Central Coast Emerging Industries Waterfront Siting + Infrastructure Study

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REACH

MOTT MACDONALD

REACH

Ideas + Action for a Thriving Central Coast

Between the nation's western space launch range at Vandenberg Space Force Base and the first tranche of Pacific offshore wind energy leases off Morro Bay, two fast-growing global industries are springing up on the Central Coast of California.

These two centers of gravity — one in a brand new industry and one with significant roots here — hold incredible potential for creating thousands of new good-paying jobs and spurring economic growth across our region.

The federal government has targeted 30 gigawatts of offshore wind power by 2030, and the development slated off Morro Bay, estimated at 3GW, is the largest to date on the West Coast. In the same timeframe, U.S. investment in the industry is expected to top $1 billion.

The global space industry is exploding, having grown 70 percent over the last decade and forecast to continue surging to $1 trillion by 2040. As the nation and a growing number of commercial ventures race to compete in a new high-stakes global space age, the U.S. Space Force expects launches at Vandenberg, now about once a month, to continue to grow in coming years.

The prospects for these industries in our region are substantial. Both industries, however, require significant infrastructure to thrive, a fact that has been underscored in regional work on the Vandenberg space master plan, REACH's offshore wind economic impact study, and extensive industry engagement.

Moreover, both industries specifically require waterfront infrastructure: for offshore wind, it's the shoreside facilities where the assembly, operations and maintenance jobs take place; for space, it's barging in the rockets and other launch components that are too large to travel by land or air.

That's why we joined together to undertake this study: to take a region-wide look at opportunities to enhance or add to the region's existing waterfront infrastructure to support the growth of these future-facing industries on the Central Coast and to capture the associated jobs and economic benefits.

On offshore wind, the report identifies potential locations for a variety of facilities, from basic boat docks to larger-scale fabrication and assembly stations. On space, it pinpoints two alternatives: modest updates to the existing Vandenberg boat dock versus a substantial upgrade to accommodate different vessels and new operations.

To be clear: this report lays out what *could* be done, not what *should* be done. Our goal with this study was to present the breadth of possible options on the Central Coast for further examination and consideration by a range of stakeholders and to inform decision-making on policy and investment by the public and private sector. Though additional work remains to be done, we are collectively eager to further explore these options and ultimately drive forward jobs and investment for our region.

Both space and floating offshore wind remain largely uncharted territory, and the Central Coast has a momentous opportunity to pioneer both domains. Let's stake our claim.

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We are grateful for the engagement of our waterfront infrastructure owners and operators, space and offshore wind industry users, and community stakeholders.

The opinions and conclusions expressed in this report are those of the authors and do not necessarily represent those of REACH or other partners in the study.

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EXECUTIVE SUMMARY

1 EXECUTIVE SUMMARY

The Central Coast Emerging Industries Waterfront Siting and Infrastructure Study was commissioned by the Regional Economic Action Coalition (REACH) through funding by the County of San Luis Obispo (SLO), the County of Santa Barbara (SB), and the City of Morro Bay. On Dec. 6, 2022, the federal government held the first U.S. West Coast offshore wind auction to lease an estimated 3GW of floating offshore wind (FOW) power off the Central Coast. The State of California has set a goal of reaching 2-5GW of offshore wind power by 2030 and 25GW by 2045. However, there are no public studies investigating in detail how waterfront infrastructure constructed in SLO or SB Counties can support the emerging offshore wind industry. A Central Coast waterfront infrastructure assessment for offshore wind is needed because infrastructure in the two-county area was historically developed to serve other industries such as commercial and recreational fishing, oil and gas, and recreational users. The purpose of this assessment is to:

- Engage with industry to refine infrastructure considerations and requirements for enabling both offshore wind farm construction and operations and maintenance;
- Identify existing waterfront infrastructure gaps and capabilities to meet these needs;
- Assess the technical opportunities and constraints of how and where waterfront infrastructure can be modified or created to support the FOW sector;
- Develop example waterfront infrastructure upgrades and layouts; and
- Develop opinions of associated planning-level construction cost estimates.

There are a variety of FOW functions that SLO County and SB County could potentially serve. These include:

- Small Facilities — to support servicing of the windfarm over its operational lifetime and/or staging of anchors, mooring lines, barges, and vessels during construction.
- Large Facilities — to support assembly of the wind turbines to the foundations (e.g., integration) and/or fabrication/assembly of the floating foundations.

Figure 1 shows the study focus areas. A conceptual screening assessment was conducted to identify site options for further investigation and focus the waterfront infrastructure

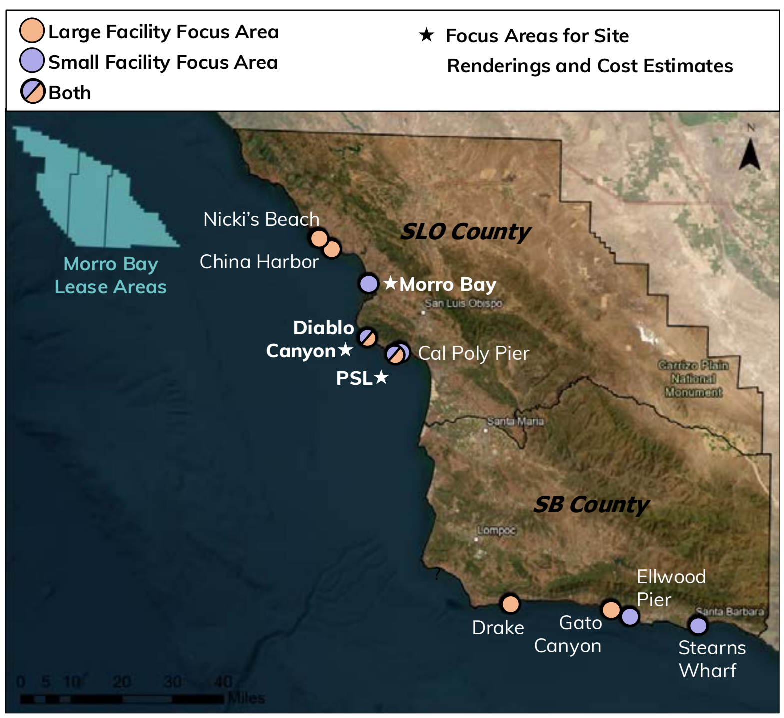


Figure 1. Summary of focus areas for potential Small or Large Facility development. These areas were selected through a conceptual screening process to help geographically focus this study. More detailed evaluation was conducted for the focus areas indicated with a star.

technical assessment on a short list of potential development areas. The findings of the assessment are listed below. The study focus areas selected in coordination with the Technical Steering Committee were evaluated to understand the level of investment required in SLO or SB Counties to support various types of FOW activities.

SMALL FACILITIES (less than 10-20 acres)

Morro Bay, Diablo Canyon, Port San Luis (PSL), Cal Poly Pier, Ellwood Pier, and Stearns Wharf meet the screening criteria to serve as a Small Facility, with varying degrees of site improvements needed, though some may not be suitable for construction staging. The construction cost of waterfront infrastructure upgrades for these types of facilities is expected to be in the range of $11m-40m (in 2022 dollars), and could include:

- **Wharf:** New wharf to accommodate larger (>200ft length) service offshore vessels (SOVs). New floats to accommodate smaller (<130ft) crew transfer vessels (CTVs);
- **Marine Navigation:** Channel and berth dredging to accommodate SOVs and anchor handling tug vessels (AHTVs) that could support staging of anchors and mooring lines; and
- **Various Other Improvements**: Such as new mooring dolphins, a new fueling dock, and localized pier reconfiguration.

Other waterfront facilities, such as the Vandenberg boat dock, did not meet the screening criteria to serve as a Small Facility but could potentially serve more discrete functions with varying degrees of site improvements.

LARGE FACILITIES (more than 50 acres)

There is no existing infrastructure or harbor in the study area that can be upgraded to be a Large Facility with localized (minor, targeted) upgrades only, and therefore requires development of a new facility. Two example sites were selected for further assessment based on a conceptual screening assessment: Diablo Canyon and Port San Luis. In both cases, a new port facility appears technically feasible but would be subject to numerous onshore and in-water constraints and would need to be planned to avoid, minimize, and mitigate potential impacts. To accommodate land conservation efforts, regulatory considerations, existing uses, and onshore site constraints, significant new overwater coverage would be needed to build a port facility at either site. A new Large Facility at either Diablo Canyon or Port San Luis would be required to have the following minimum requirements:

- **Wharf:** New 1,500ft long (or greater) high-capacity wharf structure (4,000-10,000psf, 5-10 times the strength of a typical container wharf);
- **Storage Yard:** Installation of a high-capacity, overwater storage yard for components such as blades, tower sections, nacelles; likely pile-supported;
- **Marine Navigation:** Water depths of at least 38ft and a wide entrance channel;
- **Breakwater:** New breakwater or extension of existing breakwater is likely required, depending on focus site; and
- **Wet Storage**: Deep-water, semi-protected mooring locations for floating foundations (hulls) is needed to reduce schedule delays during construction.

Construction costs for development of a port to support these activities is estimated to be in the range of $1.3-$6.2 billion. Of the two example sites considered, a new facility in the Port San Luis area would likely cost less due to the existing wave protection and more favorable construction access to in-water areas. Noise and light considerations for a 24-hour facility will need to be considered in final site selection.

This type of facility exceeds the technical requirements of most industries. If site logistics allow, large FOW facilities could likely be utilized for other purposes.

GENERAL CONSIDERATIONS

- A single site is not likely to support all FOW functions for windfarms offshore the Central Coast, and the general industry consensus is that a network of ports is needed. At present, there are no wharves along the U.S. West Coast that can support waterfront integration.
- Consultations with 10 FOW developers indicate the following related to siting of Small and Large Facilities:
    1. There is an overall preference toward locating waterfront facilities that support FOW in close proximity to wind farms.
    2. Small Facilities within the study area will be required to support wind farm operations within the current Lease Areas; there is general agreement with the site development options considered in this study.
    3. A Large Facility within the study area is preferred and may be required considering state FOW development goals.
- The outcomes from this geographically focused study will likely be coordinated with the California State Lands Commission's Assembly Bill (AB) 525's[1] Seaport Infrastructure Readiness Planning efforts and the National Renewable Energy Laboratory's West Coast Ports Strategy Study, which will progress FOW port development strategy on larger state and regional scales.
- This pre-feasibility level study is intended to provide an overview of what could be developed. It is not intended to designate preferred development location(s) for FOW facilities, because doing so will require evaluation of important environmental, regulatory, social/environmental justice, and workforce considerations that are beyond the scope of this study. Additional stakeholder engagement, marine resource evaluations, and cultural resource investigations will be needed prior to further development of any site.

Potential next steps for the Counties of SLO and SB and the City of Morro Bay include:

- All: Coordination with ongoing studies such as AB 525's Seaport Infrastructure Readiness Planning and NREL's West Coast Ports Strategy Study.
- All: Coordination with winners of the Morro Bay lease auction to better define the need and timeline for facilities, including both Small and Large Facilities.
- City of Morro Bay: Depending on the site and scale of upgrades for Small Facilities (e.g., operation and maintenance bases, construction staging), public and private entity coordination may be required, along with review of applicable waterfront use policies. Engagement with

[1] AB-525 Energy: Offshore Wind Generation: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB525

interested developers should be conducted to align O&M strategies with infrastructure improvement needs and plans.

- SLO County:
  - Considering that the potential Large Facility site locations are overwater, a project sponsor/public developer entity for a new Large Facility may need to be designated. Coordination with AB 525's Seaport Infrastructure Readiness Plan, the California State Lands Commission, and the California Energy Commission is recommended.
  - In coordination with the ongoing and planned state-level work to support AB 525, a more detailed but focused Phase 2 of this study should be undertaken to provide local jurisdictions and decision makers with the information needed to recommend where and what development should be pursued and who the project sponsors and steering committees should be. Phase 2 could be supported by the $1 million in funding provided by the State of California to study options for integration site development in SLO County.
- SB County:
  - Coordination with industry, AB 525's Seaport Infrastructure Readiness Plan and the National Renewable Energy Laboratory's West Coast Ports Strategy Study to coordinate options for supporting O&M activities (e.g., at Ellwood Pier or Stearns Wharf).

Potential Next Steps to Define Preferred Projects:

<u>Environmental and Permitting:</u>
Early coordination of permitting agencies and engagement with stakeholders will be a vital step so that impacts can be avoided, minimized, and mitigated. These considerations should be incorporated into future work to evaluate and identify preferred development locations.

- Identify and engage stakeholders including but not limited to tribal stakeholders, U.S. Army Corps of Engineers, U.S. Coast Guard, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, and the United State Fish and Wildlife Service, as well as California state and local agencies, and commercial and recreational fishing communities;
- Initiate informal agency consultation to identify potential environmental constraints and required environmental assessments. Develop permit matrix, including high-level schedule and anticipated lead times;
- Initiate cultural and marine resource assessment work that is informed by agency and stakeholder input; and
- Develop assessment of likely critical path items based on refined project definition.

<u>Economic/Social:</u>

- Coordination with AB 525's Seaport Infrastructure Readiness Plan and the West Coast Offshore Wind Port Strategy Study being undertaken by the National Renewable Energy Lab;
- Continued industry and stakeholder outreach;
- Synergies with other industries such as commercial fishing and recreational fishing;
- User conflict and marine and onshore traffic conflict assessments;

- Workforce development and training assessment; and
- Refinement of funding options for various project stages.

Technical:

- **Site Geometry and Alternatives:** Conduct a comparative alternatives assessment for each activity considering additional non-technical parameters. Refine facility site plans (yard geometry, wharf line elevation, etc.) to refine costs based on results of further investigations;
- **Wharf and Berth Orientations and Locations**: Need to be refined based on a detailed coastal engineering analysis to consider maintenance dredging needs;
- **Breakwater**: Refine harbor geometry requirements to minimize length and installation depth of breakwater and conduct wave transformation modeling to aid in geometry refinement;
- **Downtime**: Conduct metocean downtime assessment to refine downtime assumptions included within throughput modeling;
- **Site Investigations:** Plan and conduct extensive subsurface investigation and report prior to refinement of the wharf structure design. Conduct biological resources field surveys. Conduct land/hydrographic surveying within the project area for planning and engineering design work;
- **Fabrication:** Refine assessment of the feasibility of fabricating and launching floating foundations on site and/or delivering foundations that have been fabricated elsewhere;
- **Wet Storage:** Quantify wet storage capability within San Luis Obispo Bay. Wet storage orientation and location need to be refined based on a detailed coastal engineering analysis to consider maintenance dredging needs, wave exposure, and other environmental conditions; and
- **Schedule:** Refine project schedule and identify key milestones needed to meet target development date.

2 ACRONYMS, ABBREVIATIONS AND TERMINOLOGY

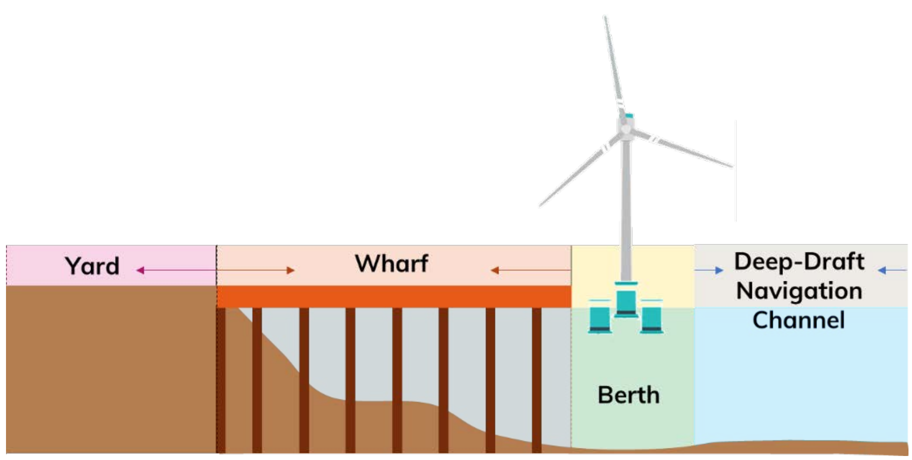
Acronym/Term	Definition
AACE	Association for the Advancement of Cost Estimating
AHTV	Anchor Handling Tug Supply Vessel
AB	Assembly Bill
ATONs	Aids to Navigation
BOEM	Bureau of Ocean Energy Management
B	billion
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CDIP	Coastal Data Information Program
COD	Commercial Operation Date
CSLC	California State Lands Commission
CSU	California State University
CTV	Crew Transfer Vessel
CY	Cubic Yards
DCPP	Diablo Canyon Nuclear Power Plant
E	East
EIS	Environmental Impact Statement
FAR	Federal Aviation Regulation
FNC	Federal Navigation Channel
FOW	Floating Offshore Wind
ft	feet
GW	Gigawatt
Hs	Significant Wave Height, defined as the average wave height of the highest one-third of waves in a sea state
Integration	Assembly of floating offshore wind turbines — affixing the turbine components (nacelle, blades, and tower) to the floating foundation
Integrated Device	Assembled floating offshore wind turbine, including foundation and wind turbine generator
km	kilometer
LAT	Lowest Astronomical Tide
m	meter or million
mi	mile
MLLW	Mean Lower Low Water
MPA	Marine Protected Area
MSL	Mean Sea Level
MW	Megawatt
N	North
NDBC	National Data Buoy Center
NEPA	National Environmental Policy Act
NM	Nautical Mile
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
OMF	Operation and Maintenance Facility
OSW	Offshore Wind
psf	pound per square foot
PSL	Port San Luis

REACH	Regional Economic Action Coalition
RORO	Roll-on Roll-off, a method of loading/offloading vessel cargo by rolling it on wheels
ROW	Right-of-way
SATV	Service and Accommodation Transfer Vessel
SB	Santa Barbara
SKS	Sea Keeping Systems (systems employed to stabilize the floating devices, e.g., anchors and mooring lines)
SLO	San Luis Obispo
SMA	Service and Maintenance Agreement
S	South
SOV	Service Offshore Vessel
T/m2	Ton per meter squared
UKC	Under Keel Clearance
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
VSFB	Vandenberg Space Force Base
W	West
WAMS	Waterways Analysis and Management System
WTG	Wind Turbine Generator
WTG Components	Nacelle, blades, and tower — see individual components defined in Table 1.

2.1 WATERFRONT INFRASTRUCTURE TERMINOLOGY

This section provides a brief introduction to select terms associated with waterfront infrastructure that are used frequently throughout this report volume. Select definitions are shown schematically in the figure below.

- **Berth**: Designated location where a vessel may be moored. For overwater structures, the berth is the part of a wharf or pier where people, equipment, and components are moved to and from vessels or devices. The berth area needs to provide sufficient depths for moored vessels/devices for all water levels.
- **Deep-Draft Navigation Channel**: Deep-draft navigation channels are defined by the USACE (2006) as channels with depths greater than 15ft (4.6m) that provide access to U.S. port and harbors.
- **Federal Navigation Channel (FNC)**: A FNC is a navigation channel that is managed and maintained by the USACE.
- **Moorage**: Securing a vessel or floating device to a fixed structure (a berth, quay, mooring dolphin, pier, etc.).
- **Pier**: An overwater berth structure that is typically oriented perpendicular to the shoreline.
- **Protected Harbor**: An area that is protected from direct wave attack by anthropogenic structures (e.g., breakwater, jetty, etc.) or natural features (spit, natural harbor, etc.).
- **Quay**: The quay or quay wall is the seawards edge of the wharf where vessels and/or floating devices are moored.
- **Wharf**: Overwater structure that is usually parallel with the shoreline, typically "open" (pile- or column supported) or "closed" (solid fill with bulkhead or caissons).
- **Yard**: Upland part of a marine terminal supporting integration, utilized for storage of components, office space, etc.



INTRODUCTION

3 INTRODUCTION

The Regional Economic Action Coalition (REACH) engaged the services of Mott MacDonald to identify the constraints, opportunities, needs, and planning level costs required to leverage existing and/or construct new waterfront infrastructure to support planned floating offshore wind (FOW) farms in federal waters off the coastline of the Central Coast of California.

This study was funded by the County of San Luis Obispo (SLO), County of Santa Barbara (SB), and the City of Morro Bay. The federal government on Dec. 6, 2022, auctioned leases for approximately 3GW of wind resource within the Morro Bay Wind Energy Area, which is adjacent to these counties. Additionally, the State of California has set a goal of reaching 25GW of offshore wind power by 2045.[2] However, there are no publicly available studies identifying if and how Central Coast waterfront infrastructure can support FOW. Secondly, at present, there are no ports in California (or anywhere else on the U.S. West Coast) that can perform all functions needed to support the industry. **To meet renewable energy goals, significant investment in new infrastructure and/or upgrades to existing facilities is needed.**

Figure 2. Initial Study Area.

