sea level rise through:

- Governance: By adding language to overarching policies/plans and in technical guidelines, both planners and designers will start thinking about climate change from the start of a project
- Initiatives: By introducing initiatives, stakeholders and Port staff can continue to evaluate impacts on operations and physical damage that are associated specifically with climate change
- Infrastructure: By modifying existing infrastructure, such as strengthening sea walls or raising electrical equipment, the Port can be more prepared for future climate-related events.

2.7 Sediment

Sediments in the study area comprise sand, silt, and clay of varying proportions. Gravel, cobble, and debris may be encountered in limited quantities, within project depths. A thin layer of semi-floating silt and mud (clay) exists atop the ocean bottom surface, in areas of less disturbance or where recent man-made activities (e.g., dredging and harbor modifications) have not altered the surrounding natural subsurface conditions. This layer is approximately 2 to 6 inches thick and overlies a very loose unconsolidated layer of sand or silt. Underlying this shallow surface sediment are thick alternating layers of silty sand and sand with some silt, with some occasional thin layers of clay. Sandy portions of the sediment are predominantly fine grained, rounded and composed of quartz and mica minerals. Minor thin layers and localized lenses of gravel and clays are present within the sandy sediment and are found mostly within the upper 50 feet; some cobble and boulder size stone (up to 3 feet in maximum dimensions) may be present seaward of the breakwater and may be encountered in the Approach Channel. The sediment is unconsolidated and increases in density with increasing depth. A deepening project ending in 2001 encountered material harder to dredge (consolidated material) than anticipated in the approach channel; Cone Penetration Testing (CPT) will be performed during PED to ensure the dredgeability of material in the project area. For more information on sediment characteristics see Appendix C.

2.8 Sediment Transport

The San Pedro Bay has a stable bathymetry, with very little sedimentation and sediment transport. The area is located at the beginning of the San Pedro Littoral Cell (Patsch and Griggs 2006), where sediment transport is blocked from the north and west by the Palos Verdes peninsula, and the stability created by the breakwaters limits accretion or loss of sediment. Since the Los Angeles River was diverted in 1923 to its present course, the sediment load carried by the river is diverted to areas away from the port facilities. The main sources of sedimentation within the inner port and berths is prop wash from the large propellers of commercial vessels along with the small amounts of sediment inflow from the channel through Queen's Gate. Recent surveys by USACE show that even the exterior of the breakwater is very stable, as since the deepening of the Approach Channel by USACE in 2001 there has been only a small 40,000 cubic yard shoal of sedimentation in the channel, which currently does not impact navigability. Maintenance dredging within the port harbor and berths is performed occasionally by the POLB under a Waste Discharge Requirements Authorization from the State of California Regional Water Quality Control Board for maintenance dredging, which is renewed every five years (most recently in 2018).

3 Design Considerations

3.1 Vessel Inventory and Forecast

Vessels calling port in the POLB include container ships and liquid bulk tankers. The port currently handles more than 7 million twenty-foot equivalent units (TEUs) in container traffic, more than 75 million tons of cargo, and has over 2,000 vessel calls. As shown on Figure 3-1, from 1995 through 2017, total container throughput at the Port increased from about 2.84 million TEUs to about 7.54 million TEUs, representing an increase of 165%, or an annual compound growth rate of 4.54%. Strong growth in throughput is projected to continue until the Port's facilities reach a capacity of about 15 million TEUs, which is anticipated in 2035. Future land-based operations capacity will be added as part of the POLB "Port Master Plan," a long-range plan to establish policies and guidelines for future development within the POLB. Liquid forms of bulk cargo include gasoline, miscellaneous chemicals, and the primary liquid bulk commodity of crude oil imports. Crude oil imports have varied with no discernable trend from 2006 through 2016, and projected imports are not anticipated to be significantly different from historical volumes.