The proximity of SLO and SB Counties to the Morro Bay Lease Areas and the likely development of additional FOW off the coast of California to meet the state's offshore energy goal may create opportunities for local, sustainable economic development if wind farm construction or maintenance activities are conducted along the Central Coast. Based on the outcomes of the *Economic Impact of Offshore Wind Farm Development on the Central Coast of California* study (REACH and Cal Poly, 2021), waterfront infrastructure was identified as a key economic driver for enabling the FOW industry to take root in Central California. To help inform decision makers, an investigation of the options and challenges associated with leveraging existing waterfront infrastructure and/or developing new facilities to support the industry within these two counties is needed. The information presented in this report is not intended to be a detailed evaluation for identifying preferred development areas. Rather, this report presents a pre-feasibility level assessment of the likely scale of upgrades and investment required to support the Central Coast's role in supporting the FOW industry. The outcomes of this work are meant to complement and inform other ongoing and future studies being conducted by the State of California and federal government.[3]

[2] Lease area locations to meet the goal of 25GW by 2045, beyond the 4.5GW California lease auction held in December 2022, have not yet been identified and therefore are not included in this study.

[3] A summary of the relationship between this Central Coast study and other ongoing/future studies is presented in Section 4.1 Study Methodology.

FOW turbines are among the largest structures ever constructed (DOE, 2022), standing taller than the Golden Gate Bridge, and are affixed to a floating foundation that can be larger than a baseball field. Therefore, the waterfront infrastructure needed to support certain wind farm construction and maintenance activities are very large and robust compared to a typical port facility. To meet all the needs of the emerging industry in California and elsewhere along the U.S. West Coast, a network of ports is needed. To support FOW buildout, the port network will include both large facilities to enable component manufacturing, foundation fabrication, and turbine integration, as well as smaller facilities that are needed for pre-construction storage of installation materials (anchors, mooring lines, cables) and long-term wind farm operations.[4]

Historically, waterfront infrastructure in the two-county area was developed to serve the commercial and recreational fishing industries, the oil and gas industry, and other recreational users. This report therefore evaluates the potential upgrades needed to conduct various FOW functions at existing waterfront sites and at potential greenfield (new facility on undeveloped land), brownfield (re-development of disused facility) and existing facilities sites.

This study applied a systematic approach for assessing which areas within the two-county region are more favorable for supporting a range of activities. Once geographic focus areas were selected, development concepts were generated, and the associated construction costs were estimated. This volume of the report contains the following sections, which reflect the approach and findings of the study:

Basis of Assessment: Documents existing waterfront infrastructure and shoreline characteristics for the two-county study area; includes industry and agency outreach to align facility requirement assumptions; documents study assumptions.

Waterfront Infrastructure Screening: Applies a systematic framework to identify geographic focus areas for each type of FOW facility.

Waterfront Infrastructure Assessments: Assesses different regions of the coastline relative to the facility requirements for different FOW activities; outlines potential opportunities and constraints to support different activities at each site; presents construction cost estimates and example 3D renderings.

Governance and Financing Review: Outlines potential frameworks for development and operation of FOW port facilities; includes review of different models applied on the U.S. East Coast for similar purposes.

Conclusions and Next Steps: Summarizes findings and potential next steps.

[4] For more information see the inset on the following page.

Technical Background: Waterfront Infrastructure for Floating Offshore Wind

Unlike the existing fixed foundation offshore wind industry, FOW turbines are likely to be integrated (e.g., assembled) at port. Integration refers to the process of affixing the wind turbine components (e.g., the tower, nacelle, and blades) to the foundation. Fixed foundation wind turbines are typically integrated offshore using wind turbine installation vessels (WTIVs). WTIVs are purpose-built jack-up vessels with legs that extend down to the seabed, enabling them to function like a temporary fixed platform offshore. Relative to fixed foundation wind farms, FOW farms are installed in deeper water, typically at depths greater than 200ft (60m). Since currently available WTIVs can't function at these depths, FOW turbines need to be integrated within a port facility before they are towed offshore to the wind farm location.

FOW turbines and their components are very large. When fully integrated, a floating turbine can be over 1,000ft in height (taller than the Golden Gate Bridge), with a foundation up to 425ft wide (larger than a baseball field). Due to the size and weight of FOW devices and their components, port requirements for conducting FOW turbine integration exceed the capabilities of existing port facilities on the U.S. West Coast. The bearing capacity of a wharf needed to support FOW integration is 5-10 times higher than most typical wharves used to offload shipping containers and therefore will be costly to construct.

At present, there are no ports along the U.S. West Coast that can support quayside, land-based integration of FOW turbines.

Smaller facilities to support the operation and maintenance (O&M) of FOW farms will also be needed near the wind farms.

Distance to the wind farm is a key factor in siting FOW port facilities. Ports adjacent to windfarms reduce transport times, emissions, and logistical challenges. However, the tradeoffs of siting ports close to the wind farm may be weighed with other considerations (e.g., environmental, social, and economic).

Source: Mark Harrington/Newsday RM

Fixed foundation turbine integration offshore.

Source: MHI Vestas

Floating foundation turbine integration in a port before tow-out for installation offshore.

BASIS OF ASSESSMENT

4 BASIS OF ASSESSMENT

This section outlines the key assumptions and criteria that formed the basis for the FOW portion of this study. Criteria for assessing waterfront infrastructure to support the emerging FOW industry was developed in coordination with a concurrent study commissioned by the Bureau of Ocean Energy Management (BOEM) titled *U.S. Pacific Outer Continental Shelf Region – Infrastructure Needs and Impacts*.[5] Additionally, REACH and Mott MacDonald engaged with various FOW developers interested in the Central Coast region to confirm assumptions, develop additional criteria, and discuss region-specific considerations. For consistency across studies, the criteria from the BOEM study were applied, as appropriate, in this *Central Coast Emerging Industries Waterfront Siting and Infrastructure Study*, in additional to region-specific input from developers.

This section includes assumptions and analysis of: Study Methodology, Study Area, Development Scenario, Wind Turbine Generator (WTG) and Foundation Geometry, FOW Facility Requirements, Waterfront Facility Screening and Siting Approach, Site Conditions, Noted Data Gaps, Regulatory Considerations, and General Project Assumptions.

4.1 STUDY METHODOLOGY

A summary of the study methodology is provided in Figure 3 and outlined below.

Data Gathering: This pre-feasibility level study was based primarily on desktop review, publicly available information, industry (FOW developer) outreach, and stakeholder engagement. No new data collection or site investigations were collected.

Feedback and Technical Review: Meetings with the Technical Steering Committee were held monthly to share technical updates and solicit feedback. A technical review of this report was conducted by the National Renewable Energy Laboratory (NREL) to confirm that study assumptions and outcomes are aligned with their ongoing research. Developer engagement and stakeholder engagement was provided on a rolling basis throughout the study.

Site Visits: Site visits to key waterfront facilities were conducted in August 2022 to view site conditions/observations, confirm and update assumptions around infrastructure and operations, and meet with asset owners and harbor directors. No detailed inspections were performed. Feedback from asset owners on the potential for conducting certain FOW activities at their facilities was incorporated into the screening assessment.

Coordination with Parallel Studies: Other ongoing studies are investigating options for supporting the FOW industry elsewhere in California and along the U.S. West Coast. Mott MacDonald consulted with the following studies to coordinate assumptions and site screening criteria.

- BOEM's *U.S. Pacific Outer Continental Shelf Region – Infrastructure Needs and Impacts Study.* This segment of the BOEM study is focused on options for conducting integration within Coos Bay, Oregon. We consulted with the BOEM study to coordinate and align integration facility criteria.

[5] To be published in December 2022.

- California State Lands Commission's (CSLC's) *Alternative Port Assessment to Support Offshore Wind Study*. This study is focused on evaluating potential FOW port development options in the region of California between San Francisco and Los Angeles/Long Beach. We coordinated with the CSLC study to align on site screening criteria applied in both studies to identify geographic focus areas. This REACH Central Coast study is intended to provide more detail on technical opportunities and challenges within the SLO and SB County coastal region.

Coordination with Ongoing/Future Studies: Outcome from this study will feed into studies that are expected to be completed in 2023. These studies will build off of previous geographically focused work, including this Central Coast assessment, to evaluate port network strategies for California (CSLC) and the larger U.S. West Coast (NREL).

- CSLC's *Seaport Infrastructure Readiness Plan.* AB 525 requires the California Energy Commission (CEC) to establish a strategic plan for FOW development by June of 2023. The Seaport Infrastructure Readiness Plan, commissioned by the CSLC, will evaluate potential FOW port development locations in California to support FOW industry buildout and will consider both technical and non-technical (environmental, regulatory, workforce, environmental justice) considerations.
- NREL's *West Coast Ports Strategy Study*. The study will work to "develop a roadmap for a strategically designed U.S. West Coast ports network that can unlock the potential of commercial-scale floating offshore wind energy deployment," (NREL, 2022a). Outcomes of this *Central Coast Emerging Industries Waterfront Siting and Infrastructure Study* will help inform options for port development in SLO and SB Counties and will be incorporated into NREL's work.

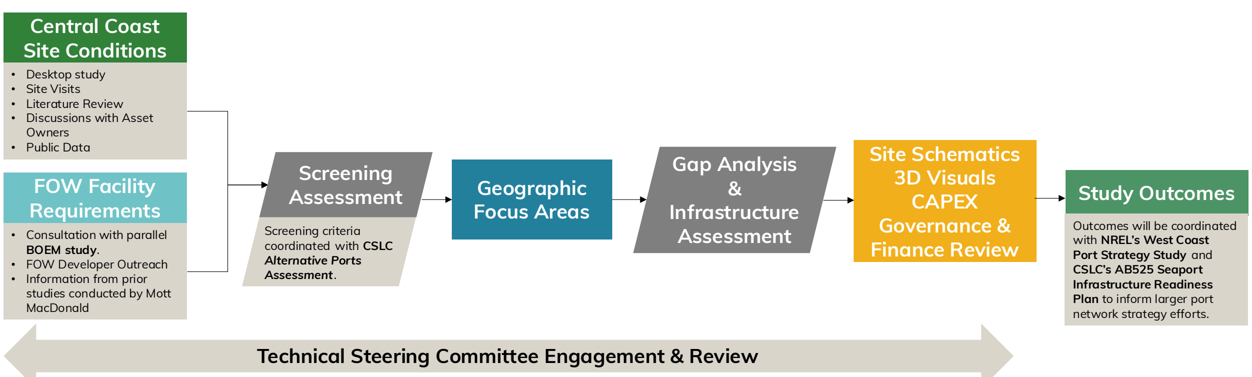


Figure 3. Summary of study methodology and coordination with other studies.

4.2 STUDY AREA

This study will consider the outer shorelines of SLO and SB Counties (approximately 175-200mi {280-320 km} of waterfront) to identify potential development opportunities for FOW infrastructure. For the purposes of this study, "Central Coast" refers to the shoreline within SLO and SB Counties, as shown in Figure 2.

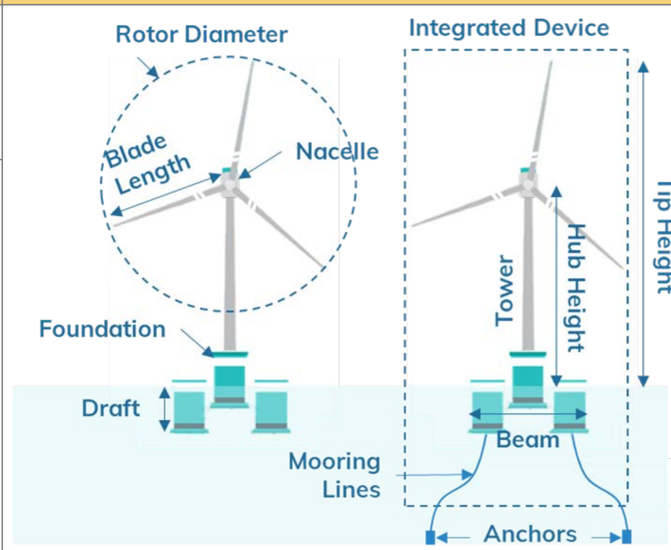
4.3 DEVELOPMENT SCENARIO AND TIMELINE

This study focuses on waterfront infrastructure to support multiple large-scale (e.g., 800-1,200+MW) FOW projects in federal waters. Infrastructure to support the proposed pilot-scale FOW farms in state waters are not the focus of this study. The target commercial operation date (COD) for the first phase of projects in federal waters is assumed to be at or around 2030, which would likely require wind farm installation to begin a year or two prior (2028 or 2029). Note that the construction of a permitted port for a larger facility may take 3-5+ years, depending on construction windows, construction complexity, etc. It is assumed that FOW buildout will continue at least through 2045 to meet California's state goal of 25GW by 2045.

4.4 WIND TURBINE GENERATOR AND FOUNDATION GEOMETRY

The assumed device geometry is provided in Table 1 and was compiled based on developer outreach (BOEM, 2022). The WTG rating contemplated for potential future deployment in the Central Coast is between 15 and 25MW.[6] The wide range of turbine rating is assumed to account for the uncertainty in the rate of future turbine technology evolution and commercial-scale adoption. Though the rate of turbine size has been rapidly increasing in recent years, the rate of future development is unknown (NREL, 2022b). The parameterized geometries are not specific to any technology or design and are intended to capture the likely envelope of potential component sizes envisioned for deployment in the Central Coast. The floating foundation may consist of concrete, steel, or hybrid solution.

Table 1. Device geometry assumptions (per BOEM, 2022).

	Geometry Assumptions	WTG + Foundation Geometry Definitions
WTG Geometry	Rotor Diameter: ≤1,100ft (335m) Hub Height: ≤600ft (183m) Tip Height: ≤ 1,000ft (305m)	
Foundation Geometry	Draft (light/foundation only): 15-18ft (4.5-5.5m) Draft (integrated): 20-50ft (6-15m) Beam: ≤425ft (130m) *Note: foundation geometry varies with the technology employed. A 425ft (130m) beam is the upper limit of device width contemplated for the region within the assumed study timeline (see Section 4.3 Development Scenario and Timeline).*	

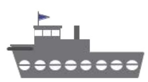
[6] The 15MW WTGs are nearly commercially available, and the availability of 25MW WTGs is anticipated, but speculative.

4.5 FLOATING OFFSHORE WIND FACILITIES AND TECHNICAL CRITERIA

The construction, operation and maintenance of a FOW farm requires port facilities that can support a variety of vessels and functions. Given the scale of FOW buildout envisioned for the U.S. West Coast, it is likely that FOW activities will be distributed across a collaborative network of regional waterfront facilities (NREL, 2022a), which may not all be sited within the two-county study area. The specific FOW activities being considered for the Central Coast region affect the requirements for supporting waterfront infrastructure.

This section summarizes the types of FOW activities involved in the construction, operation and maintenance of FOW farms and the associated infrastructure requirements to enable these activities. The FOW port facilities were categorized into two groups based on the scale of waterfront infrastructure and investment needed for development:

Large Facilities – generally larger than ~50 acres (20 hectare); includes integration, foundation fabrication, component manufacturing; &



Small Facilities – generally smaller than ~20 acres (8 hectare); O&M facility, installation support (subsea cable storage, anchor & mooring line storage, temporary vessel/barge moorage).

The graphics above are included throughout this volume of the report to clarify content related to Large or Small Facilities.

4.5.1 SMALL FACILITIES 

This section describes the small waterfront facilities needed to support the FOW industry. Such facilities would support various FOW activities but would not be locations where the turbines themselves would be integrated or towed for repairs, which would take place at a Large Facility.

OPERATIONS AND MAINTENANCE FACILITY

The O&M facility (OMF) is a base for crew transfer vessels (CTVs), service and accommodation transfer vessels (SATVs), and/or service offshore vessels (SOVs) that transport crew and equipment for conducting turbine repairs offshore at the wind farm (see Figure 4). The OMF must provide upland storage area for equipment and warehouses and moorage for O&M vessels. Proximity between the OMF and wind farm location is a key cost and crew comfort driver. Several OMFs will likely be needed on the Central Coast to support FOW buildout of several commercial wind farms.

The facility requirements for an OMF depend on the project size, distance to the wind farm, and the strategy of the contractor or Original Equipment Manufacturer (OEM) executing the Service and Maintenance Agreement (SMA). The O&M vessel feet may consist of a combination of CTVs, SATVs, SOVs, and helicopters, and the specific fleet composition will depend on the O&M strategy adopted.

Conceptual minimum requirements for a single OMF are summarized in Table 2. These criteria were confirmed through engagement with FOW developers interested in the Central Coast region, and the criteria are intended to cover an envelope of potential strategies.

Component exchange and major repairs. For this study, it is assumed that component exchange or other major turbine repairs that need to be conducted in a protected harbor will be completed at the integration facility, not at the OMF.

SERVICE OFFSHORE VESSEL (SOV): Supports multi-day O&M trips to FOW farm.

Length: 200-400ft (61-122m)
Draft: 16-25ft (5-8)
Beam: 50-80ft (15-24m)
Offshore duration: 2+ weeks

SERVICE ACCOMODATION TRANSFER VESSEL (SATV): Intermediate between SOVs and CTVs, with ability to sleep on board for multiday trips.

Length: 100-130ft (30-40m)
Draft: 10-16ft (3-5m)
Beam: 30-50ft (9-15m)
Offshore duration: ~4-5 days

CREW TRANSFER VESSEL (CTV): Supports transfer of crew and light supplies for day trips to the FOW farm.

Length: 65-90ft (20-27m)
Draft: 5-10ft (2-3m)
Beam: 22-30ft (7-9m)
Offshore duration: <1 day

Figure 4. O&M vessel fleet options.

Table 2. Minimum conceptual requirements for OMF criteria.

OMF Criteria	Minimum Concept Requirement	Source
Waterfront Moorage	Wharf/slip length and depth to accommodate fleet of CTVs, SATVs, and/or SOVs (see Figure 4); SOV requires a fixed wharf; CTVs may moor at floats with controlled access	MM prior project experience and developer engagement
Wharf Bearing Capacity	500-1,000psf (2-5T/m^2) for wharf; moorage floats not subject to same loading capacities	MM prior project experience and developer engagement
Upland Area	≥2-10 acres (1-4 hectare)	BOEM, 2022
Wave Exposure	Protected harbor needed for safe moorage of smaller vessels (e.g., CTVs) year-round	MM prior project experience and developer engagement
Navigable Access	Vessel base must have safe, navigable access for approach and maneuvering of associated vessel fleet	MM prior project experience and developer engagement
Other Considerations	• Helipad may be needed • Due to the distances between the wind farm and O&M facility and the wave climate, smaller CTVs may not be preferred by FOW developers • Multiple OMFs are likely needed to support multiple projects • Access to fueling facilities will be needed for all vessels and can require significant fuel volumes (if carbon based) • Ability to conduct 24-hour operations may be needed	MM prior project experience and developer engagement

INSTALLATION SUPPORT

Waterfront facilities to support WTG installation activities will be needed during wind farm construction to provide options for vessel moorage and temporary upland storage. The "installation support" activities considered within this study are described in the subsections below.

Sea Keeping Systems (SKS) Storage

SKS storage includes the storage of mooring lines and anchors prior to installation. Requires navigable access for an anchor handling tug supply vessel, such as AHTVs, which will transport and install the anchors at the wind farm location (see Figure 5A). The size ranges of AHTVs are provided in Figure 6 and Figure 7. There are various types of anchors (e.g., drag-embedded anchor, suction pile, etc.), and the size and type of AHTV needed will depend on the specific anchor technologies and mooring line designs utilized. The AHTV would preferably also be used to tow out integrated devices to the wind farm location, though towing may require higher bollard pull capabilities (see Figure 5B).

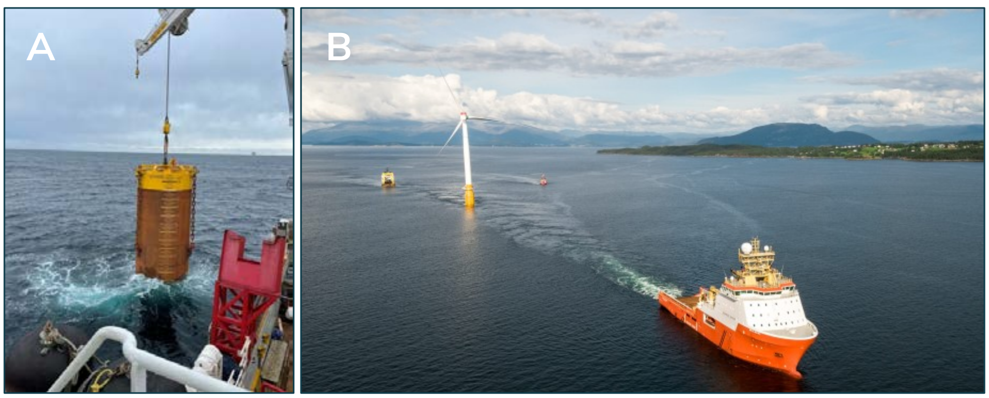


Figure 5. Uses for AHTVs during FOW installation. Plate A: Installation of suction pile anchor. Source: Semar AS. Plate B: Tow-out of an integrated WTG for the Hywind Scotland project; Source: Øyvind Gravås / Statoil.

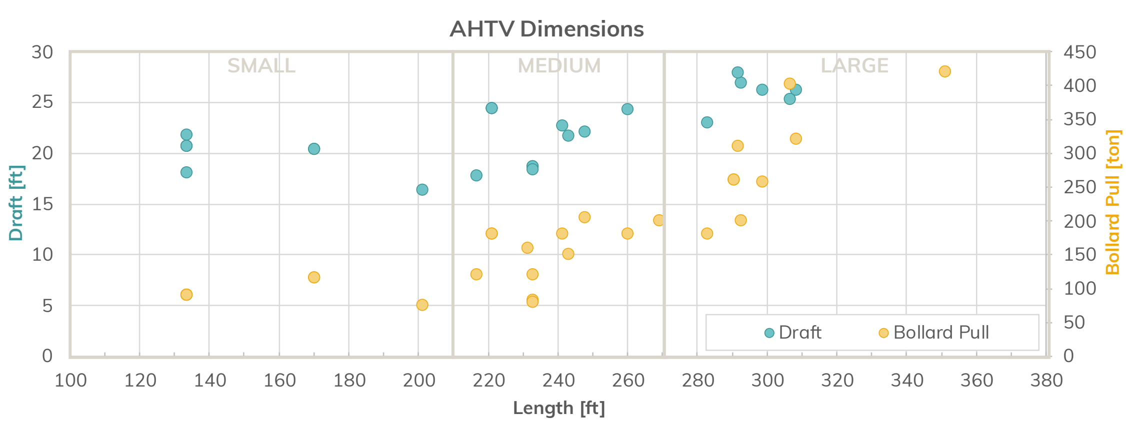


Figure 6. Range of AHTV dimensions and associated bollard pull, based on vessels currently available from three suppliers (Ulstein, Boskalis, and Damen).

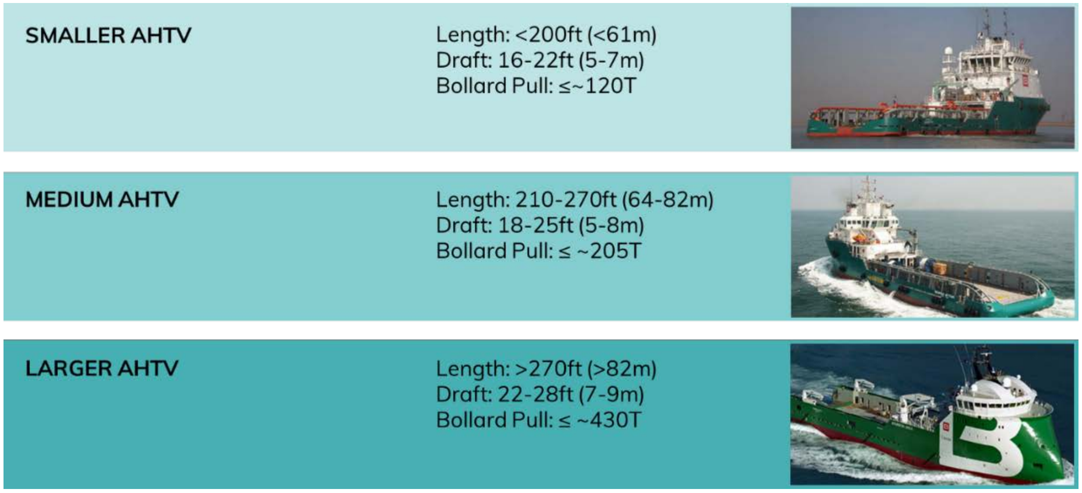


Figure 7. Example AHTV size ranges based on plot in Figure 6. Images courtesy of Bourbon Offshore.

The conceptual minimum criteria for anchor and mooring line storage are shown in Table 3 below.

Table 3. Minimum concept requirements for SKS storage criteria, based on FOW developer engagement.

Seakeeping Storage Facility Criteria	Minimum Concept Requirement (ft)	Source
Waterfront Moorage	Wharf length and depth to accommodate AHTV and/or feeder barges	MM prior project experience and developer engagement
Wharf Bearing Capacity	500-1,000+psf (2-5+T/m²)	MM prior project experience and developer engagement.
Upland Area	≥5-10+ acres (2-4+ hectare)	MM prior project experience and developer engagement
Other Considerations	Staging and storage of mooring lines and anchors near the Morro Bay lease areas is preferred	MM prior project experience and developer engagement

Vessel or Barge Anchorage

Throughout wind farm construction, various types of vessels will be utilized for installation of subsea cables, SKS and the integrated WTGs. Further, barges may be utilized for floating storage of equipment. Vessels and barges may need to be temporarily moored, anchored in a bay or harbor during periods of downtime, where they are not directly exposed to oceanic swells. The required depths and size of anchorage areas depend on the type and number of vessels/barges seeking anchorage at a given time. This study will identify potential anchorage areas or moorage within existing harbor areas along the Central Coast that may be leveraged to support installation activities during wind farm construction.

Subsea Cable Storage

Storage of subsea cables (inter-array cables, export cables) prior to installation via cable-lay vessel may be needed, depending on installation length and supply logistics. This may be co-located at a Large Facility; however it is unlikely existing harbors could be utilized because deep-draft vessels are typically required.

4.5.2 LARGE FACILITIES

The large waterfront facilities needed to enable buildout of the FOW industry include:

INTEGRATION FACILITY

The integration facility is where the WTG components (tower, blades, and nacelle) are affixed to the floating foundation prior to towing the assembled equipment to the wind farm location. Integration operations require very calm wave conditions due to the height of the turbines; a small wave-induced motion at the base of the WTG translates to a larger displacement at hub height (defined in Table 1). Therefore, the wharf of the integration facility must be within a protected harbor. An integration facility must be able to receive, store, stage, maneuver, lift, and affix large turbine components (up to 600-800 tons {540-730 metric tons}) to the foundation. During the operation of the wind farm, major WTG repairs will likely be conducted at the integration facility. Since integrated WTGs will be towed between the integration facility and the wind farm location throughout the asset's life, and towing operations will be limited to favorable weather conditions and restricted to slower towing speeds (Carbon Trust, 2018), it is preferred to site the facility closer to the wind farm. The vessels that will likely be needed at an integration facility are summarized in Table 4, noting that regional-specific vessels may not yet be designed that could service this industry.

Conceptual minimum requirements for an integration facility are summarized in Table 3. The scale needed for a facility is shown in an example rendering in Figure 8.

Table 4. Integration facility vessels.

Vessel Type	Purpose	Approximate Dimensions
Component Delivery Vessels	Deliver WTG components to the integration facility	Length: ~450-650ft (137-198m) Beam: ~80-140ft (24-43m) Draft: ~18-35ft (5-11m)
Ocean Tugs	Support the maneuvering and tow-out of integrated devices from the integration facility to the wind farm location	Length: ~90-150ft (27-46m) Beam ~30-40ft (9-12m) Draft: ~10-20ft (3-6m)
Anchor Handing Tug Supply Vessels (AHTVs)	Used to tow out the integrated devices from the integration facility to the wind farm location; also used to install foundation anchors (see Figure 5)	Length varies from <200ft to >300ft, (see Figure 7)

Table 5. Conceptual minimum integration facility technical criteria, based on FOW developer engagement.

Integration Facility Technical Criteria	Minimum Concept Requirement	Source
Berths	1 component delivery berthand2 WTG berths[7]	BOEM, 2022
Wharf Length	≥1,500ft (450m)	BOEM, 2022
Wharf Bearing Capacity	≥6,000psf (30T/m^2)[8]	BOEM, 2022
Berth Depth	38ft (12m)	BOEM, 2022
Sinking Basin Depth	40-100ft (12-30m) for float-off of semisubmersible vessel; alternative launching method may be utilized, depending on location of fabrication facility and foundation assembly methods	BOEM, 2022
Yard Area	60-100 acres (12-30 hectare)	BOEM, 2022
Yard Bearing Capacity	≥2,000-3,000psf (10-15T/m^2)	BOEM, 2022
Wave Protection	Wave protection is needed to provide calm conditions (Hs<1ft {0.3m}) for sensitive quayside integration operations.	MM prior project experience and developer engagement
Other Considerations	• Ability to conduct 24-hour operations • Ring cranes may be needed for turbines larger than 15MW • RORO capacity • Designed for equipment to be electrified • Standard ship services and security requirements • Indoor storage/warehouses may be required • Vessel fueling will be a consideration - options for alternative fueling methods may be considered	BOEM, 2022; MM prior project experience and developer engagement

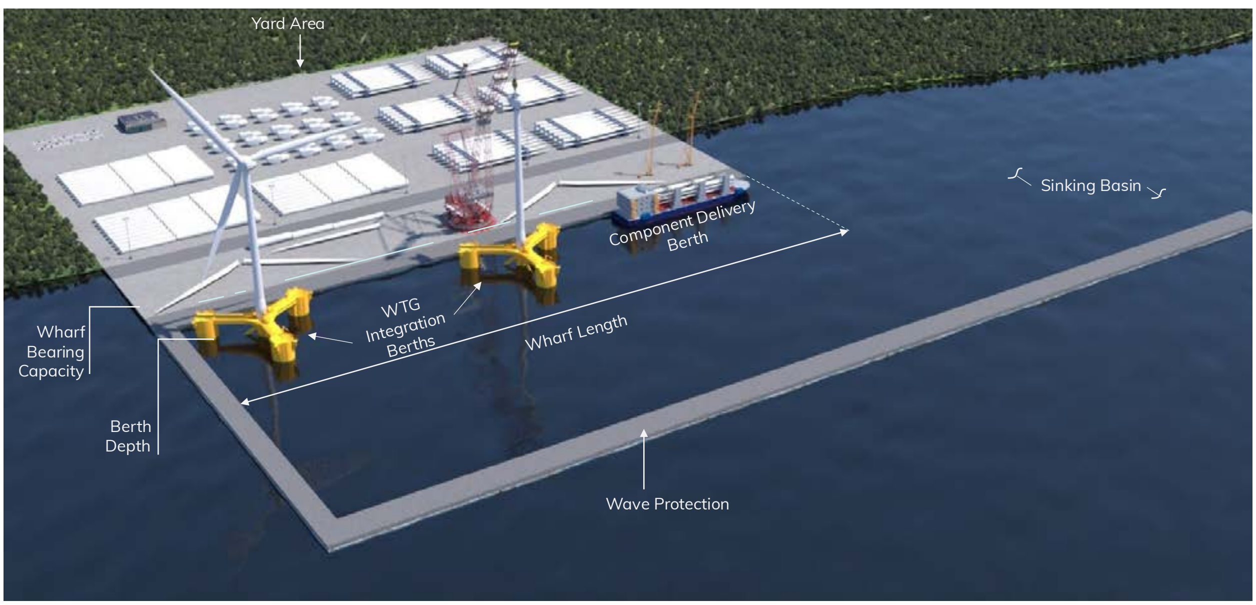


Figure 8. Example integration facility and key elements (total upland area ~100 acres {40 hectare}).

[7] Depending on upland and wet storage areas, availability of additional commissioning berths, and turbine rating, this length of wharf can support a construction throughput of approximately 400-700MW per year. If a higher throughput is needed to meet state goals, additional berths (and a longer wharf), would likely be required.
[8] Up to 10,000psf (50T/m^2) in the location of the crane pad may be required.

The concept technical requirements in Table 5 are intended to represent minimum values for an integration port facility. Input from FOW developers indicates that some values may need to be higher than those shown depending on the foundation technology employed and targeted level of contingency. Some key technical details to consider in the development of an integration facility include:

- **Yard Area.** Seasonal restrictions and the Pacific wave climate will likely require contingency to be built into the construction schedule. This means storage facilities may need to be on the larger side of the listed criteria range (e.g., 80-100+ acres {32-40+ hectare}) to store enough components to prevent schedule delays due to late component deliveries.
- **Wharf Bearing Capacity.** With the rapid scaling up of WTG sizes, it is likely that 20MW turbines will be deployed offshore California. Components of this size could require portions of wharf that are 10,000psf (50 T/m^2), or like a full-size elephant every square foot. This bearing capacity is 5 to 10 times higher than most typical wharves used to offload shipping containers and therefore will be costly to construct.
- **Wharf Length.** To meet annual throughput goals for build-out, additional integration and/or commissioning berths may be needed, which would therefore require a longer wharf (beyond the 1,500ft {450m} minimum).
- **Technology Uncertainty.** The size of WTGs and the specific size/geometry of foundation technology that will be employed in Central California is uncertain, which presents a challenge for constraining port requirements and conceptual port layouts.

The delivery or on-site fabrication of the foundation is a key component of logistical planning as well. Figure 9 below shows a number of options for the delivery (A), fabrication (C) and respective launching (B and D) of the foundation into the water.

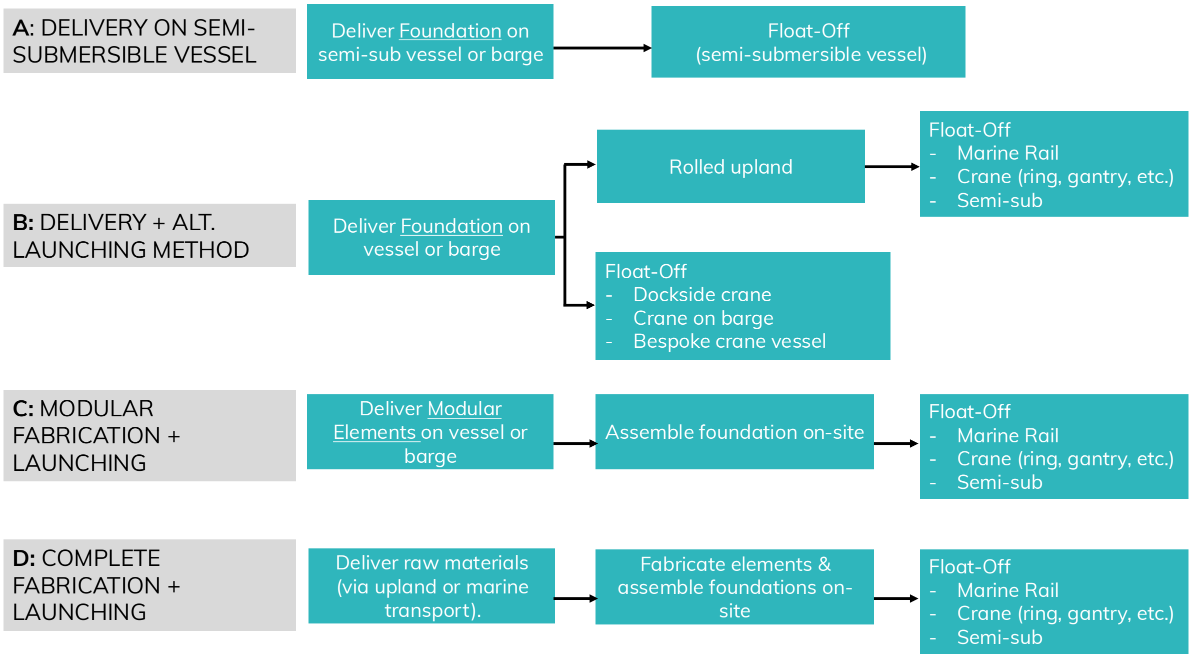


Figure 9. Example foundation delivery/launching options to support integration (from Porter and Gostic, 2021).

Foundation Fabrication Facility

This is where the floating foundations are assembled. Assembly may include complete fabrication of the floating structure from raw materials or receipt and final assembly of modular sub-components (see Figure 10 Plate A). The method of foundation delivery/assembly and the type of foundation technology employed both significantly impact facility requirements, which presents challenges for concept-level (prior to project definition) port planning. The facility should be able to receive and store raw materials or prefabricated elements, assemble and store the large (up to 425x425ft {130x130m}) foundations, and launch the foundations into the water. The foundation fabrication facility may be a standalone facility or may be co-located with the integration facility. Co-location would require a larger port facility (larger than the requirements in Table 3) to meet the needs of both foundation fabrication and WTG integration. Note: *Specific fabrication facility requirements are highly dependent on the foundation technology and assembly method employed, and thus will not be the focus of this study. Further site and technology-specific investigation will be required to determine if a Foundation Fabrication Facility could be co-located with an Integration Facility on the Central Coast or at a separate location.*

WET STORAGE

Wet storage areas (storage of foundations in the sea) are needed for temporary moorage of floating foundations prior to, or in some cases after, integration. The foundations could be temporarily moored to a structure (e.g., quayside, mooring dolphins) or anchored to the seabed. Wet storage areas may be sited at the integration facility or at a nearby anchorage area with sufficient depth. The minimum required water depths for wet foundation storage prior to integration are estimated to be on the order of 20-24ft (6.1-7.3m) Mean Lower Low Water (MLLW), but greater depths may be needed depending on the foundation technology employed. Water depths for fully integrated foundations will be greater, though it would vary significantly based on the technology used.

COMPONENT MANUFACTURING FACILITY

This type of facility (see Figure 10 Plate B) manufactures and exports WTG blades, towers, and nacelles. In California, certain types of anchors may be manufactured as well. These components will be transported to the integration facility on vessels capable of traveling long distances, and it is likely that each component manufacturing facility will serve the wider industry, given the need for turbine supply chain development on the U.S. West Coast (NREL, 2022c). Though not as strict as integration facility requirements, component manufacturing facility requirements include a large upland area (50-100+ acres {20-40+ hectare}), a higher-capacity wharf (≥3,000psf {15T/m²}), and deep-draft navigation channels. Relative to integration facilities, siting a component manufacturing facility in close proximity to the wind farm is less critical, since components can be shipped to and stored at integration facilities. SB and SLO Counties do not appear to have competitive advantage for siting a component manufacturing facility, due to the likely cost required to develop this type of large waterfront site relative to the lower demand for siting a facility on the Central Coast. Note: *WTG components are likely to be sourced from outside of the Central Coast and delivered to the integration site; thus, Component Manufacturing Facilities are not the focus of this study.*

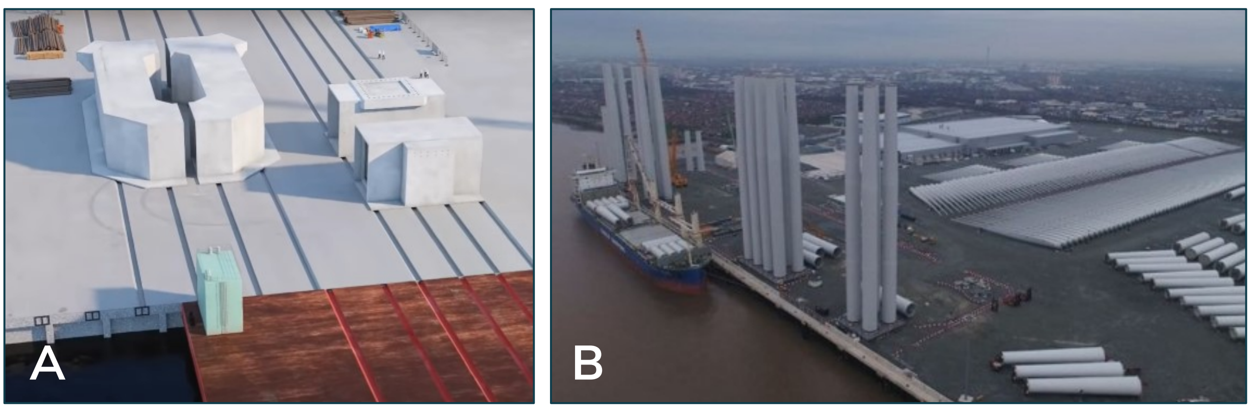


Figure 10. Plate A: Example foundation final assembly of modular sub-components. Source: Ideol. Plate B: Siemens Gamesa component manufacturing facility. Source: Grimsby Telegraph.

4.5.3 NAVIGATION CRITERIA

In addition to the Small and Large Facility requirements listed in the previous sections, each FOW facility must be accessible by navigation channels that are deep and wide enough to accommodate the associated design vessels and/or floating devices. To develop conceptual navigation criteria, various methods were referenced (DNV 2015, PIANC 2014, USACE 2006, Thoresen 2003), and outreach to marine transport contractors was conducted. These guidance documents and contractor input were used to assess the navigation capacities of existing harbors and to develop conceptual channel geometries for the development of new facilities. Conceptual navigation criteria were applied to evaluate required channel depths, channel widths, harbor maneuvering areas and turning basin geometries.

4.6 WATERFRONT FACILITY SCREENING AND SITING APPROACH

Siting of a Large FOW Facility on the Central Coast shoreline would require a greater scale of development and economic investment relative to a smaller support facility. To identify and evaluate potential locations within SLO and SB Counties for waterfront facility development, the following assumptions were made related to Small and Large Facilities:

Small Facilities: It is assumed that a new greenfield development with a new Pacific Ocean breakwater would not be constructed to support a Small Facility alone. All existing waterfront facilities within the initial study area will be screened to identify opportunities for siting a Small FOW Facility, but greenfield developments will not be considered.

Large Facilities: No existing port along the Central Coast can meet the needs of a large FOW facility without major modifications. The Initial Study Area (see Figure 2) will be screened, including greenfield sites, brownfield sites, and existing facilities, to identify potential Large Facility development locations.