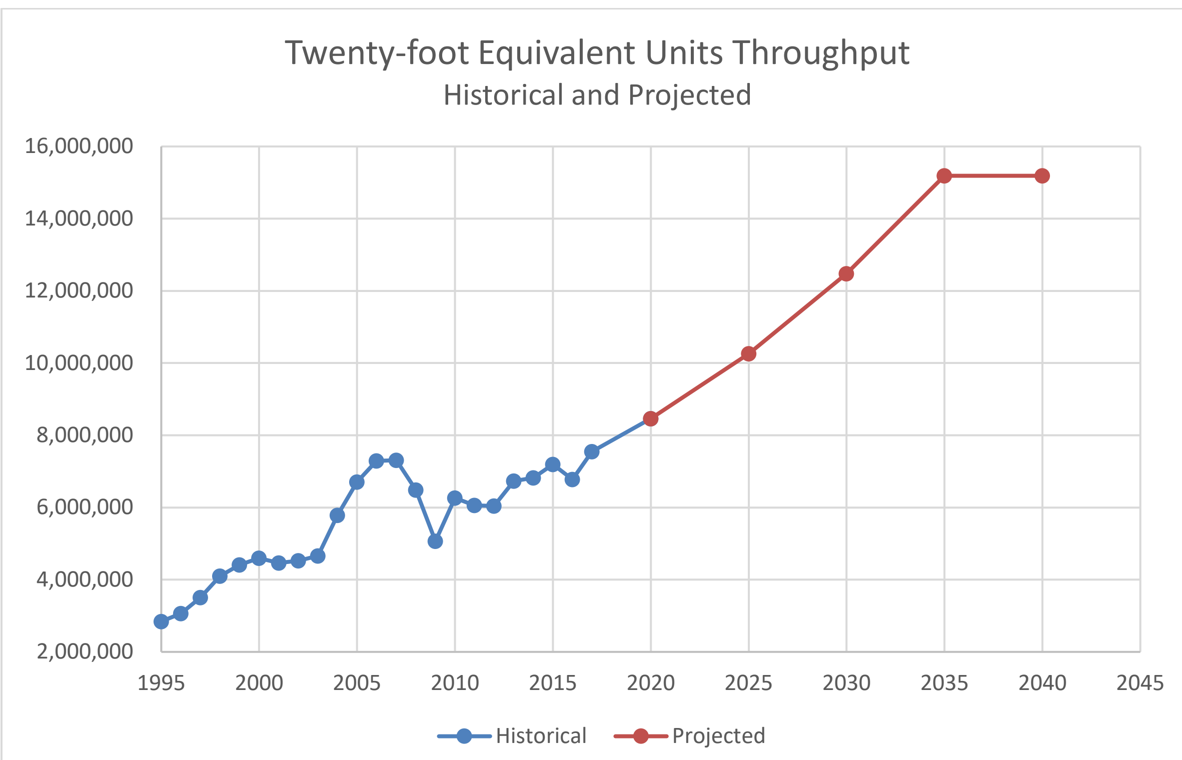

Figure 3-1 Port of Long Beach Container Unit Throughput, Historical and Projected

Vessel speeds in the approach channel are typically 10 knots, with a maximum allowable speed of 12 knots. As vessels approach the Queen's Gate they slow to 8 knots in preparation for the turn after passing through the breakwater. After, their speed exiting the turn is typically around 3 knots, which they maintain through the rest of the Main Channel area. Upon entering the Pier T Turning Basin, the West Basin, or the Pier J Approach, tugboats take over speed and maneuvering for the vessel.

3.2 Design Vessel

Vessels are progressively getting larger and future vessel fleet forecasts continue to show this trend. The container and liquid bulk design vessels were determined based on input and forecasts from the Port of Long Beach, professional judgment of Harbor Pilots, and data collection and analysis by the Planning Center of Expertise for Deep Draft Navigation supported by the Institute for Water Resources. The container design vessel characteristics are 1,300 feet long overall, summer load line of 52 feet, 193-foot beam, 188,000 deadweight tonnage (DWT), and 18,000-19,000 twenty-foot equivalent units (TEU). This is roughly the equivalent to a “Triple E” or “Post-Panamax Generation IV” containerized carrier. The liquid bulk design vessel characteristic are 1,100 feet long overall, 200-foot beam, 325,000 DWT, and 70 feet summer load line draft. This vessel is within the Very/Ultra Large Crude Carrier class also known as VLCC and ULCC.

3.3 Ship Simulation Study

A ship simulation was performed in accordance with ER 1110-2-1403 to evaluate channel navigability of the approach and main channels. A site visit to the port was performed to observe navigation conditions and take photographs for the model’s visual scenes. The ship simulations were conducted in Vicksburg, Mississippi at the Coastal and Hydraulics Laboratory of the Engineer Research and Development Center (ERDC). Two POLB pilots, experienced in navigating the Port of Long Beach channels, participated in the effort. Various conditions of ship size, wave, and current conditions were tested. Model vessels readily available in the ERDC library were chosen for the feasibility level testing, including the containership *Superium Maersk* (length 1,300 feet, beam 191 feet, draft 53 feet)and the VLCC *Elizabeth I. Angelicoussi* (length 1089 feet, beam 190 feet, draft 70 feet). Both of these model vessels are similar to the design vessels, and were good approximations for the simulation testing. As a result of the study, based on feedback from the harbor pilots using the larger design vessels, bend easing of portions of the Main Channel was added to the scope of the project. The pilots also concurred, based on their experience in the simulator, that the recommended design depths (as seen in the following section) were acceptable for the new design vessel sizes.