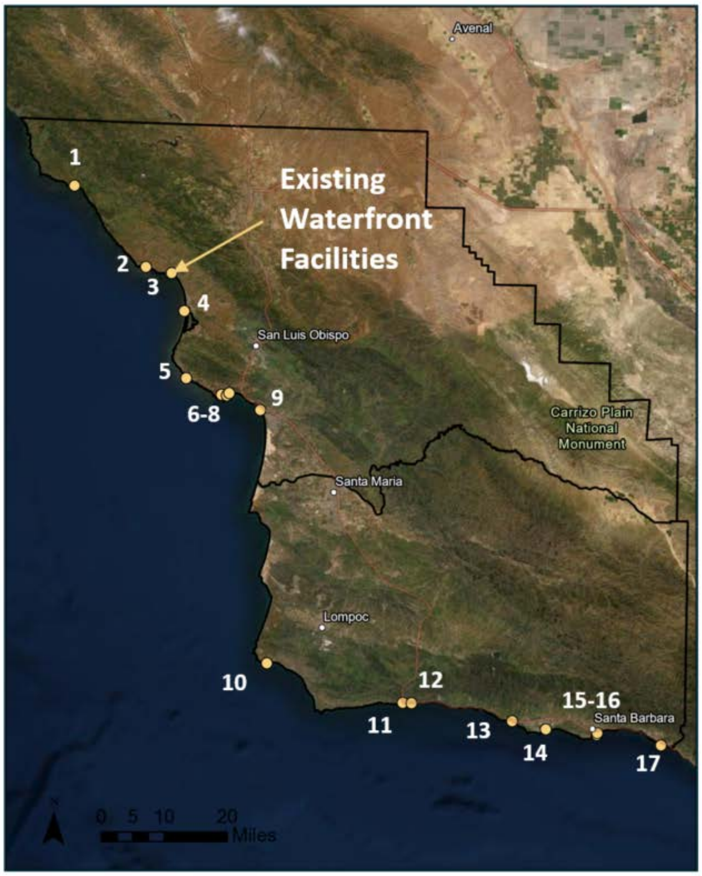
4.7 SITE CONDITIONS

The site conditions summarized in the subsections below were reviewed by Mott MacDonald to inform the evaluation of potential waterfront infrastructure development opportunities to support FOW. Additional information on site conditions throughout the study area (including water levels, airspace restrictions, elevations, and geology) can be found in Appendix A.

4.7.1 EXISTING WATERFRONT INFRASTRUCTURE

An inventory of existing waterfront infrastructure in SLO and SB Counties was compiled based on review of satellite imagery. The database (see Figure 11) was intended to document all waterfront infrastructure (coastal piers, marinas, harbors, docks, wharfs, municipal facilities) along the Central Coast.

Mott MacDonald compiled key characteristics for each existing facility within an Existing Waterfront Infrastructure Database for use in the Screening Assessment (see Appendix B). Included in the assessment but not shown here are technical parameters such as structure type, current use, water depths, wave protection, and channel geometries.



No.	Existing Facility Name	Existing Infrastructure Type
1	William Randolph Hearst Beach	Pier
2	Water Treatment Plant/Abalone Farm	Water Treatment Plant, may have small derelict boat ramp
3	Cayucos Pier	Pier
4	Morro Bay	Protected harbor
5	Diablo Canyon	Power Plant, Protected Basin.
6	Port San Luis Pier & Breakwater	Pier & Breakwater
7	Cal Poly Pier	Pier
8	Avila Pier	Pier
9	Pismo Beach Pier	Pier
10	Vandenberg (VSFB) Boat Dock	RoRo Dock
11	Gaviota Beach	Pier
12	Gaviota Substation	Substation
13	Ellwood Pier	Pier
14	Goleta Pier and Slough	Pier
15	Santa Barbara Harbor	Marina
16	Stearns Wharf	Wharf
17	Casitas Pier	Pier

Figure 11. Existing waterfront infrastructure within Initial Study Area.

4.7.2 WAVE CONDITIONS AND SEASONALITY

A high-level understanding of wave conditions is needed to constrain the likely duration of the installation season and to evaluate the need for wave protection at an integration facility sited within the study area. It is likely that installation activities will be conducted sometime between April and November based on review of public data from National Data Buoy Center (NDBC) Buoy 46028, which is located adjacent to the Morro Bay Lease Areas. Even during the summer months, which are characterized by calmer metocean conditions and lower wave heights, a fixed bottom (e.g., caisson or rubblemound) breakwater will be needed to provide wave protection from Pacific Ocean swell for a new integration facility. Integration operations can require quayside wave heights below ~1ft (0.3m).

Further details on wave conditions to support these study assumptions are provided in Appendix A.

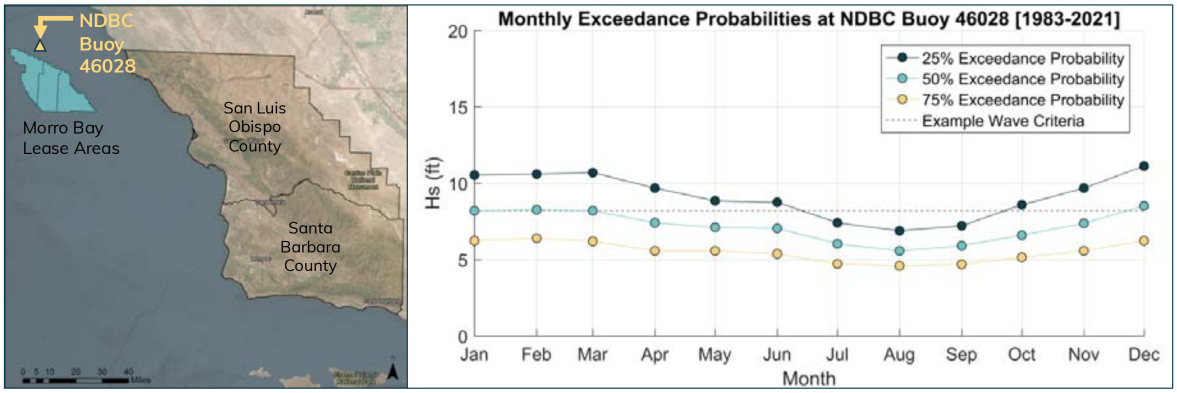


Figure 12. Monthly offshore wave height exceedance probabilities at NDBC Buoy 46028.

4.7.3 OVERLAND TRANSPORT

Overland connections (e.g., highways and railroads) were not evaluated in detail. It is anticipated that additional overland transportation studies will be required considering the volume and type of truck traffic required to support waterfront FOW facilities within the two-county area.

4.8 NOTED DATA GAPS

- **Metocean:** Only concept-level wave modeling was conducted. Detailed wave modeling is required to refine the orientation, location, and length of any new breakwaters.
- **Sedimentation:** Historical sedimentation patterns were not reviewed and could result in changes to preferred dredging locations. A change in dredging patterns could result in changes to maintenance dredging requirements and was not assessed as part of this study.
- **Geological:** Site and project-specific geophysical and geotechnical investigations are required.
- **Technological:** FOW is still a growing industry, and there may be technological advancements in WTG ratings, floating foundations, installation methodologies, or vessels, that could result in a change in assumptions/criteria for this study, and therefore a different result.
- **Lease Area Locations:** Lease area locations to meet the goal of 25GW by 2045, beyond the 4.5GW California lease auction held in December 2022, have not yet been developed, and therefore were not incorporated into this report.
- **Vessel Traffic:** This study did not assess vessel traffic patterns or how a new port facility may impact existing marine operations. A navigation and safety risk assessment will be needed for any new port facility.
- **Throughput Assessment:** Integration facility requirements were developed largely based on developer outreach; the specific wharf length, storage area, and number of berths will need to be investigated based on specific WTG rating and construction throughput targets.

4.9 REGULATORY CONSIDERATIONS

Detailed regulatory assessments to attain permits are not part of this scope of work. The parallel CSLC study (see Section 4.1 Study Methodology) includes additional detail on environmental and regulatory conditions and complexities for the region. Limited investigation of regulatory complexities was conducted. The following regulatory considerations have been included at a conceptual level:

- Jones Act
    - WTG component delivery and foundation delivery vessels can be foreign-flagged if the origin is an international location. Vessels transporting equipment or components from a U.S. port to another U.S. port or facility (such as a windfarm) must be U.S.-flagged (Porter and Phillips, 2020).
    - Tugboats, crew vessels, supply vessels, and other installation assist vessels must be U.S.-flagged and inspected by the U.S. Coast Guard (USCG) but are assumed to be available (Porter and Phillips, 2016).
- Regulatory Permit and Stakeholder Considerations:
    - Planning and construction of a large integration facility is likely to be very complex. The exact project has not yet been defined, and therefore the specific permitting process has not been developed. There are critical habitats and species in all segments of the shoreline considered which will need to be integrated into planning and siting any new facilities.
    - There are a range of local, state, and federal permits that will be required for development of such a facility. This phase of the study is not intended to capture the permitting requirements of the potential facilities within the study area. Neither governmental nor non-governmental outreach was conducted.
    - The in-water work window for construction of waterfront infrastructure can affect construction duration and must be considered. This will likely require full consultation with regulatory agencies to determine.
    - We have assumed that conceptual site developments should avoid mapped submerged aquatic vegetation as much as possible. Habitat mitigation options should be assessed in a future phase of work.
    - No assessments or investigations were conducted to document risk of site contamination.

4.10 STUDY ASSUMPTIONS AND EXCLUSIONS

The FOW waterfront infrastructure assessment was based on the following study assumptions:

- This study was limited to SLO and SB Counties only, and it did not consider other locations within California.
- Potential infrastructure upgrades and developments were generated at a pre-feasibility assessment level.
- The study was based on prior project experience, public information, input from local stakeholders, and engagement with FOW developers. The database of existing site conditions is limited to relevant characteristics based on readily available public information, and it is not intended to be comprehensive.
- FOW industry developments may allow for differences in WTG component geometries, foundation designs and construction and maintenance schemes beyond those considered in this study.
- Navigation assessments were conducted at a conceptual level only; device and vessel-specific maneuverability and operational details were not included. These will need to be investigated at a later project phase.

- Preliminary environmental and regulatory considerations were developed to inform site screening and outline potential regulatory constraints for development in various locations. This study did not include a detailed review of these considerations, and further work will be needed to identify critical path items, along with a refined site design.
- Waterfront infrastructure concept schematic development did not include detailed engineering calculations; planning-level concepts were developed based on review of site conditions and likely loading criteria.
- Study exclusions:
    - Detailed numerical metocean modeling or vessel simulations;
    - Analysis of navigation channel sedimentation rates;
    - Detailed condition assessments, inspections, surveys, or new data collection;
    - Detailed geotechnical or structural analysis;
    - Assessment of decommissioning;
    - Assessment of disposal options for dredged material; open-water disposal was assumed for cost estimating purposes;
    - Assessment of vessel space use conflicts;
    - Assessment of specific equipment needs (e.g., cranes). Specific equipment selections may affect infrastructure requirements;
    - Detailed construction schedules;
    - Phased construction options and considerations;
    - Skilled labor workforce estimates;
    - Habitat mitigation assessment;
    - Development of permitting matrix and permitting roadmap;
    - Comprehensive stakeholder outreach;
    - Comprehensive biological resources compilation and assessments; and
    - Engagement with regulatory bodies.

WATERFRONT INFRASTRUCTURE CONCEPTUAL SCREENING

5 WATERFRONT INFRASTRUCTURE CONCEPTUAL SCREENING

This section presents the screening assessment, which was conducted to identify geographic areas of focus within the initial study area (Figure 2). As described in the Basis of Assessment, different approaches were taken to screen the Central Coast to identify potential development areas for a Large Facility versus a Small Facility. The approaches, methodology, and results of the screening assessment are described herein.

Given the pre-feasibility level of this study, the screening assessment was not intended to identify preferred development location(s) within SLO and SB Counties. Rather, the assessment was conducted to select potentially suitable locations for developing example renderings and planning-level costs to represent the scale of upgrades needed to support certain FOW activities along the Central Coast, thereby providing key information for decision makers.

A larger network of U.S. West Coast ports, beyond the Central Coast, will be needed to meet the needs of commercial-scale FOW buildout for the U.S. West Coast. Identifying the preferred location for constructing FOW waterfront infrastructure will require evaluation of other important environmental, regulatory, social/environmental justice, and workforce considerations that were not incorporated into this geographically focused technical screening assessment.

5.1 SMALL FACILITIES SCREENING

Screening of the study area was conducted to focus the Small Facilities assessment on certain existing waterfront facilities within SLO and SB Counties. Small Facility screening was conducted through the following stages:

- **Develop screening criteria.** Develop Small Facility screening criteria and confirm facility requirements through engagement with FOW developers.
- **Compile existing waterfront infrastructure database.** Generate database of all existing waterfront infrastructure within SB and SLO Counties.
- **Apply screening criteria to identify focus areas.** Compare conditions at existing sites relative to screening criteria for each type of small support facility considered.

5.1.1 PRELIMINARY SCREENING CRITERIA

The screening criteria associated with each category of Small Facility is summarized in Table 6. This screening criteria was confirmed through discussions with FOW developers.

Table 6. Small Facility screening criteria. The colors correspond to the activity legend in Figure 13.

Activity	Small Facility Screening Criteria		
	Navigable Access (Min.)	**Wave Exposure**	**Current Use**
Crew and Equipment Transfer	Depth ~10-12ft Width ~35-90ft	Year-round wave protection not necessarily needed – can conduct crew transfer activities during favorable sea states – similar to historical crew transfer for oil rigs offshore	Avoid displacing infrastructure dedicated to recreational use (e.g., fishing, restaurants, other leisure activities). Preference toward industrial or vacant facilities.
CTV and SATV Moorage	Depth ~10-15ft Width ~35-90ft	Year-round protected harbor needed	
SOV Moorage	Depth ~20-23ft Width ~50-225ft	Wave protection needed, to a less extent than CTVs	
Installation Support (Anchor, Mooring Line, Subsea Cable Storage; Temporary Vessel/Barge Anchorage)	Depth ~20-23ft Width ~50-225ft	Full wave protection not necessarily needed	

5.1.2 SMALL FACILITY SCREENING RESULTS

The results of the Small Facility screening for each facility that passed the screening assessment are presented in Figure 13.[9] The Small Facility screening framework and justification for screening out each facility is summarized in Appendix B. For some locations, the screening results indicate that more than one activity may be possible at a given location. Ideally, it would be preferred for anchor, mooring line and/or cable storage to be co-located with an OMF; however, the potential for co-locating Small Facilities was not fully investigated as part of this assessment.

Multiple OMFs are likely needed, as there are likely to be multiple windfarm operators on the Central Coast. Secondly, the developers will prefer an OMF that is close to the windfarm due to cost, crew comfort, emissions and other considerations. Screening results show a cluster of potential sites close to the Morro Bay Lease Areas. SB County locations may provide a supportive role such as crew transfer and SOV moorage if harbor space is limited, recognizing preference for proximity.

[9] Results of this assessment are to provide the project team with focus areas for assessment but do not confirm feasibility.

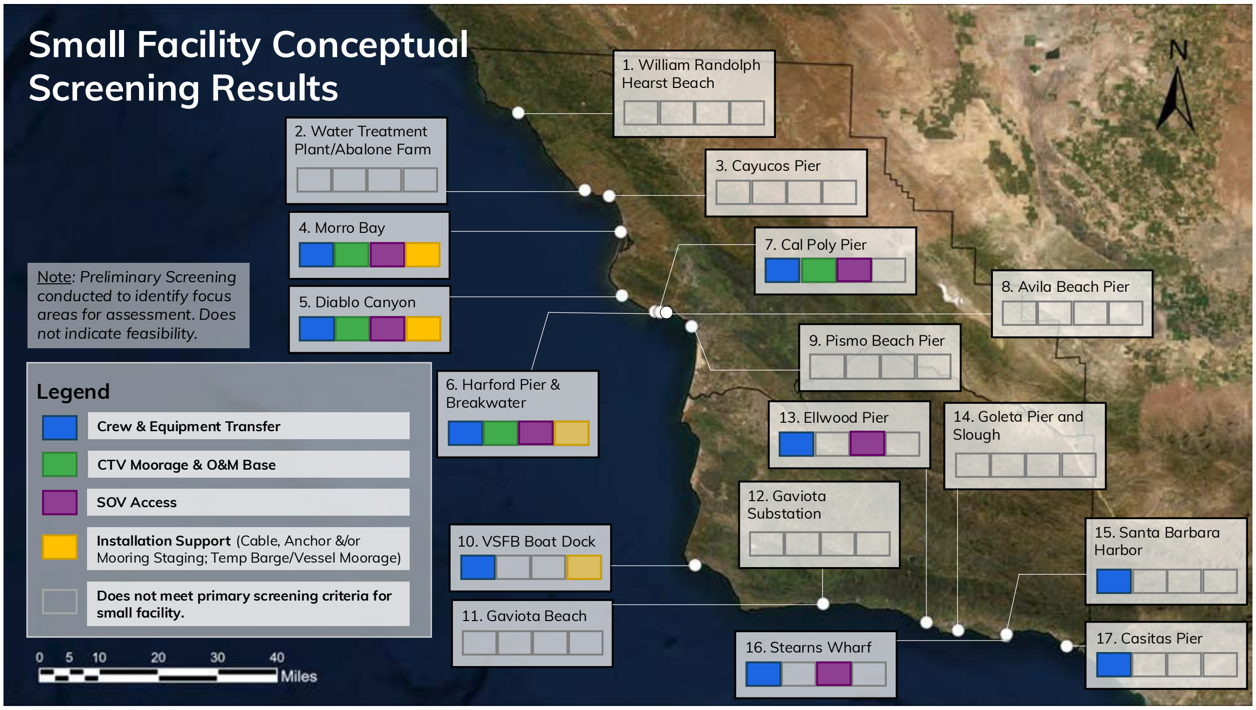


Figure 13. Small Facility conceptual screening results, identifying sites that may be further evaluated to determine suitability for FOW development.

5.2 LARGE FACILITIES SCREENING

Screening of the study area was conducted to focus the Large Facilities assessment on certain geographic areas within SLO and SB Counties. The Large Facilities screening focused on siting of an integration facility, since fabrication and component manufacturing may be conducted outside of the Central Coast. Greenfield, brownfield, and existing facility development types were considered in the Large Facilities screening assessment. The screening criteria and methodologies were developed to complement a concurrent study commissioned by the CSLC. This collaboration provides a consistent framework for identifying geographic focus areas for FOW waterfront infrastructure. The screening was conducted through the following stages (shown visually in Figure 14):

- **Preliminary Conceptual Screening.** Develop and apply preliminary screening criteria to identify "precluded areas" for development within the Initial Study Area. *Outcome: Long list (~13 sites) of potential integration focus areas for further evaluation as part of this study.*
- **Secondary Conceptual Screening.** Collect additional data on long-listed sites and assess the sites against the data to further refine the likely precluded areas. *Outcome: Short list (~6 sites) of potential integration focus areas for further evaluation as part of this study.*
- **Technical Site Evaluation and Selection of Example Sites.** Evaluate short-listed sites to select focus areas in coordination with REACH and the Technical Steering Committee for further evaluation and assessment and development of example construction costs. *Outcome: Identify focus areas (2 sites) for further assessment, conceptual site layout development, and construction cost estimation as part of the waterfront infrastructure assessment.*

Each screening stage is described in further detail in the sections below.

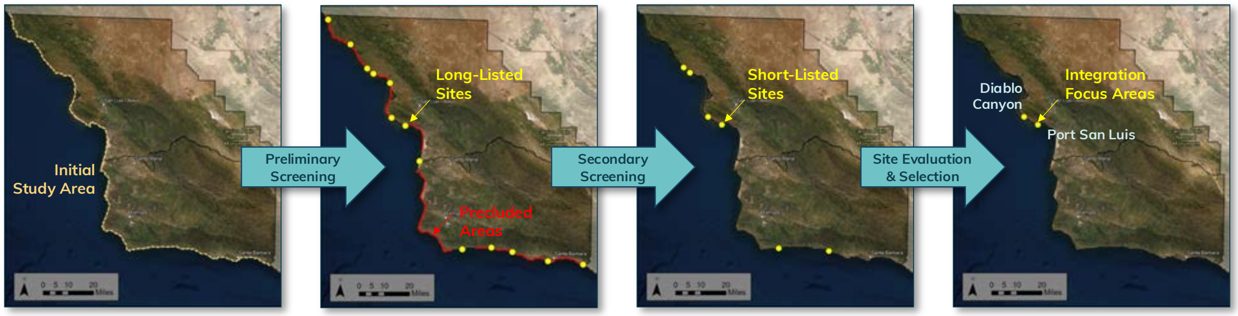


Figure 14. Large Facility screening assessment framework diagram - staged approach.

5.2.1 PRELIMINARY SCREENING

The preliminary screening criteria, which were applied to identify assumed precluded areas for a Large Facility development within the two-county study area, are listed in Table 7.

Table 7. Large Facility preliminary conceptual screening criteria.