3.4 Recommended Design

The current POLB standard of operation is to allow only one-way traffic in and out of the port. The USACE Engineering Manual on deep draft navigation (EM 1110-2-1613) recommends a design channel width for one-way ship traffic of a dredged trench type channel of 3.25 times the design beam width for current speeds between 0.5 and 1.5 knots (at Queen’s Gate) and 2.75 for current speeds between 0.0 and 0.5 knots (inner channels). Thus, the navigation channel will require a width of 650 feet at Queen’s Gate and 550 feet for inner channels for liquid bulk design vessels moving under their own power, with container vessels requiring less. These widths are reached for all channel designs.

Channel depth design, as directed by EM 1110-2-1613, "is determined … by an economic analysis of the expected project benefits compared with project costs. Once the design ship and channel depth are determined [by economic analysis], the safety and adequacy of the channel depth for operational design ship transits will be determined". An adequate design channel depth is determined by the design vessel draft and a set of underkeel safety allowances, as well as needs of the local harbor pilots. A summary of the underkeel safety allowances follows, and can be seen in Figure 3-2:

- Minimum safe clearance. A minimum of two additional feet in depth is required under the keel after all other requirements for depth have been met. This is needed to avoid damage to ships propellers from sunken timbers and debris, to avoid fouling of pumps and condensers by bottom material, reduce propeller wash effects, provide allowance for spot shoals, and offset poor steerage effects caused by under keel clearance close to the seabed.
- Freshwater sinkage. Passing from seawater into a freshwater system will increase vessel displacement. However, due to high salinity in the port, fresh water sinkage is anticipated to have a negligible effect on vessel displacement.
- Trim. The difference between the vessel draft at midship and the bow or stern is termed trim. It is often complex and expensive to keep a ship at even keel and a nose down vessel does not maneuver well, so a vessel is often loaded to keep the stern lower than the bow. For the Port of Long Beach, this provision is not necessary, due to the needs and requirements of local pilots.
- Squat. A moving ship causes a drawdown of the water surface causing the vessel to ride lower relative to a fixed datum. Squat is dependent upon many variables including vessel speed through the water, water depth, and vessel to channel blockage ratio. Vessel speed controls this design value, and calculation is provided in EM 1110-2-1613.
- Tidal and wave effects. In order to eliminate tidal delays in the waterways an allowance is included for transits during low tides and effects from wave motion.