Preliminary Conceptual Screening Criteria	Source
Airport Runway Approaches with Part 77 Surface Elevations< 1,100ft (335m)	*Airport Boundaries* Dataset (gis.data.ca.gov) Airport FAR Part 77 Airspace Restriction Maps
Military Bases	Military Bases Dataset (data-usdot.opendata.arcgis.com)
Existing National Marine Sanctuaries	Monterey Bay National Marine Sanctuary – *MPAs* Dataset (marinecadastre.gov)
Urban and Residential Areas	Manually delineated based on aerial imagery
Vandenberg Space Force Base (VSFB) Danger Zones (Launch Evacuation Zones)	*Danger Zones* Dataset (marinecadastre.gov)
State Marine Protected Areas (MPAs)[10]	*MPAs* Dataset (marinecadastre.gov)
State Parks	California State Park Boundaries Dataset (parks.ca.gov)
National Forests	US *National Forests* Dataset (data-usfs.hub.arcgis.com)

A "precluded areas" layer was generated for each preliminary screening criteria to identify areas of shoreline within the Initial Study Area that were likely unsuitable for a large waterfront FOW development (see Table 8 and an example shown in Figure 15). These screening layers were overlaid to generate a suitability map and identify the remaining areas for further consideration. After screening out the precluded areas, the segments of shoreline remaining with >1,500ft (450m)[11] of shoreline were flagged for further consideration. The results of the preliminary screening are shown in Figure 17.

[10] MPAs, as defined by the State of California, include State Marine Reserves, State Marine Parks, State Marine Conservation Areas, State Marine Recreational Management Areas, and Special Closures.
[11] 1,500ft (450m) is the assumed minimum wharf length needed for an integration facility (see Table 5). Length required may be longer depending on annual throughput (MW/year of installed wind power) needed.

PRELIMINARY LARGE FACILITY SCREENING EXAMPLE: MORRO BAY AND PORT SAN LUIS

To demonstrate the preliminary screening process used to create a long list of sites, an example is provided to justify why certain sites for Large Facilities were screened in or out through the process. As shown in Figure 15, Morro Bay did not pass the preliminary screening assessment due to a combination of State Parks (Morro Bay State Park, shown in deep red) and State MPAs (Morro Bay State Marine Recreational Management Area, shown in blue). Conversely, the area around Port San Luis was screened in because even though it contains an important water body with critical habitats, the area is not currently designated as an MPA. This is not to say that construction of an integration port at Morro Bay is technically infeasible with significant investments and a reconfiguration of the harbor. However, based on the screening criteria applied in this study (and as coordinated with the parallel CSLC study), port development within the boundaries of State Parks and California State MPAs is assumed to be unfavorable.

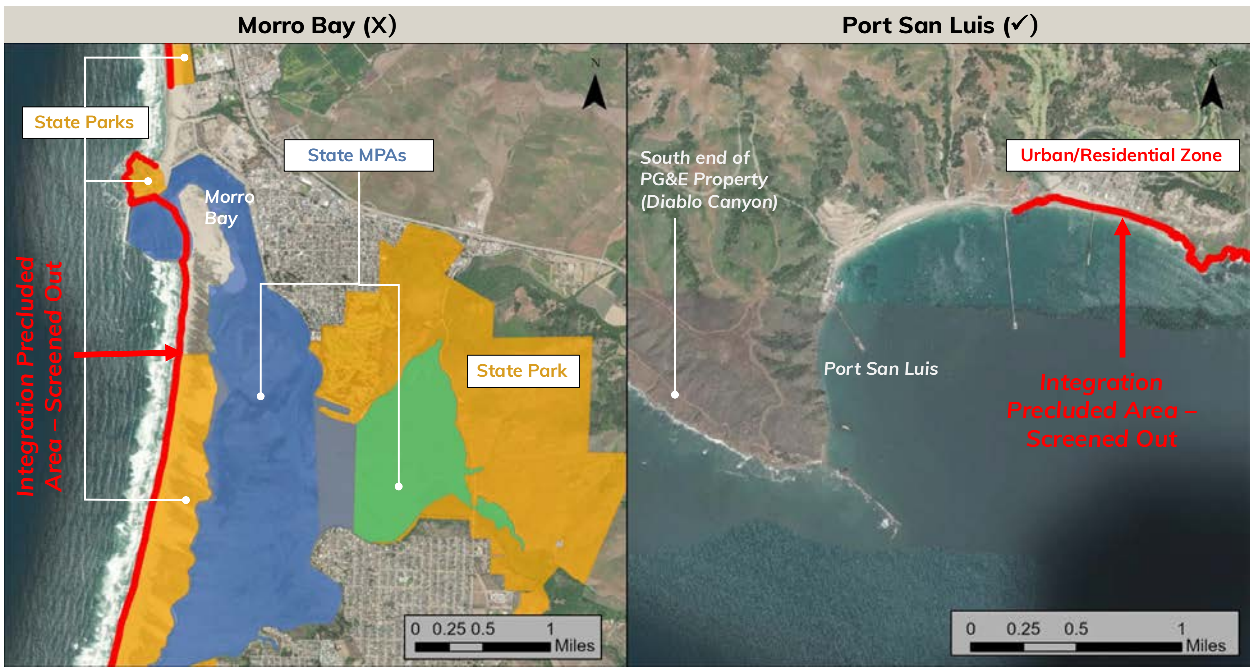
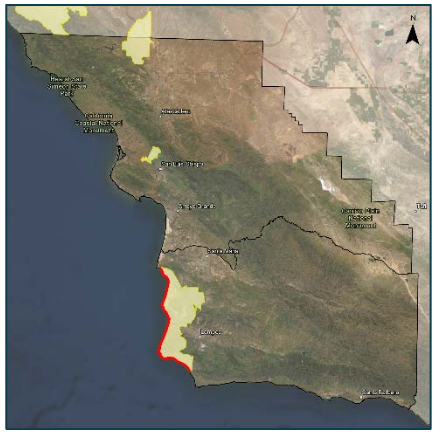


Figure 15. Example Large Facility preliminary screening results for Morro Bay (screened out) and Port San Luis (passed preliminary screening).

Table 8. Preliminary screening criteria layers. The red segments of shoreline show the precluded areas where each preliminary screening criteria overlaps with the study area coastline. These precluded area layers were overlaid to identify the initial long list of potential sites for further consideration, shown in Figure 17. The percentages provided in the table below indicate the percentage of the study shoreline that was screened out based on each criterion.

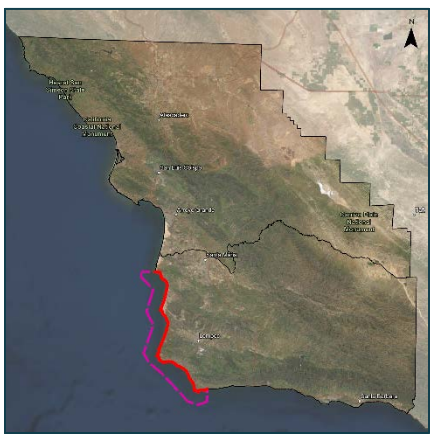
Airspace Restrictions (16%)



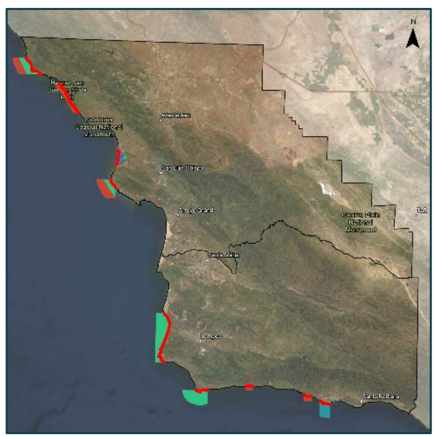
Military Bases (22%)

Existing National Marine Sanctuaries (15%)

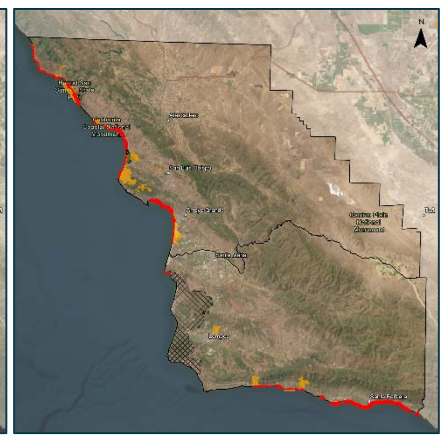
Urban and Residential Zones (16%)



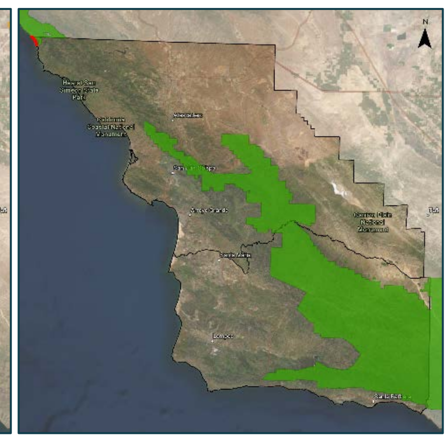
Danger/Launch Evacuation Areas (23%)



State MPAs (27%)



State Parks (33%)



National Forests (1%)

5.2.2 SECONDARY SCREENING

The secondary screening stage included additional data collection and an abbreviated evaluation for each long-listed site (see example in Figure 16). Additional information compiled included site elevations (bathymetry and topography data), land ownership, land use, and potential interference with existing infrastructure.

Unlike the preliminary screening stage, where the long list of sites was developed by eliminating areas associated with one or more preliminary precluded areas, the secondary screening considered various factors that may influence technical feasibility or relative favorability for development of an integration facility. Secondary screening criteria included existing county parks, city parks, nature preserves, and wildlife sanctuaries. Relative favorability from a conceptual engineering standpoint was also considered in screening out long-listed sites to establish a short list of sites for further evaluation in this study.

The results of the secondary screening are presented in Table 9 and Figure 17. It should be noted that all the short-listed sites except for Gato Canyon are sited within the proposed Chumash Heritage National Marine Sanctuary boundaries. This and other important regulatory considerations should be included in further site development assessments moving forward.

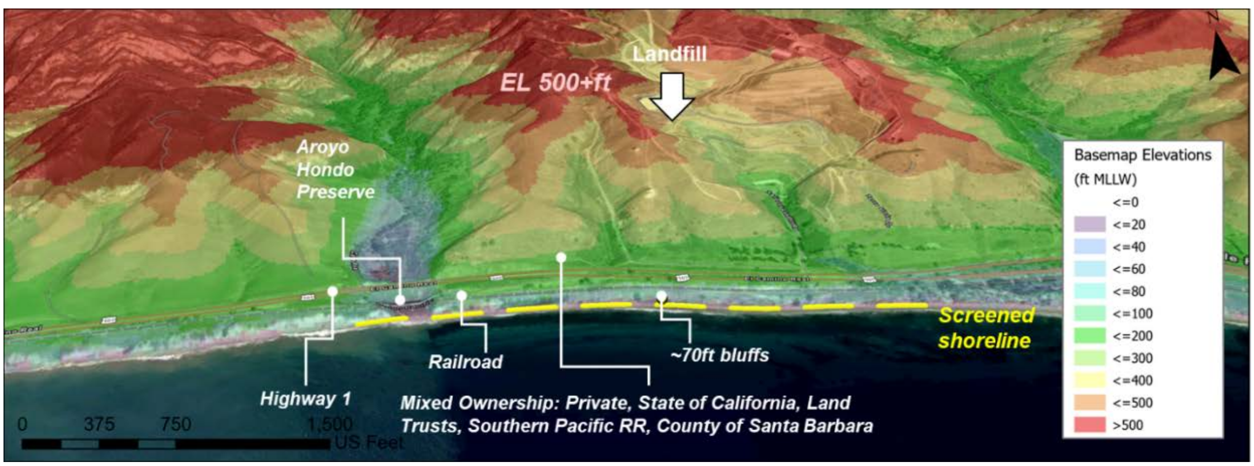


Figure 16. Example site assessment at long-listed site (Tajiguas Landfill).

Table 9. Summary of secondary screening considerations and results.

Long-Listed Sites	Secondary Screening Result	Justification, if screened out
Nicki's Beach	✓	*Passed secondary screening*
China Harbor	✓	*Passed secondary screening*
Toro Creek	X	Adjacent to residential areas; Highway 1 runs adjacent to shoreline
Diablo Canyon	✓	*Passed secondary screening*
Port San Luis	✓	*Passed secondary screening*
Guadalupe-Nipomo Dunes	X	Nature Preserves – Rancho Guadalupe Dunes Preserve (SB County Park); Point Sal Preserve (SB County, Land Conservancy of SLO County)
Drake	✓	*Passed secondary screening*
Tajiguas Landfill	X	Nature Preserve – Arroyo Hondo Preserve; Southern Pacific railroad and Highway 1 run adjacent to shoreline; challenging topography (~70ft {21m} bluffs at base of 500ft+ {152m} coastal mountains); potential interference with Tajiguas Landfill
Gato Canyon	✓	*Passed secondary screening*
Arroyo Burro Beach	X	County Park with heavy recreational use – Arroyo Burro Beach County Park
Carpinteria	X	Nature Preserves and Wildlife Sanctuaries: Carpinteria Seal Sanctuary, Carpinteria Bluffs Nature Preserve Conservation Easement (Land Trust for SB County), Rincon Bluffs Preserve Conservation Easement (City of Carpinteria); Rincon Beach County Park; Union Pacific Railroad runs adjacent to shoreline/bluff edge; shoreline consists of ~90ft (27m) bluffs

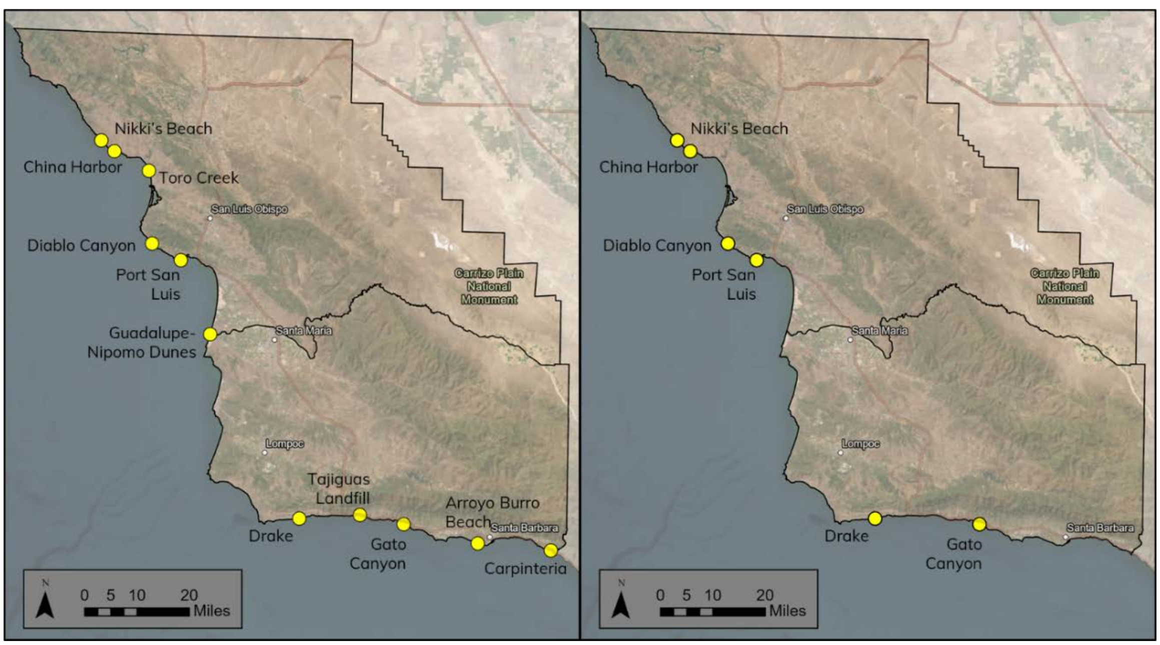


Figure 17. Left: preliminary screening results (long-listed sites). Right: secondary conceptual screening results (short-listed sites).

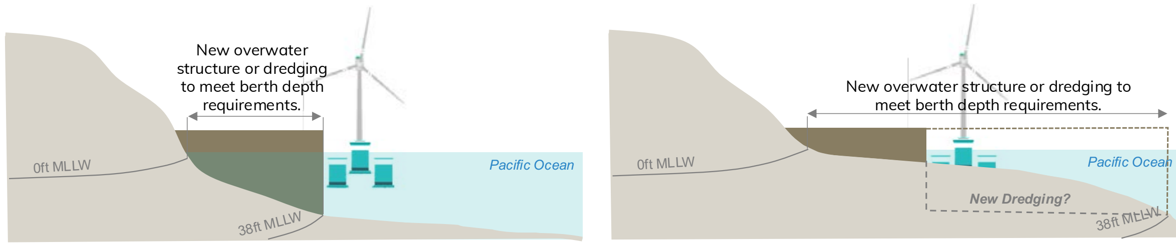
5.2.3 CONCEPTUAL SITE EVALUATION AND SELECTION OF LARGE FACILITY FOCUS AREAS

A conceptual technical site evaluation was conducted to aid in selection of two geographic focus areas for further evaluation of the potential Large Facility development. This evaluation was not intended to be considered a robust alternatives assessment between sites. Instead, this evaluation was intended to provide site characteristics of the short-listed areas in order to select example focus areas for further assessment in the Waterfront Infrastructure Assessment portion of the report. The factors considered in the site evaluation are listed in Table 10.

Table 10. Large Facility site evaluation considerations.

Consideration	Purpose	Proxy Measurement	Data Source
Distance to Deep Water (see Figure 18)	Further distance can result in more dredging or overwater structure to provide needed water depth for vessels and integrated turbines	Straight-line distance from 0ft MLLW contour to 38ft MLLW (12m) contour	Project Basemap Elevations (see Basis of Assessment)
Distance to Transmission Line[12]	The port will require substantial power needs; not related to windfarm export cable	Straight-line distance from 0ft MLLW contour to nearest transmission line	*California Electric Transmission Lines* (gis.data.ca.gov)
Existing Road Access	Truck access will be required for construction and may be required during operation	Straight-line distance from 0ft MLLW contour to nearest existing road.	Aerial Imagery and Google Maps
Potential Interference with State or Interstate Highway	Would likely constrain development extents onshore	Straight-line distance from 0ft MLLW contour to nearest highway	National Highway System (gis.data.ca.gov)
Potential Interference with Railroad Corridor	Would likely constrain development extents onshore	Straight-line distance from 0ft MLLW contour to nearest railroad right-of-way	*California Rail Network* (gis.data.ca.gov)

[12] Note that the *Distance to Transmission Line* parameter was included as a proxy measurement for the extent of additional transmission infrastructure that would be needed to provide power to a new port facility. Wind farm export cable grid injection options were not considered in this assessment.



Deep water closer to shoreline – less overwater structure or dredging needed to meet berth depth requirements.

Deep water further from shoreline – more overwater structure or dredging needed to meet berth depth requirements.

Figure 18. Schematic showing impact of *Distance to Deep Water* on engineering favorability.

The characteristics associated with each short-listed location were estimated and compiled into an evaluation matrix to provide an overview of risks and benefits of the various sites relative to the considerations above. Each of the six short-listed sites were discussed and evaluated together with the Technical Steering Committee. The qualitative assessment in Figure 19 was intended to guide a decision process but not to prescribe specific sites for further analysis.

	Distance to 38ft Contour	Distance to Transmission Line	Existing Road Access	Potential Interference with State Highway	Potential Interference with Railroad Corridor	Shoreline/Land Use Sensitivities
Nikki's Beach	~2,000 feet	3-4 miles	Nikki's Beach Drive - gravel road	~1 mile	N/A	Private Beach
China Harbor	~2,600 feet	3-4 miles	~1 mile to Highway 1	~2,000 – 6,000 feet	N/A	Hiking trails, adjacent to state park
Diablo Canyon	~1,150 – 1,900 feet	<1 miles	Diablo Canyon Road	N/A	N/A	Power plant, PG&E, activities, conserved lands
Port San Luis	~3,300 feet	<3 miles	Avila Beach Drive/ Lighthouse Road	2-4 miles	N/A	PSL Harbor District, Conserved lands
Drake	~1,600 feet	~7.5 miles	<1 mile to Rancho Road, ~4 miles to Highway 1	~4 miles	350 – 700 feet	Private Ownership - Conservation Focus
Gato Canyon	~1,100 feet	~1 mile	<1 mile to Highway 1	660 – 3,300 feet	160 – 1,300 feet	University of California SB

Figure 19. Site evaluation matrix.

The Technical Steering Committee and Elected Review Panel provided guidance to the project team to proceed with Diablo Canyon and Port San Luis (PSL) as integration focus areas for further evaluation. The selection for visualization of the two identified sites with existing waterfront facilities/harbors was considered but does not confirm favorability over the other greenfield sites. These areas were selected in this study for performing a gap analysis, identifying needed upgrades, and conducting conceptual engineering works (planning-level layouts and costs) to understand the scale of investment in waterfront infrastructure that would be needed should an integration facility be sited within SLO or SB Counties. Upon further analysis, stakeholder engagement and site investigations beyond the scope of this study may reveal that other sites in the two-county area are more suited for Large Facility development.

5.3 CONCEPTUAL SCREENING ASSESSMENT RESULTS

The results of the screening assessment for Small and Large FOW Facilities on the Central Coast are summarized in Table 11 and Figure 20. The screening assessment results are not intended to identify the "best" FOW development opportunities within the Central Coast region but rather to use a standardized process and criteria to identify representative sites for further evaluation and estimation of construction cost estimates in the following study section.

Table 11. Conceptual screening assessment results and summary of areas selected for further evaluation as part of the Waterfront Infrastructure Assessment.

Assessment Area	Assessment and Gap Analysis	Long-listed Sites for Large and/or Small Facility	Potential Facility Considered	3D Rendering and Costs
Harmony – Point Estero Region		Nicki's Beach	Large Facility	
		China Harbor	Large Facility	
Morro Bay	✓	Morro Bay	Small Facility	OMF
Diablo Canyon	✓	Diablo Canyon	Large and/or Small Facility	Integration
San Luis Obispo Bay	✓	Port San Luis	Large and/or Small Facility	Integration
		Cal Poly Pier	Small Facility	
Vandenberg Space Force Base	✓	VSFB Boat Dock	TBD, pending site upgrades (see Volume II of this report)	Space (see Volume II)
South SB County	✓	Gato Canyon/Drake	Large Facility	
		Santa Barbara Harbor/ Stearns Wharf/Ellwood Pier	Small Facility	

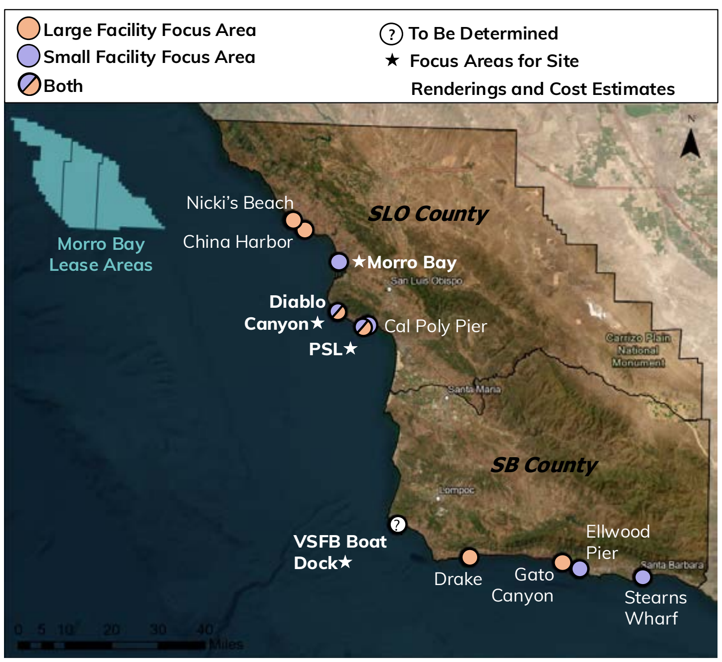


Figure 20. Summary of focus areas for waterfront infrastructure assessment.

WATERFRONT INFRASTRUCTURE ASSESSMENT

6 WATERFRONT INFRASTRUCTURE ASSESSMENT

The Waterfront Infrastructure Assessment contains further investigation of the focus areas identified through the site screening process (see Figure 20 and Table 11). This chapter is organized geographically from north to south within the Initial Study Area. Each subsection is dedicated to one of the locations that was screened as being potentially favorable for a waterfront area/facility that could potentially support FOW. For each focus area, this chapter presents a summary of site conditions, a gap analysis (comparison of site conditions to FOW facility requirements), and the resulting elements likely needed to support specific FOW functions. Additional engineering analysis was conducted at a number of sites, which were selected in coordination with the Technical Steering Committee (see Table 11), to inform development of 3D site renderings and associated planning-level construction cost estimates.

6.1 SAN LUIS OBISPO COUNTY

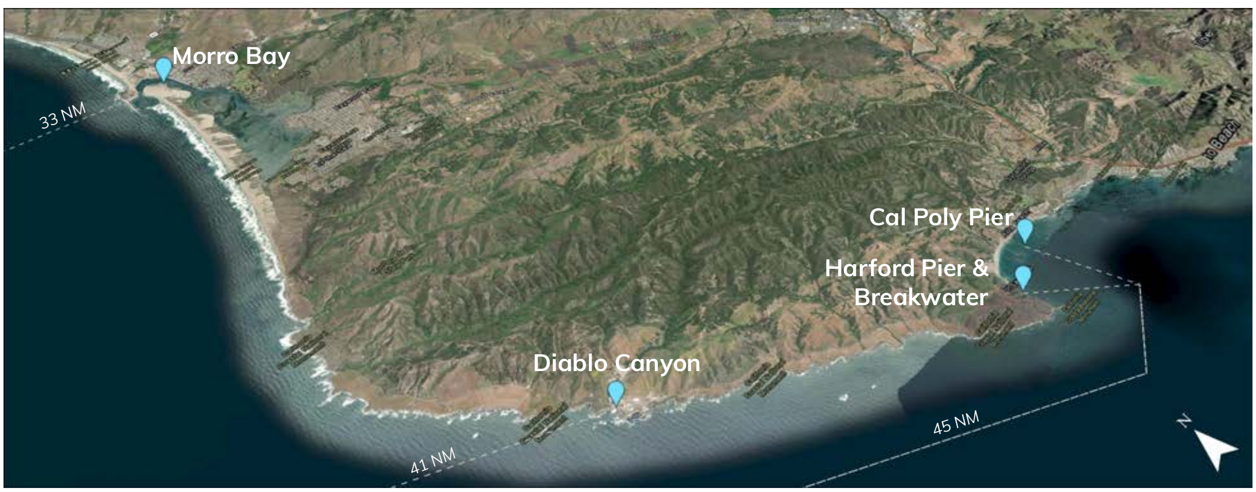


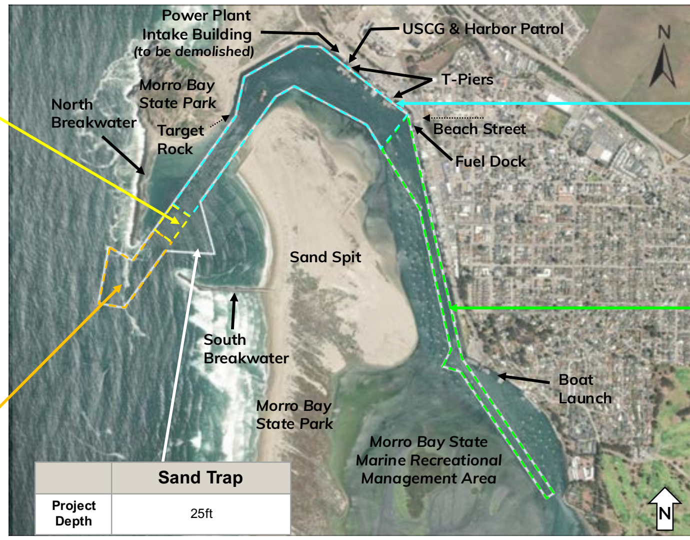
Figure 21. Assessment areas within SLO County and approximate distances to the Morro Bay Lease Areas.

In line with the screening results, several sites in SLO County — Morro Bay, Diablo Canyon, and the Port San Luis Harbor District (including the Harford Pier and Breakwater and Cal Poly Pier) were selected for further assessment to evaluate potential infrastructure upgrades to support FOW functions. Collectively, these sites are the closest existing port and harbor sites to the Morro Bay Lease Areas. Consultations with industry have confirmed strong interest for potential utilization of these sites for small and large FOW facilities.

6.1.1 MORRO BAY

SITE CONDITIONS SUMMARY

Morro Bay is a protected estuary and the northern most harbor within the study area. The harbor entrance leads to the Pacific Ocean and is stabilized by two breakwaters.



	Transition Channel
Project Depth	Transitioning from 30 feet to 16 feet
Width	350 feet

	Entrance Channel
Project Depth	30 feet, with 10 feet advanced maintenance dredging
Width	350 feet

	Sand Trap
Project Depth	25ft

	Main Channel & Navy Channel
Project Depth	16 feet
Width	350 feet

	Morro Channel
Project Depth	12 feet
Width	150 feet

Figure 22. Morro Bay site overview. The channel dimensions represent FNC design geometries.

- **Existing Use.** Morro Bay hosts the only USCG facility between Monterey and Santa Barbara. Historically and presently, the harbor has supported the local commercial and recreational fishing industry. Several docks are currently underutilized, including the public T-Piers. The Morro Bay Power Plant site, which is owned by Vistra Energy, is scheduled to be decommissioned, and the Power Plant Intake Building (see Figure 22) will no longer be in use. There is an anchorage area opposite the T-Piers.
- **Operations.** Entrance channel is dredged annually (typically >100,000CY); Inner channels haven't been dredged in 6-7 years; largest vessel to regularly access and turn around in the harbor is the *Yaquina* (200ft length, 9-14ft draft); Existing fuel dock has 10,000-gallon tank.
- **Topography.** Morro Bay is protected by a long (~4mi {6km}) sand spit feature. The City of Morro Bay is situated within a low-lying coastal plan that slopes upwards towards the landward mountains landwards of Highway 1.
- **Bathymetry.** The USACE maintains a system of Federal Navigation Channels (FNCs), as shown in Figure 22.
- **Geology.** Based on nearby upland explorations, the depth of bedrock appears to be around 50-70ft below the surface and is overlain by layers of marine, estuarine, and dune deposits (TRC 2000, Earth Systems Pacific 2005, Bengal Engineering Inc., 2014). The USACE analyzed sediment samples (to a depth of -25ft {7.6m} MLLW) within the FNC, which classified channel sediment primarily as poorly graded sand (USACE, 2013).
- **Wave Climate.** The harbor is protected from Pacific Ocean swell by the sand spit feature and two federal breakwaters stabilizing the entrance channel. The USCG occasionally temporarily closes the entrance channel to navigation during periods of severe waves.

- **Potential FOW Development Areas.** In coordination with city representatives, three areas were identified for potential waterfront facility developments: North T-Pier, South T-Pier, and the footprint of the existing Morro Bay Power Plant Intake Building and associated infrastructure (owned by Vistra Energy).
- **Air Draft and Height Restrictions.** There are no air-draft restrictions in Morro Bay.

WATERFRONT INFRASTRUCTURE ASSESSMENT SUMMARY

A gap analysis and navigation assessment were conducted to evaluate potential development opportunities for Small and Large Facilities in Morro Bay. Details of the assessment are provided in Appendix B, and a summary of the outcomes are provided below.

Small Facilities

Morro Bay is well positioned to support O&M and construction staging. The distance to the Morro Bay Lease Areas is approximately 33 nautical miles. Water depths in the navigation channel can likely accommodate a range of support vessels such as CTVs, SATVs, and the small end of SOVs and AHTVs. Waterfront, upland space for a warehouse and equipment laydown is likely available at the Vistra property. A new multi-purpose wharf and fuel dock at the old intake structure could potentially serve other maritime users.

To service moorage of SOVs (long-term operations) and AHTVs (during construction support), a new fixed wharf is needed within the harbor. Developers may prefer or need SOVs and AHTVs that are larger than the size that can presently fit in the harbor. Deepening of the main and Navy channels by several feet, in conjunction with an expanded dredge area to provide a wider turning basin, would likely be required to allow for a wider range of these vessels to access the harbor. If a new wharf is constructed at the Vistra property, it would likely require localized removal of a portion of the adjacent T-Pier to accommodate longer vessels and berth dredging. These upgrades would need to be designed considering the adjacent eelgrass beds, which may constrain the size of the berth.

Large Facilities

Morro Bay has limited options for an integration facility or other Large Facility. Due to the width and draft of the floating foundations, development of a new marine terminal would require significant harbor and breakwater reconfiguration as well as new infrastructure on the sand spit. The sand spit, which separates the bay from the ocean, is snowy plover habitat and a state park, which would both need to be considered in assessing potential environmental impacts. As noted previously, Morro Bay did not pass the screening criteria used in this study for a Large Facility.

CONCEPTUAL ENGINEERING CONSIDERATIONS AND CONCEPT DEVELOPMENT

Morro Bay was selected as a focus evaluation area for development of a concept OMF facility layout and the associated construction cost estimate. The concept layout was developed to meet the OMF facility requirements presented in the Basis of Assessment (see Table 2) and with consideration for the items below.

Small Facility Site Selection and Concept Design Basis

- **Example Site Selection and Development Constraints**. The footprint of the decommissioned Power Plant Intake Building was selected as an example OMF development site based on coordination with REACH and the Morro Bay Harbor Department. The Intake Building parcel appears to extend from shore into the water approximately 200ft (61m) and is privately owned by Vistra Energy. The Vistra Energy parcel is only about 200ft (61m) long along the shoreline. Changes to local zoning laws may be needed to enable a development at this site extending beyond 200ft (61m) in length (to support mooring of larger SOV or AHTV vessels). It may be possible to construct a smaller facility (to support CTVs only) within the current Intake Building parcel.

- **Storage Yard.** Relative to other sites within Morro Bay, the Intake Building has better access to vacant upland lots. At present there are other uses planned for the Vistra property in the area east of Embarcadero, so the parking, offices, and warehouse area (see Figure 24) may be located elsewhere.

- **Navigation and Maneuvering.** The maneuvering area and turning basin are wider at the Vistra property relative to the T-Pier sites, since the T-Piers extend further into the FNC. The site may be able to accommodate berthing of larger vessels (e.g., SOVs, AHTVs, SATVs) in addition to CTVs. Further information on conceptual engineering conducted to assess dredging requirements for the example OMF facility are provided in the Conceptual Navigation Assessment Section below.

- **CTV Moorage.** CTVs can likely leverage the existing finger floats area landwards of the T-Pier. In the example site layout, the existing Harbor Patrol vessels are relocated to the south side of the pier.

- **Multipurpose Wharf.** The example site layout includes a new pile-supported wharf approximately in the footprint of the existing Intake Building. The wharf is intended to support vessel berthing as well as loading and storage of components and equipment.

- **Navigation.** Please refer to Appendix C, Conceptual Navigation Assessment.

Other Considerations/Complexities

- **Fuel Dock Access.** The existing fuel dock is located just south of Beach Street (see Figure 22), with less channel width and maneuvering area relative to the Vistra property site. The fuel dock may need to be modified to provide better access for larger vessels. Further, the fueling system may need upgrades to be able to meet the capacities needed to support larger vessels. Alternatively, a new purpose-built fuel dock may be needed at a new location.

- **T-Pier Interface**. In the example site concept, the existing T-Pier is modified to accommodate the wharf length needed to support larger vessels. The details of the T-Pier modifications will need to be further assessed in coordination with the City of Morro Bay.

Example Site Development Rendering

Site renderings showing existing conditions (Figure 23) and an example OMF development (Figure 24).

Figure 23. Existing conditions at potential development area in Morro Bay.

Figure 24. Site rendering of example OMF sited in Morro Bay. The total developed area In this example is approximately 5 acres.

6.1.2 DIABLO CANYON

Diablo Canyon Nuclear Power Plant (DCPP) is located on the Pacific Ocean at the base of a coastal mountain range and is exposed to Pacific Ocean swell. The area of focus is not at the location of the reactor building but on the shoreline area to the south of the desalination plant, extending to the southern extent of Parcel P. Note that the area considered for development also extends offshore of Parcel P boundary, which roughly follows the shoreline.

SITE CONDITIONS SUMMARY

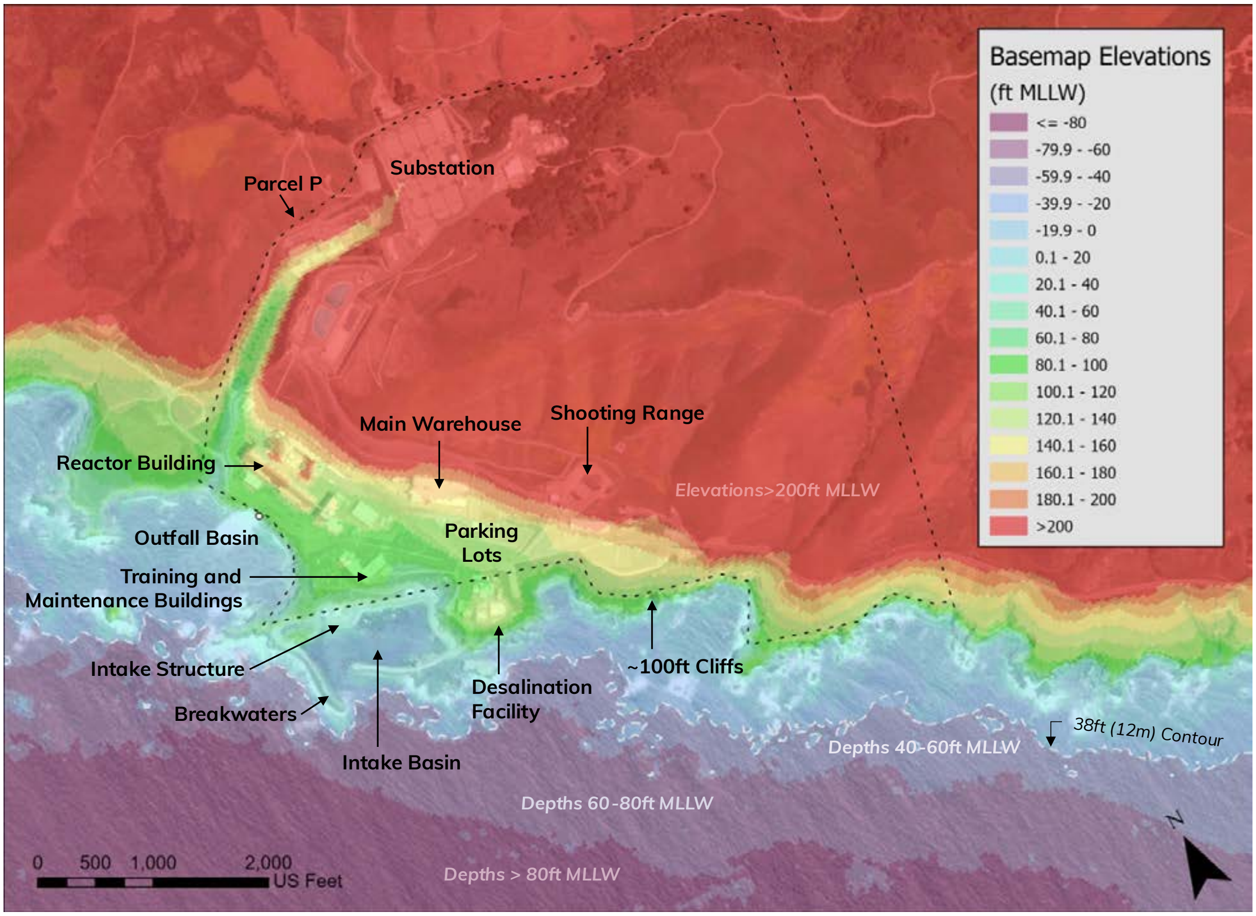


Figure 25. Overview of Parcel P at Diablo Canyon.

- **Existing Use.** The site contains the operational DCPP. In September 2022, California lawmakers approved bill SB 846, which may extend DCPP operations through 2029-2030. Blasting for grading, dredging, or demolition is assumed[13] to be prohibited in certain areas or on the entire site.
- **Existing Harbor.** The intake basin is protected by two interlocking armor unit breakwaters. There are plans to convert the existing intake structure into a wharf to support debris removal during decommissioning. Elevations within the intake basin are shown in Figure 26.

[13] Based on engagement with PG&E representatives.

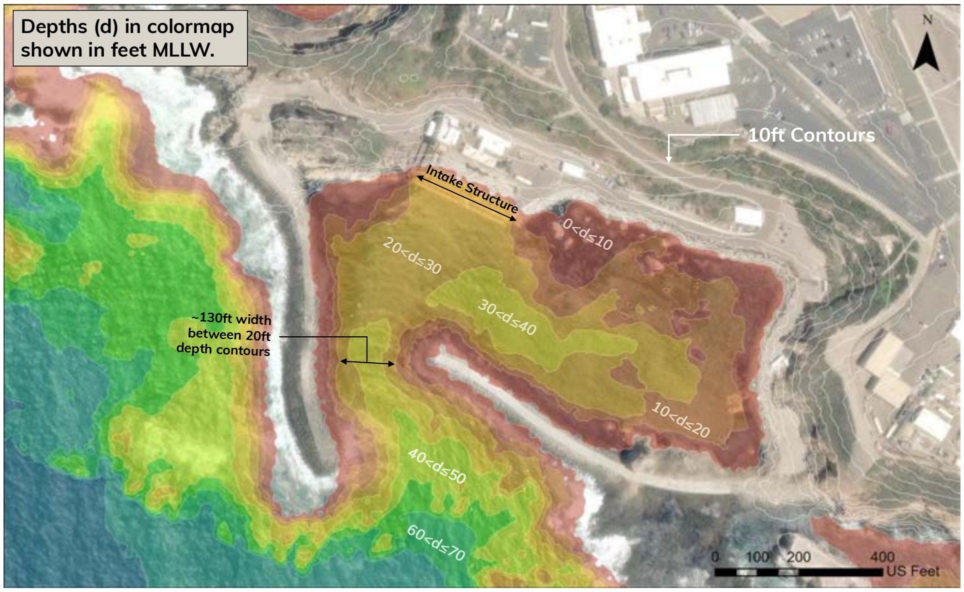


Figure 26. Overview of intake basin. Elevations shown based on public data (NOAA 2006 and California State University 2009).