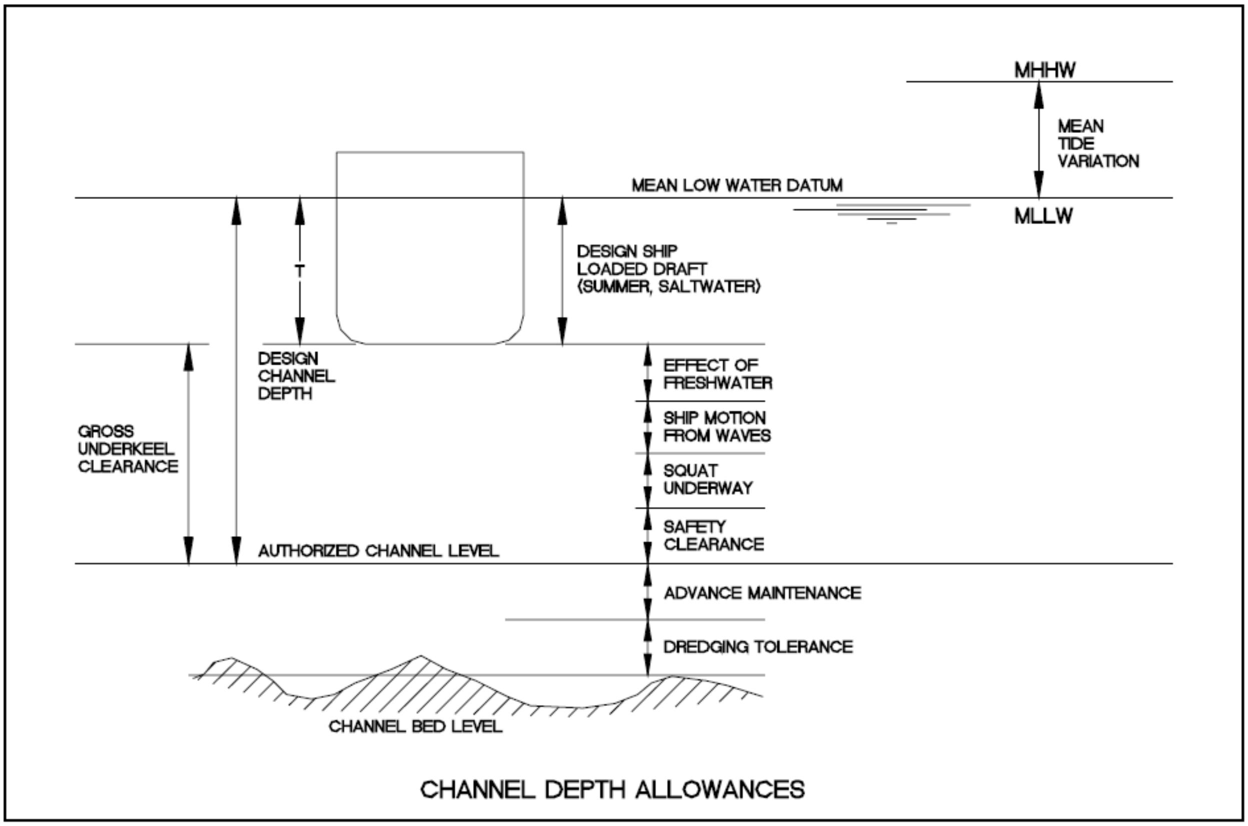

Figure 3-2 Design Channel Depth Allowances and Underkeel Clearance

3.4.1 Approach Channel

For the approach channel, depths are driven by the draft of the design liquid bulk vessel. The total underkeel clearance required by EM 1110-2-1613 is the liquid bulk vessel draft of 70 feet, plus the 2 feet of safe clearance, 2.5 feet of squat effects, and 4 feet from local tidal and wave effects, for a total of 78.5 feet. The economic analysis justifies a design depth of -80 feet MLLW, which meets minimum operational safety for navigability of both design ships in the channel.

3.4.2 Main Channel

In the main channel, the liquid bulk vessel slows down, decreasing the squat effects to 0.5 feet. Wave and tidal effects are also reduced to 2 feet due to the sheltering of the Middle and Long Beach Breakwaters. These effects, plus 2 feet of safe clearance, produce a total underkeel clearance required of 74.5 feet. The current depth of the main channel is -76 feet MLLW. Based on pilot feedback from the ship simulation study, bend easing will be done to several areas of the main channel, to accommodate the increased turning radius of the larger design liquid bulk and container vessels. EM 1110-2-1613 guidance for channel turns and bends recommends a turn width increase ranging from 0-2 times the ship beam, depending on the angle of the turn/bend in the channel. The proposed bend easing would comply with the worst case scenario of 2 times the ship beam throughout the main channel, even though that multiplier is not required for the turn angles present (note: the Navy Mole channel bender is classified as an ‘angle turn’, not requiring an increase in channel width). The regions where bend easing will occur are shown in Figure 1-3, which includes west and east sides of the Pier F/Navy Mole channel bender, western portion of the main channel from station 355+00 to 425+00, and the east edge of the main channel from station 350+00 to 460+00. The current design depth of -76 feet MLLW will be maintained, as justified by the economic analysis.

3.4.3 West Basin

Container vessels enter the west basin under control of tugboats at slow speeds. Due to this, squat effects can be assumed small, and the underkeel depth only needs to account for an addition of 2 feet of clearance and tidal/wave effects. The economic analysis justifies a federally authorized design depth of -55 feet MLLW in the area, which is larger than the required underkeel clearance for safe navigability. Currently, much of the west basin is already at or deeper than this design depth, and approximately 30% of the area will require dredging, located at the north and south ends of the area shown in Figure 1-3.

3.4.4 Pier J Basin Approach

The channel alignment design of this area was chiefly driven by feedback from local port pilots prior to and during the ship simulation study and was justified by the economic analysis. Container vessels will enter the Pier J Basin Approach under control of tugboats at slow speeds. Due to this, squat effects can be assumed small, and the underkeel depth only needs to account for an addition of 2 feet of clearance and tidal/wave effects. The economic analysis justifies a design depth of -55 feet MLLW in the area, which surpasses underkeel safety considerations. A transitional depth from the Approach and Main Channel design depths to the Pier J Basin Approach design depth will also be created.

Since this will be a new federal channel, design considerations from EM 1110-2-1613 need to be taken into account to ensure this locally and economically driven design meets safe navigation criteria. Pier J will only need to accommodate the design container vessel, with a beam of 193 feet, and will allow one-way ship traffic. As previously mentioned, the channel widths throughout the entire project area meet minimum safe navigability requirements for one-way traffic. The angle of the turn moving from the Approach Channel to the Pier J Approach requires an increase width factor of 1 times the ship beam, resulting in a needed width in the turn of 820 feet, which the current design meets. The turning basin at the head of the Pier J Approach needs to be 1.2 times the length of the design vessel, or 1560 feet for the project design container vessel, which the turning basin diameter surpasses. The depth for the turning basin has the same safety requirements as the channel.