- **Topography.** Rocky cliffs (elevation ~100ft {30m}) line the coast. The cliffs are backed by a sloped marine terrace, transitioning to coastal mountains with elevations exceeding 1,000ft (300m) within a half mile {0.8km} of the shoreline.
- **Bathymetry.** Depths near the base of the cliffs are around -5 to -10ft (-1.5 to -3.0m) MLLW. From the cliffs, the transition to deep water (e.g., -38ft {-12m}, sufficient for floating foundation clearance), is fast relative to other areas along the Central Coast.
- **Geology.** Sedimentary and volcanic bedrock are present under approximately 3-36ft (1-11m) of near-surface Pleistocene sediment. The ground can likely support grading on the order of 2H:1V, depending on site investigations. Installation of new piles to support wharf structures may require drilling into rock. Excavation or dredging may require blasting or rock ripping methods. There is documented landslide risk within Parcel P.
- **Wave Climate.** The site is mostly exposed to Pacific Ocean swell, with the exception of the intake basin, which is protected by armor unit breakwaters. Based on review of the nearby wave buoy,[14] wave conditions vary seasonally — both in wave height and direction. The average significant wave heights vary significantly by month, as shown in Figure 27, with a range of peak wave periods between around 7 seconds to around 15 seconds. Wave direction is primarily out of the W/NW, with swell out of the S/SE also present, as shown in the wave rose in Figure 27. Between May and October, wave direction is out of the S/SE direction approximately at 30-40% occurrence rate.
- **Site Constraints.** For this study, it is assumed that new developments to the property owned and operated by PG&E will be limited to a 585-acre (237 hectare) upland industrial parcel of land titled "Parcel P," as shown in Figure 25, since other parcels are reserved for conservation

[14] CDIP Station 076, which is less than 1mi (1.6km) offshore of Diablo Canyon in water depths of approximately 90ft (27m).

and tribal land restoration efforts. The submerged lands offshore Parcel P are state-owned and under the jurisdiction of the CSLC.

- **Cultural Significance.** Historical tribal settlements have been recorded along the Diablo Canyon coastline. Consultations with tribal stakeholders and a cultural resources assessment should be conducted at an early stage as part of further analysis.
- **Air Draft and Height Restrictions.** There are no air-draft restrictions at Diablo Canyon.

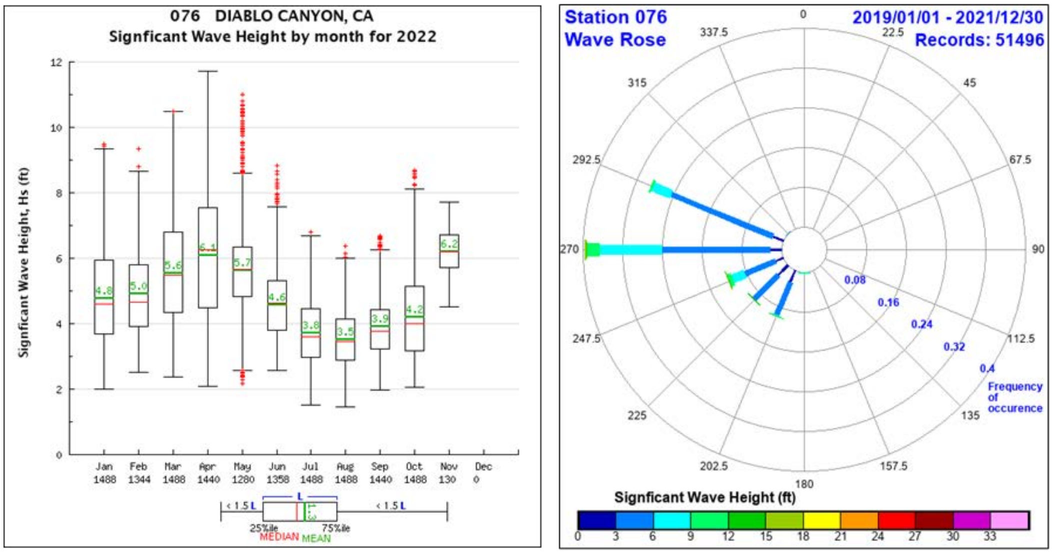


Figure 27. Summary of wave height variation by month (left) and a wave rose (right) at the Diablo Canyon 076 CDIP Wave Station, located less than 1mi (1.6km) offshore the site.

WATERFRONT INFRASTRUCTURE ASSESSMENT SUMMARY

A gap analysis and conceptual navigation assessment were conducted at the Diablo Canyon site to assess potential development options for Small and Large FOW Facilities. The findings are summarized below, with further details provided in Appendix C.

Small Facilities

The existing intake basin may be utilized for small craft vessels, such as CTVs or SATVs, but further analysis (hydrographic survey, maneuvering assessment) is needed to assess whether the basin size can safely accommodate SOVs. The distance to the Morro Bay Lease Areas is 36 nautical miles. There are plans to convert the intake structure (see Figure 26) into a wharf, which may provide additional use for vessel/barge berthing or anchor/mooring line staging, if coordinated with power plant decommissioning activities. Upland area is available for offices and parking. An image of marine offload within the intake basin is provided in Figure 28 below.

Figure 28. Example barge offload within the DCPP intake basin, which may be used as part of a Small Facility but is not large enough to support a Large Facility.

Large Facilities 

The existing intake basin (see Figure 25) is not large enough to support Large Facility activities. Developing a new marine terminal to support integration at this site is technically challenging due to steep cliffs, wave climate, shallow bedrock, and construction limitations due to continued operation of the power plant (e.g., assume no/limited rock blasting on site is permitted while the plant is operational). There is also discussion as to possible future reuse opportunities at Parcel P and conservation of the surrounding lands. Given these constraints, a new wharf and storage yard will need to be primarily overwater, rather than leveraging existing onshore acreage.[15] A new breakwater is required to provide shelter from ocean swell for integration and other activities. Access to the shoreline south of the existing harbor will be needed, which is a documented landslide risk zone. Installation of a breakwater would be required prior to wharf construction to provide suitable conditions for pile driving. The wharf is likely to be pile-supported with rock sockets at the seabed.

Despite the technical challenges, there are a number of favorable parameters to support development of an integration port at Diablo Canyon, such as nearshore water depths that can support FOW activities with no/limited dredging, industrial site use, and existing onshore parking and support facilities.

CONCEPTUAL ENGINEERING CONSIDERATIONS AND CONCEPT DEVELOPMENT

Diablo Canyon was selected as a focus evaluation area for development of an example integration facility layout. The concept facility development and construction cost estimates were based on the integration facility requirements presented in the Basis of Assessment (Table 5) and the considerations listed below.

[15] Note that other technical solutions may be possible, but not while the plant is operational.

Small Facility Site Selection and Concept Design Basis

- **Example Site Selection.** The use of facilities at Diablo Canyon to support FOW support functions (e.g., barge offloading, CTV and SATV moorage, potential berthing of small SOVs) is considered within the intake basin due to wave protection provided by two existing breakwaters. The existing intake structure will be converted into a wharf to support power plant decommissioning efforts; this new infrastructure could also be leveraged to support the delivery of equipment for the FOW industry, if site use can be coordinated among several users. The new CTV moorage infrastructure is located adjacent to the existing floats (see Figure 30), to minimize conflicts to navigation elsewhere in the intake basin. The new floats are shown to be located around the 12ft (3.7m) MLLW, but the actual location may change pending site investigations and vessel specifics.
- **New Infrastructure.** New infrastructure will be needed to support CTV moorage. In the example rendering, a new wharf, gangway, and floats are shown to provide access for landside crew, truck access, and equipment transfer.
- **Development Constraints.** The boundaries of potential FOW site use in the vicinity of the intake basin should be coordinated with the site owners, PG&E.
- **Vessel Fleet.** An example fleet of three CTVs is shown, but the actual vessel fleet will depend on the O&M strategy adopted for a specific project.
- **Navigation.** Based on preliminary assessment of water depths within the basin and the width of the basin entrance, it appears that CTVs and SATVs can likely safely enter and maneuver within the basin. Further analysis is needed to evaluate whether SOVs can safely enter the intake basin, given the width of the channel between the breakwaters, and the requirements for a turning basin within the harbor relative to vessel draft.

Large Facility Site Selection and Concept Design Basis

- **Example Site Selection and Development Constraints**. Since the power plant will likely be operational through 2030, the example integration facility should be sited as far east (away from the reactor building) within Parcel P as possible to reduce potential construction conflicts. Because onshore development is assumed to be precluded during power plant operation, the majority of the terminal area would need to be overwater, into CSLC-managed submerged lands.
- **Earthworks**. Because construction of the FOW port would need to start prior to power plant decommissioning should the extension be granted, it is assumed that no blasting can be conducted for excavation works. Therefore, excavation and blasting should be limited to the extent possible. The FOW port would therefore need to largely be constructed on submerged lands.
- **Wharf and Yard Configuration**. The wharf length and yard configuration were developed at a concept level to yield a large storage area, in the range of 80-100 acres (32-40 hectare). Based on discussion with FOW developers, a larger storage area is preferred to enable storage of more components. Additional storage introduces more contingency into the construction schedule to mitigate for potential weather or supply chain delays. The wharf length in the example facility layout (see Figure 31) is around 3,500ft (1,000m), which is longer than the minimum conceptual requirement of 1,500ft (450m) assumed for this study. To achieve the target storage yard area, the wharf length was extended beyond the assumed minimum value in the longshore direction to avoid building the wharf and breakwater out into deeper water in

the cross-shore. The wharf length could be reduced to three berths, closer to the minimum conceptual requirement, but this would require building farther into deeper water to maintain a large storage area.

- **Wharf and Yard Foundation Structure**. King-pile combi-wall, clustered pile bulkhead wall, caisson wharf, or large pile-supported deck are likely wharf types. Concepts to reduce wave reflection against the wharf should be considered. This assessment assumes a pile-supported wharf and yard. Alternatively, the storage yard area could likely be constructed from reclaimed land (fill), which may be less expensive depending on source material type and location. The DCPP site is unlikely to be suitable as a borrow site due to present use.
- **Berth Depth**. The wharf is aligned approximately with the 65ft (20m) contour. This alignment provides sufficient depth for quayside activities and reduces the need to dredge or excavate rocky outcroppings in the nearshore.
- **Breakwater**. A breakwater is required to protect the integration facility from Pacific Ocean swell. See conceptual design considerations as part of the Conceptual Navigation Assessment below. Wet storage could potentially be feasible, to an extent, within the newly created harbor. The other option would be to utilize the deep waters of SLO Bay as an anchorage area.
- **Constructability Considerations**. The breakwater would likely need to be constructed first to provide a calmer sea state for wharf pile-driving activities. Securing access to the construction area before the yard is constructed may be challenging given the cliffs that line the shoreline. A temporary trestle or other solution may be needed.
- **Navigation**. Please refer to Appendix C, Conceptual Navigation Assessment.

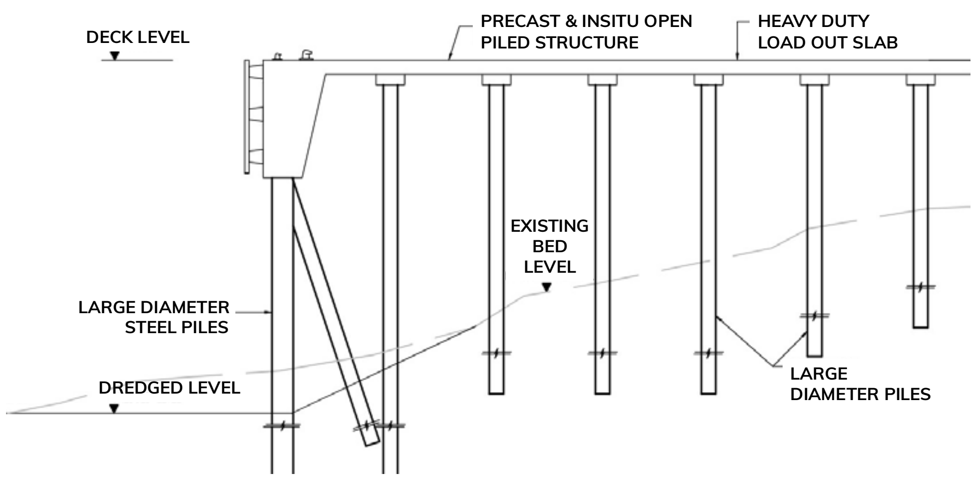


Figure 29. Example of pile-supported wharf and yard. Note that pile spacing, diameter, and embedment are not to scale.

Example Site Development Renderings

Figure 30 shows a rendering of FOW support functions being conducted within the existing intake basin at Diablo Canyon. The rendering shows barge unloading at the existing intake structure (planned to be converted into a wharf) and new infrastructure to support CTV moorage.

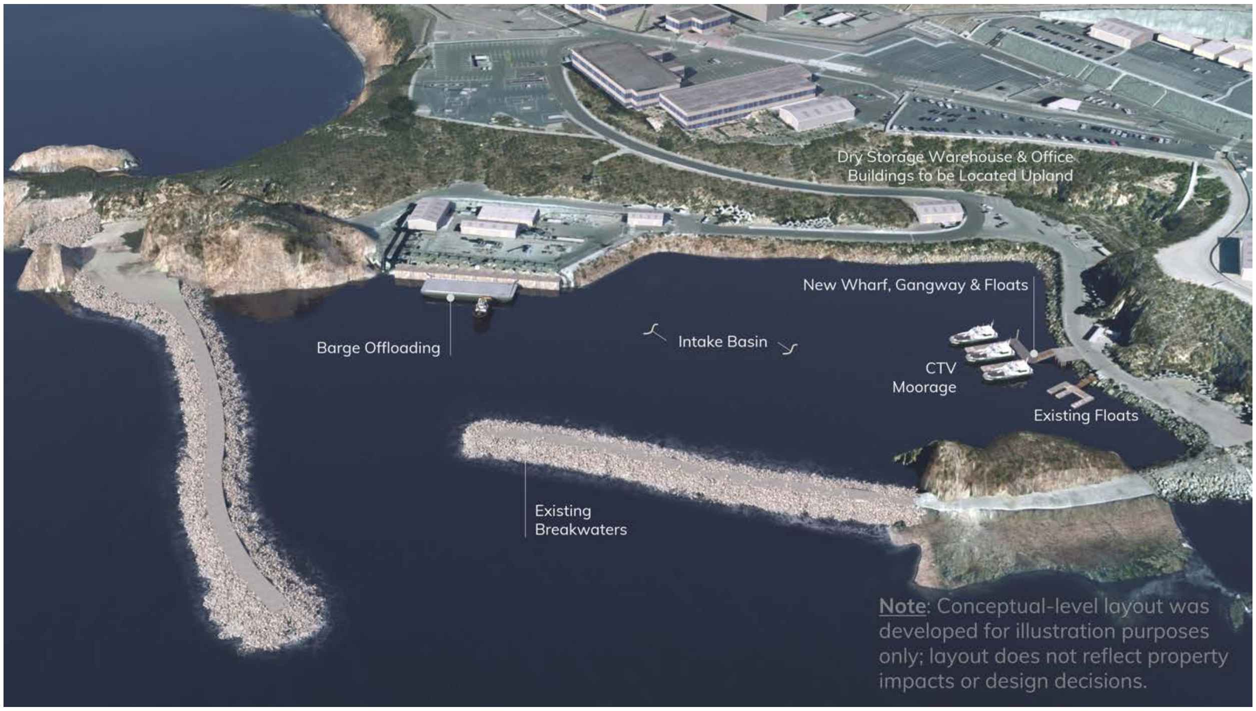


Figure 30. Rendering of potential FOW functions (barge offloading and CTV moorage) that could potentially be performed within the existing intake basin at Diablo Canyon.

An example integration facility development at Diablo Canyon is shown in Figure 31 below. The rendering is provided to show the scale of facility that may be needed to support FOW buildout along the Central Coast. Design adjustments and optimizations should be made in future phases based on project specifics, throughput targets, site investigations, and further engineering. The geometry and location of the new overwater structure may differ from the example shown, but variations (e.g., location in deeper water) may have cost implications relative to those presented in Section 6.3 Construction Cost Estimates.

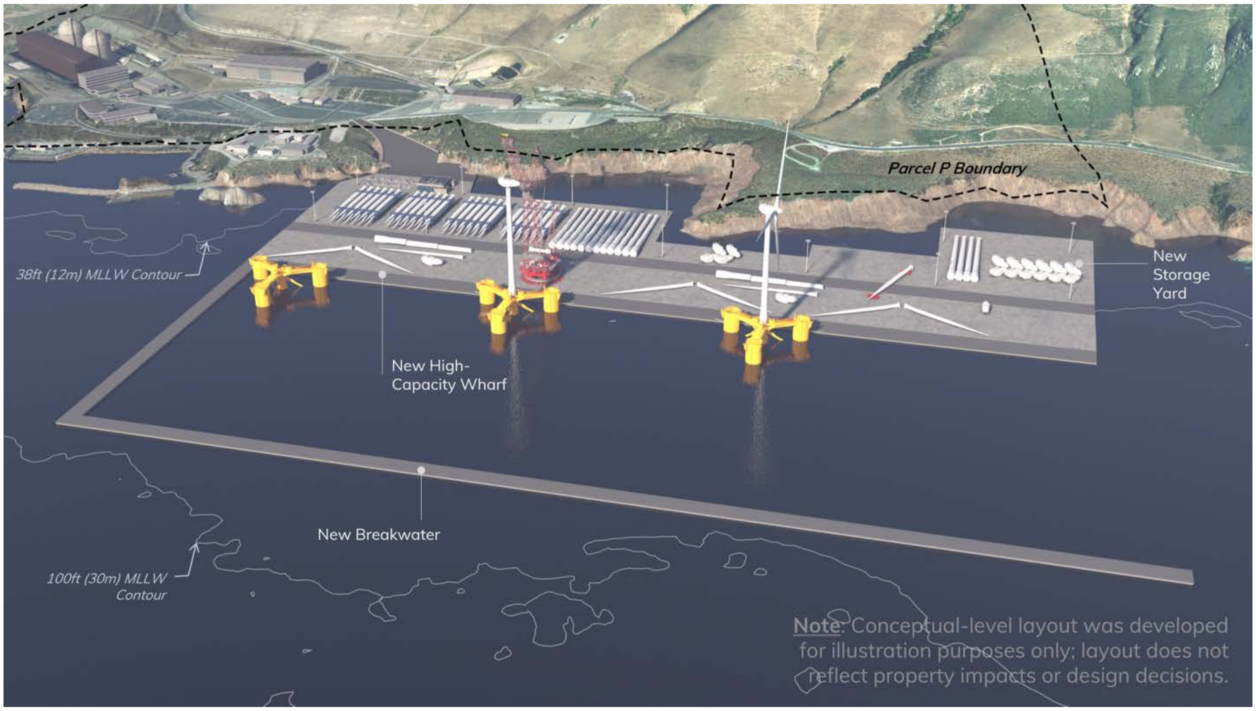


Figure 31. Rendering of example integration facility at Diablo Canyon. The wharf and storage yard shown total approximately 80 acres.

6.1.3 SAN LUIS OBISPO BAY

SLO Bay contains several waterfront facilities: two sites (the Harford Pier and breakwater and Cal Poly Pier) passed the screening assessment for further consideration and will be the focus of this section of the waterfront infrastructure assessment.