3.5 Utilities

There are not any utility relocations anticipated for this project. The only utility line crossing a portion of the channel is at the border between the middle and inner port areas. This is past the liquid bulk terminal at Pier T, and outside the project area.

3.6 Slope Stability

The recommended side slope for the federal channel is 1 vertical on 3 horizontal. This has been historically used for projects within the POLB and have proven stable for the sediment characteristics in the region. The currently proposed channel configuration for all regions of the project will not present any concerns for undercutting of structures. However, at the Queen's Gate entrance hydraulic dredging will be minimized for two reasons: most of the channel is currently at the design depth except locations away from the side slopes of the structure, as seen in Figure 3-3; and to minimize any risk of undercutting nearby structures, the Middle and Long Beach Breakwaters. Additionally, maintenance dredging is contracted for FY21 in the area, which may result in minimal to no dredging required in the area when project improvements are to be completed. Please see further analysis on slope stability in Appendix C.

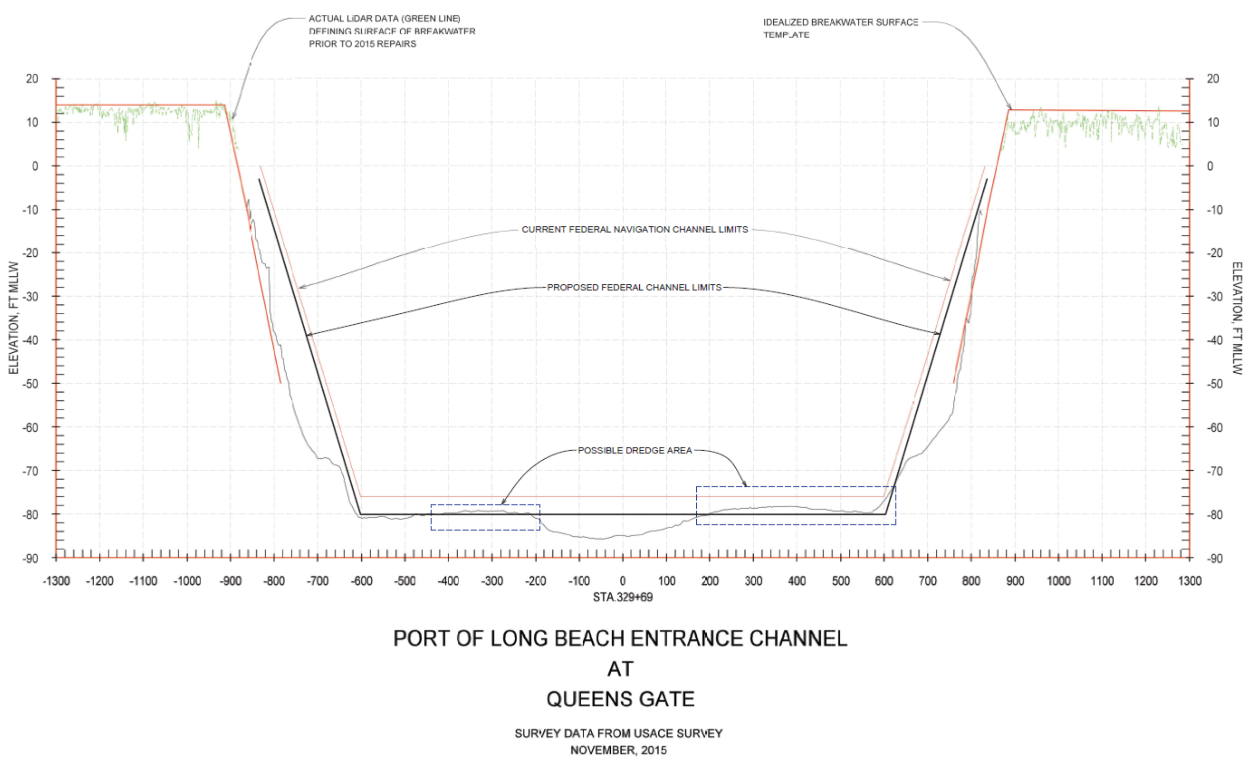

Figure 3-3 Cross-section of POLB Approach Channel and Breakwaters at Queen's Gate, with current and proposed federal navigation channel limits

3.7 Dredging

3.7.1 Dredged Material Quantities

The maximum allowable dredging depth for each alternative will include 2 feet of over dredging tolerance beyond the project design depth to account for inaccuracies during dredging operations. Table 3-1 lists the design depth, area, and dredged volume in each project area (with a reference to their footprint color from Figure 1-3). The total volume including over-depth is calculated using survey data, and is not expected to increase between current date and project construction (due to previously discussed low sedimentation of the area).

Table 3-1 Required Dredging Volumes for Recommended Design Depths

Project Area	Design Depth (feet, MLLW)	Area (square feet)	Average Cut Thickness (feet, approx.)	Total Volume Including Over-depth (cubic yards)
Approach Channel (Teal)	-80	18,780,550	3.8	2,600,000
Main Channel (Red)	-76	4,532,405	6.3	1,065,000
West Basin* (Yellow)	-55	3,010,000*	6.4	717,000
Pier J Approach (Orange)	-55	8,938,890	5.7	1,873,000
Pier J Approach, Transition (Orange)	-68	1,563,000	13.8	800,000
Total				7,055,000

*West Basin Area is approximately 30% of yellow footprint from Figure 1-3, as the majority of the area is to design depth.

3.7.2 Dredged Material Management

The USACE maintains a Dredged Material Management Plan for the Los Angeles Region which outlines strategies for management of dredged sediments from local harbors. Three locations are available for dredged material placement. A nearshore placement site near Sunset beach will be utilized. This area is a borrow pit created during USACE projects nourishing Surfside and Sunset beaches, and can contain approximately 2.5 million cubic yards of material. The U.S. Environmental Protection Agency designated Ocean Dredged Material Disposal Sites LA-2 and LA-3 will also be utilized. LA-2 is located 10 miles southwest of the project site, and has an annual maximum disposal volume of 1.0 million cubic yards. LA-3 is located 25 miles southeast and has an annual maximum of 2.5 million cubic yards (EPA SMMP 2011). These are standard, non-beneficial reuse sites. It is assumed the project will have access to place 0.9 million cubic yards and 2.2 million cubic yards at the locations per year. Relative placement site locations are shown in Figure 3-4. Dredged material from the Approach Channel will be placed at the nearshore site, with an extra 0.1 million cubic yards going to LA-2 after the nearshore site is full. All other dredging operations will place material at LA-2 and LA-3.

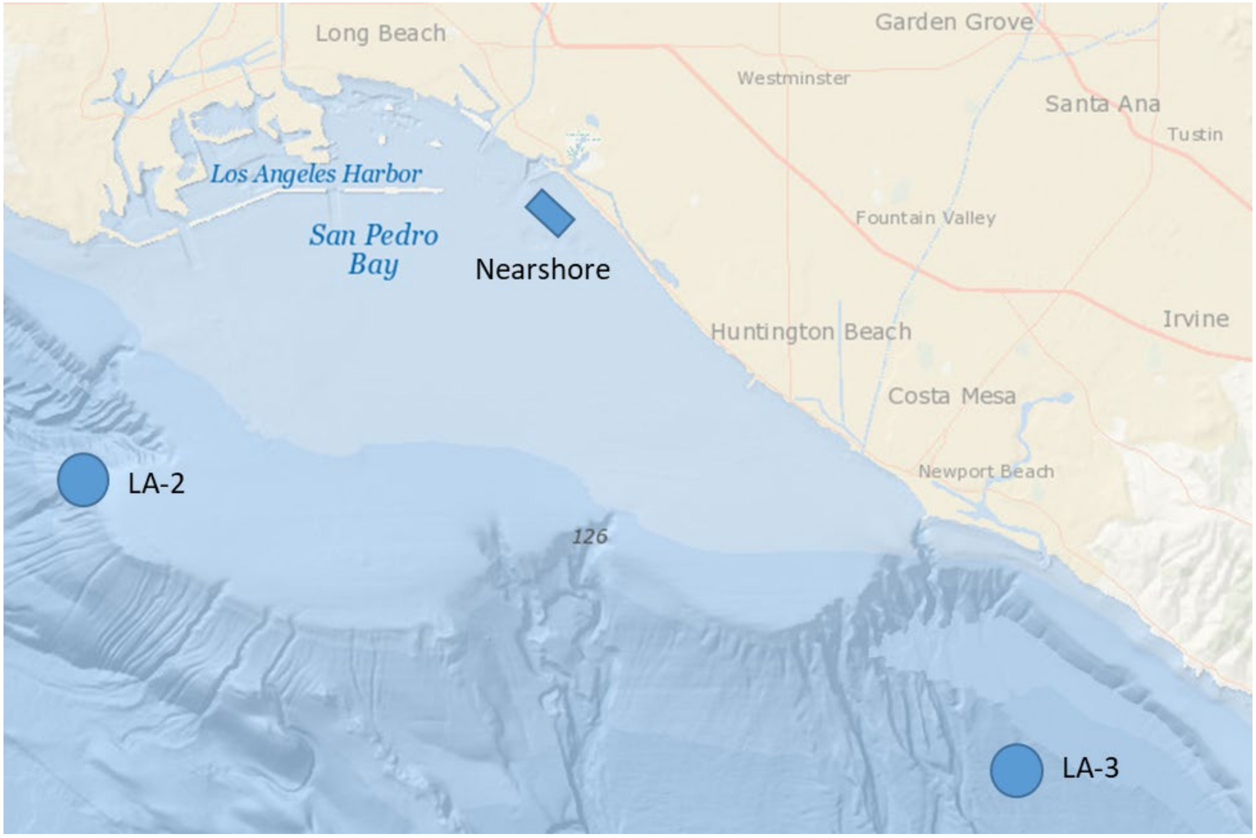

Figure 3-4 Dredging Placement Sites, Surfside/Sunset Nearshore and EPA LA-2/LA-3

3.8 Effects of Recommended Plan

The recommended design is not expected to cause a change in wave energy transmission from the exterior to inner harbor regions, as there is expected to be no decrease in wave attenuation or protection provided by the Middle and Long Beach Breakwaters. This is due to the future with project (FWP) depth increase in the entrance channel being small relative to the channel dimensions through Queen's Gate, which is also small relative to the overall size of the harbor complex. Additionally, the ship simulation study did not indicate any added wave motion due to channel modifications. Following recent repairs by USACE in 2019 the breakwaters are currently fully performing as designed, with crest elevation of 14 feet MLLW; this is expected to continue in FWP conditions. If the most aggressive sea level change ('USACE High' of Table 2-2) of 2.3 feet at 50 years occurs, the structures would maintain their designed performance in wave attenuation and protection for the life of the project, with no impact to project area function. The recommended design will have little to no impact on water circulation and current flow in the harbor and will not affect tidal flushing and water quality.

4 Construction

4.1 Equipment and Production

4.1.1 Approach Channel

The Approach Channel will be dredged using a large hopper dredge. In selecting this dredging equipment, vessel traffic, disposal site restrictions, hauling distance, and cost are considered. The hopper dredge is the equipment of choice in heavy traffic and is capable of high productions resulting in a cost effective choice. The hopper dredge maneuverability is excellent and is therefore more mobile in traffic. The hopper dredge does not need scows, thus equipment footprint in the area near Queen's Gate is reduced and vessel traffic impacts are reduced. Reduction of traffic impacts near Queen's Gate is encouraged by the project requirements. The production rate of a hopper will vary between 15,000 and 17,500 cubic yards per day, depending on distance traveled to placement site, LA-2 and nearshore respectively.

4.1.2 Other Locations

All other work within the port will be performed by an electric clamshell as a mitigation measure for air quality. The clamshell dredge is economical and suitable for site conditions: selected dredge must run on electric power, a large part of the required deepening of the sea floor runs along the wharf face, and dredging depths are -55 feet and greater. There is an existing electric substation near Pier T that can serve as a power supply to the electric clamshell dredge when working on the West Basin and Main Channel Bend Easing. A new electrical substation will be built at Pier J for work in the Pier J Approach. The clamshell production rate is expected to be 6,000 cubic yards per day.

4.2 Dredging Schedule

Project construction is expected to last two and a half years, and the expected construction sequence is shown in Figure 4-1. The Approach Channel will be completed in year one, utilizing the Nearshore placement site and LA-2. The rest of the project areas, completed by the clamshell dredge, will take approximately 2.5 years. One limiting factor on production is the disposal sites LA-2 and LA-3, due to their yearly disposal capacity. Another is the production rate that the clamshell dredge can achieve.

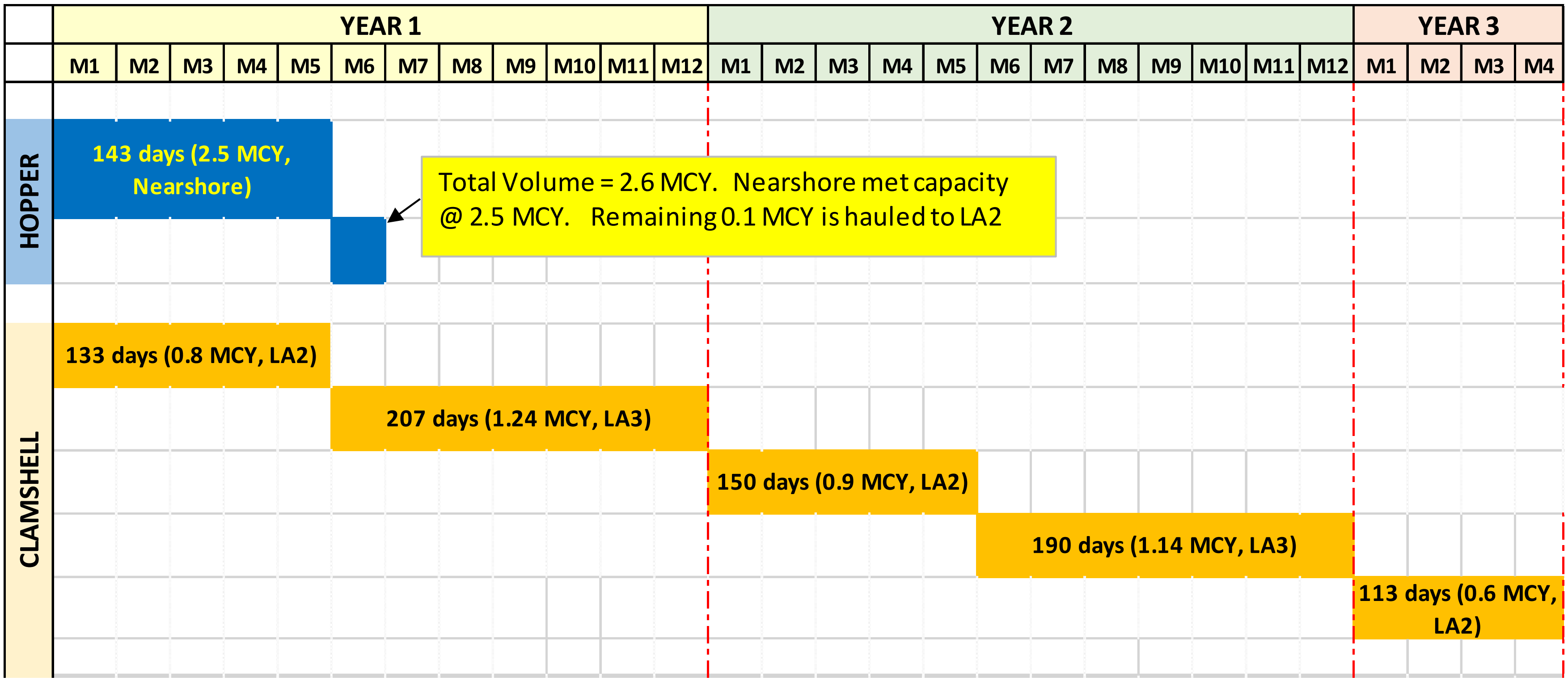

Figure 4-1 Construction Sequence, Port of Long Beach Deep Draft Navigation Study

5 Operations and Maintenance

Historically, channel deepening projects result in a net increase in operation and maintenance (O&M) dredging requirements. This has been well documented over multiple historic deepening and widening projects (Rosati 2005; Vincente and Uva 1984). Sedimentation will result in the need for O&M dredging at the recommended depth over the project life. The main sources of sedimentation within the inner port and berths is prop wash from the large propellers of commercial vessels along with the small amounts of sediment inflow from the channel through Queen's Gate.

O&M within the harbor and berth areas of the port are maintained by the Port of Long Beach Authority under a Waste Discharge Requirements Authorization from the State of California Regional Water Quality Control Board for maintenance dredging, which is renewed every five years (most recently in 2018). From 2014-2018 POLB authority maintenance dredging amounted to only 170,000 cubic yards, the majority of which was placed in LA-2. O&M for the Approach Channel is performed by the USACE, while the Main Channel has been maintained through collaboration of POLB and USACE. The USACE maintains a Dredged Material Management Plan for the Los Angeles region, which outlines strategies for management of dredged sediments, which includes offshore disposal (LA-2). Since navigation improvement dredging of the Main Channel in 2014 (as of writing of this report, a 7-year period), there has been no sedimentation within the channel requiring maintenance. For the Approach Channel, since navigation improvements completed in 2001 (as of writing of this report, a 20 year timeframe), there is presently a 40,000 cubic yard shoal within authorized channel limits, which does not impact navigability, and is scheduled for removal in a FY21 contract. Currently, O&M dredging of the federal channels at the POLB is anticipated to occur every 25 years. An increase in the frequency of O&M dredging is not anticipated within the harbor and berths, current federal channels, or the new Pier J Approach due to the implementation of the Recommended Plan.

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