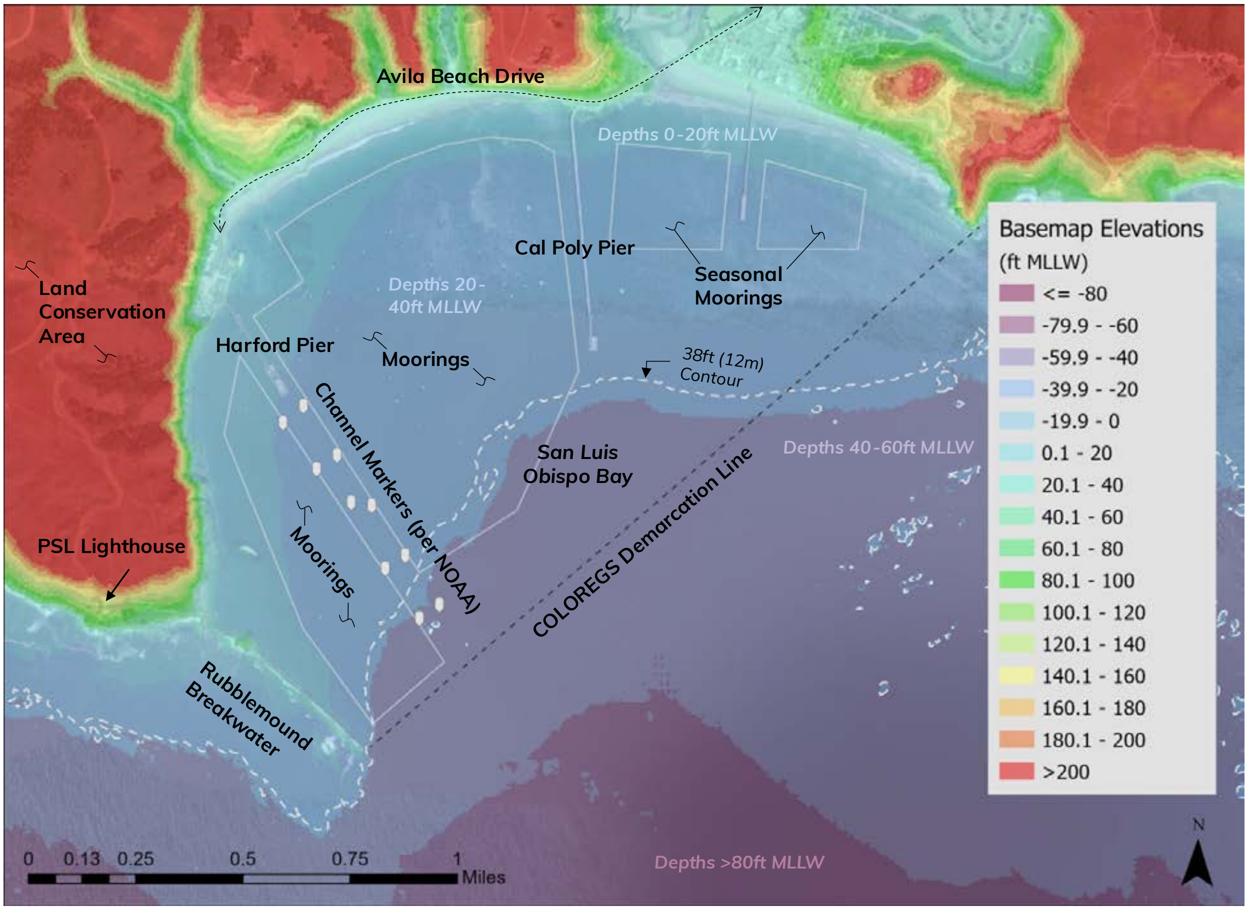


Figure 32. Overview of SLO Bay.

SITE CONDITIONS SUMMARY

- **Existing Uses.**
    - The Harford Pier has pedestrian and vehicle access and supports businesses, recreation and commercial fishing activities. The old restaurant lease site is being reconstructed and could provide additional opportunities, such as office space. Historical plans to construct a new breakwater to protect Port San Luis and create a small craft harbor were not fully permitted but remain in the Master Plan as a possibility. The fuel dock on the pier has a capacity of 12,000 gallons.
    - Anchorage areas are located within the bay, which could be used for temporary storage of barges, construction vessels, etc.
    - The Cal Poly Pier is a former oil production facility but is currently used for research purposes. It supports vessel-loading operations and equipment deployments. Cal Poly

proposes to develop a Marine Energy Innovation Hub at the pier to support testing of marine energy prototypes, autonomous underwater vehicles, and other deployments.

- **Topography.** Limited flat upland space is available around SLO Bay. The bayfront is fronted by coastal hills and mountains.
- **Bathymetry.** Deep water (38ft+ {12m+}) is available within SLO Bay (
Figure 32).
- **Geology.** Anticipated that bedrock is shallow or near surface beneath layer of Holocene marine deposits (USGS, 2015), but this needs to be investigated further.
- **Wave Climate.** SLO Bay is partially exposed to Pacific Ocean swell. The existing rubblemound breakwater provides protection to Harford Pier from westerly waves and partial protection from southerly waves. Cal Poly Pier is more exposed. Most waves approaching SLO Bay are around 3ft (1m) in height, but they are reported to reach as high as about 20ft (6m). Wave periods mostly range from 6 to 16 seconds but can range from 3 to 21 seconds (USACE, 1969).
- **Air Draft and Height Restrictions.** There are no air-draft restrictions in SLO Bay.
- **Site Constraints.** There is only one upland route for accessing the site, via Avila Beach Drive. Additionally, eelgrass, kelp, and surfgrass beds were mapped in the vicinity of Harford Pier and the rubblemound breakwater during a recent environmental assessment (USACE, 2020).

WATERFRONT INFRASTRUCTURE ASSESSMENT SUMMARY

A gap analysis was conducted to evaluate potential FOW waterfront facility development options within SLO Bay. A conceptual navigation assessment was conducted to investigate the need for a new or extended breakwater, potential navigation impacts, and potential FOW uses for existing anchorage areas. These details are provided in Appendix C. A summary of key findings for Small and Large Facility development in SLO Bay is provided in the subsections below.

Small Facilities

The distance from Port San Luis to the Morro Bay Lease Areas is 45 nautical miles. Though at present there is no small craft harbor, there are multiple potential options to support O&M, similar to historical uses.

- The Cal Poly Pier, which was a historical berth for deep-draft oil tankers, may be a favorable option for an OMF considering water depths, controlled access, and structure type (concrete). Localized widening of the pier head may be required to accommodate the transfer of equipment and goods. Additional onshore facilities would also likely be required with access to the pier. Further analysis is needed to confirm whether additional wave protection would be needed.
- The Harford Pier has historically accommodated recreation, fishing, and USCG vessels (up to 150ft {46m}) and could potentially serve as a temporary mooring site to support crew and equipment transfer and office space. This would likely require a number of upgrades, including improved vessel access to the pier, security gates, localized dredging, new mooring and breasting dolphins, and potentially widening and/or reinforcing the pier.

Installation Support. Port San Luis has designated anchorage areas in the bay that could support construction and staging. The water depths are such that either vessels or barges could utilize the anchorage areas for temporary moorage during construction. Coordination with Port San Luis is needed to identify available anchorage areas for FOW use.

Large Facilities

Integration. An integration port in SLO Bay would likely consist of a new overwater structure to accommodate land conservation efforts, regulatory considerations, upland topography, and upland space constraints. There is potentially room in the bay for a new facility to be constructed next to the existing Harford Pier. A new breakwater, or extension of the existing breakwater, may be required to shelter the terminal from ocean swell. More analysis is needed to determine the orientation and size of a breakwater extension, considering downtime risk at the terminal and seasonal construction throughput requirements.

To avoid significant bedrock dredging (which is expensive and can require blasting), the new facility may need to be located away from shore, closer to the tip of the existing breakwater, to take advantage of existing water depths. Secondly, the structure (assumed to be pile-supported) may require the use of drilled rock sockets to affix the piles to the seabed. The example facility developed was shown to avoid mapped aquatic vegetation in the area, but further refinements are needed to incorporate other constraints and considerations.

Wet Storage. SLO Bay offers potential opportunities for wet storage of floating foundations or integrated devices, given existing anchorage areas, wave protection, and access to deep water. The temporary shallow-water mooring configurations would be different than the permanent deep-water configurations. Further investigation and coordination with Port San Luis are needed to estimate the number of FOW devices that could fit within the bay.

Alternate Integration Methods. Integration via jack-up vessel may be able to be conducted in the lee of the existing breakwater, pending further analysis and confirmation of foundation geometry.

CONCEPTUAL ENGINEERING CONSIDERATIONS AND CONCEPT DEVELOPMENT

In coordination with the Technical Steering Committee, the area to the west of Harford Pier was selected as a focus evaluation area for development of a concept integration facility layout and the associated construction cost estimate. The concept facility development and construction cost estimates were based on the integration facility requirements presented in the Basis of Assessment (Table 5) and the considerations listed below.

Large Facility Site Selection and Concept Design Basis

- **Example Site Selection.** The example integration site was selected to leverage the wave protection provided by the existing breakwater, to take advantage of Port San Luis's access to deep water, to allow for maintained use of the existing piers, and to explore potential benefits to other users within SLO Bay.
- **Development Constraints.** Land conservation efforts have secured 1,200 acres of land surrounding the historic Port San Luis Lighthouse for permanent protection, which prohibits land development. Kelp and seagrasses have been mapped in the vicinity of the Harford Pier and breakwater (USACE, 2020). The development layout was configured to reduce impacts to existing aquatic vegetation to the extent possible. Eelgrass extents shown in Figure 33 were approximated based on USACE, 2020.
- **Wharf and Yard Configuration**. The example integration layout is primarily constructed on submerged lands. This is due to (a) the lack of flat, available upland space, (b) upland

conservation efforts on the land surrounding Port San Luis Lighthouse, and (c) the distance from the shoreline to deep water, which would require significant dredging to accommodate a wharf closer to the shore. The quay line in the example facility concept is aligned approximately with the 38ft (12m) MLLW contour. Additional berths for small craft or SOVs may be incorporated.

- **Wharf Length.** The wharf length is~1,500ft (450m), which is consistent with the assumed minimum concept criteria (see Table 5 in the Basis of Assessment). A longer wharf line may be required, but this configuration also has the possibility of an additional wharf on the east side of the yard/wharf structure, depending on vessel draft.
- **Yard Area.** The yard area is approximately 70-80 acres (28-32 hectare) and is largely governed by the 38ft (12m) contour on the seawards side, reducing impacts to aquatic vegetation and maintaining access to Harford Pier.
- **Breakwater.** The basis for the additional wave protection is provided in the Conceptual Navigation Assessment, provided in Appendix C. Long-period swell likely necessitates either an extension of the existing breakwater or a new detached breakwater. Further coastal engineering analysis coupled with throughput analysis is needed to confirm. A new or extended breakwater may provide sufficient wave protection to enable long-term moorage for small craft vessels near Harford Pier.

Example Site Development Rendering

A rendering of Port San Luis showing an example integration facility development is provided below in Figure 33.

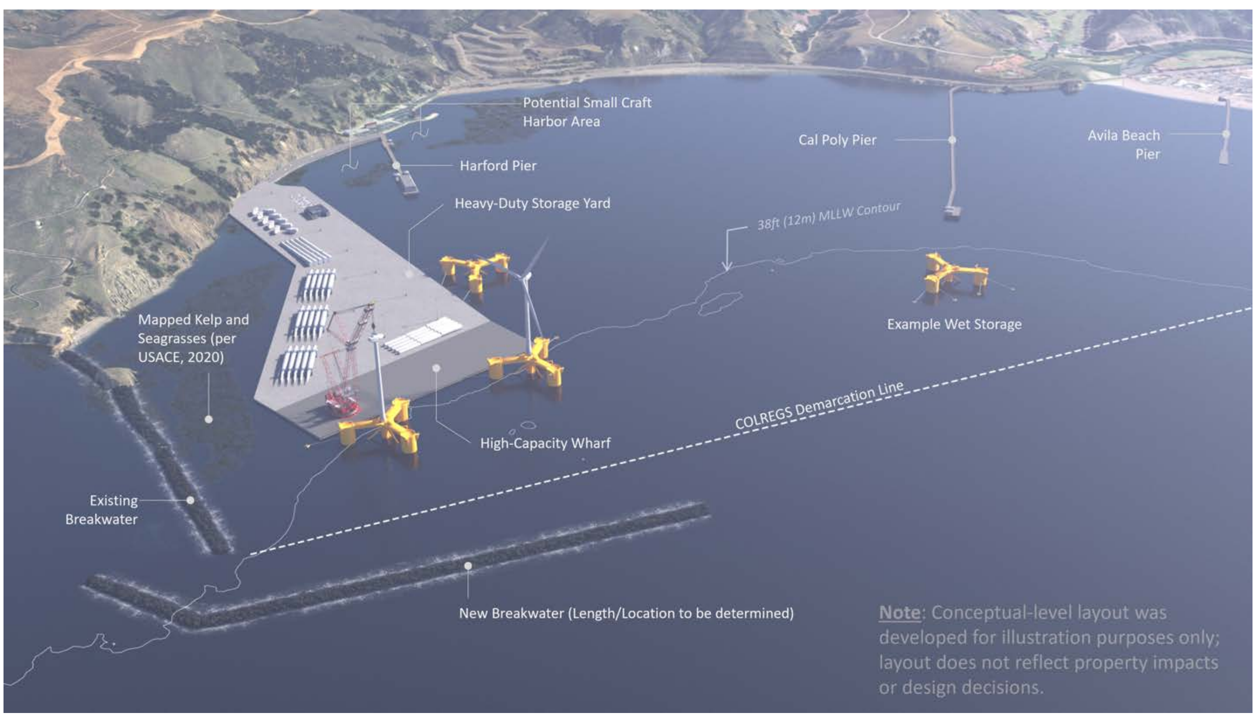


Figure 33. Site rendering of example integration facility within SLO Bay. Breakwater may or may not be required depending on the final location of the wharf, construction season, throughput

requirements, and sensitivity of the foundations to wave motions during integration. Note that a larger facility may be required to accommodate increased throughput, if needed.

6.1.4 REGIONAL SUMMARY

Figure 34 below summarizes the results of the waterfront infrastructure assessment in SLO County by highlighting which FOW activities may be able to be conducted at each focus area. The results are organized into three main categories: integration facility, OMF facilities, and installation support facilities (e.g., providing anchorage areas for construction vessels/barges, staging of anchors, mooring lines, or subsea cables, etc.).

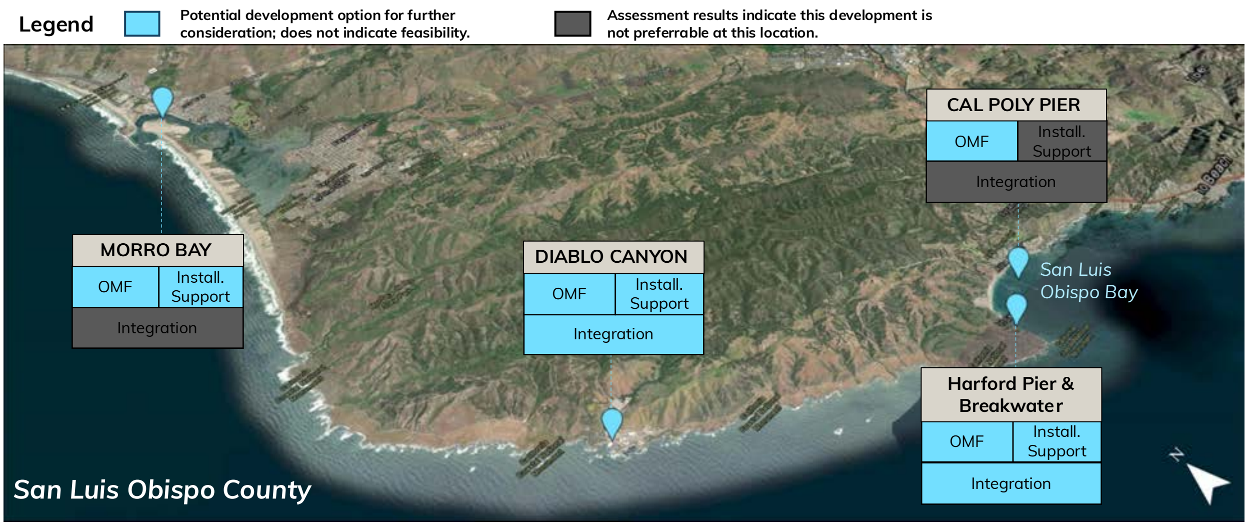


Figure 34. Summary of waterfront infrastructure assessment results for SLO County.

6.2 SANTA BARBARA COUNTY

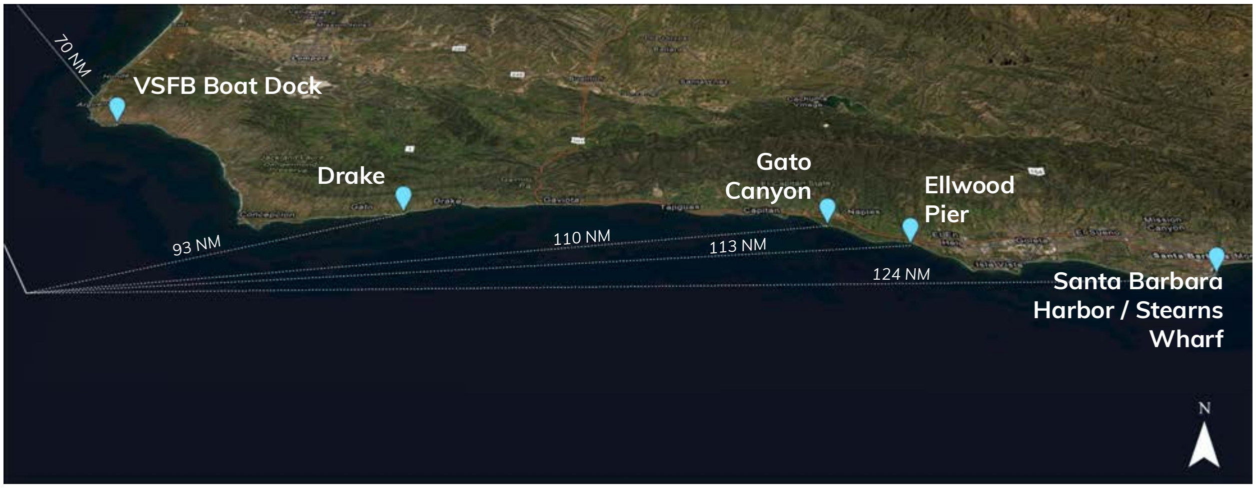


Figure 35. Assessment areas within SB County and approximate distances in nautical miles (NM) to the Morro Bay Lease Areas.

In line with the screening results, several sites in SB County — the Vandenberg boat dock, Drake, Gato Canyon, the Ellwood Pier, and SB Harbor/Stearns Wharf — were selected for further assessment to evaluate potential infrastructure upgrades to support FOW functions. The Vandenberg boat dock, Ellwood Pier and SB Harbor/Stearns Wharf are farther from the Morro Bay Lease Areas than previously assessed sites, but with upgrades they could potentially support various Small Facility FOW functions. Drake and Gato Canyon are evaluated here for Large Facility functions as they passed the screening assessment, although both sites require significant additional stakeholder consultation to determine feasibility and have specific conservation considerations.

6.2.1 VANDENBERG SPACE FORCE BASE BOAT DOCK

SITE CONDITIONS SUMMARY

The existing infrastructure at the VSFB boat dock was evaluated to identify potential upgrade scenarios that could be realized to support the space industry. A comprehensive summary of site conditions at the VSFB Boat Dock is provided in Volume II Section 13.4 of this report.

The VSFB boat dock is located within a launch evacuation zone, which means that all non-essential personnel must evacuate the premises prior to and during a rocket launch. The frequency of rocket launches at the Space Force Base is anticipated to reach 35 to 50 times per year. Because of the need to periodically evacuate the site, siting of an FOW facility within the launch evacuation area is not preferred. Therefore, a gap analysis for supporting FOW facilities was not conducted at this site.

WATERFRONT INFRASTRUCTURE ASSESSMENT SUMMARY

Small Facilities

At present, there are likely limited options to leverage existing infrastructure for FOW. If the harbor is expanded to accommodate additional launches, the infrastructure may be sufficient for berthing of CTVs. Smaller SOVs could potentially access the harbor at high tide if the harbor is deepened (see Volume II for potential VSFB boat dock upgrade scenarios). It may be able to provide storage and staging of anchors and mooring lines, if not in conflict with other users, but vessel draft would be limited. Warehouses and other crew support services are unlikely to be developed adjacent to the harbor due to space-flight operations and launch evacuation procedures.

Large Facilities

VSFB was screened out as a potential Large Facility location due to the need to evacuate the area during space launches. Further, the facility has insufficient water depths and harbor size to support development of a Large Facility.

CONCEPTUAL ENGINEERING CONSIDERATIONS AND CONCEPT DEVELOPMENT

Section 14.3.1 of Volume II of this report contains conceptual engineering considerations for two potential upgrade scenarios at the VSFB boat dock to improve operations in support of the commercial space industry. Given the evacuation launch procedures at the boat dock, it is unlikely that the site can support a permanent FOW facility. Commentary on the potential synergies between enabling infrastructure for FOW and space are provided in Section 15.2 of Volume II.

6.2.2 SOUTH SANTA BARBARA COUNTY

Drake, Gato Canyon, Ellwood Pier, Santa Barbara Harbor/Stearns Wharf

SITE CONDITIONS SUMMARY

The focus areas within South SB County are all greater than 100mi (160km) from the Morro Bay Lease Areas.

- **Existing Use.**
    - Drake: Privately owned land, with railroad right-of-way (ROW) running along shoreline.
    - Gato Canyon: Land owned by University of California-Santa Barbara with railway ROW running near the shoreline.
    - Ellwood Pier: Pier historically used for loading and unloading personnel and oil and gas supplies to service offshore oil platforms.
    - SB Harbor and Stearns Wharf: Heavily used small craft harbor, which serves as an all-weather safe harbor. The adjacent Stearns Wharf (see Figure 37) currently supports recreation and tourism activities, though historically supported maritime industry.
- **Topography.** The South Santa Barbara County shoreline is characterized by coastal mountains and canyons that rise up to high elevations in close proximity to the shoreline. The railroad and state highway ROWs are aligned close to the shoreline in much of this region to avoid routing through the mountains (see Figure 36).

- **Bathymetry.** The distance from the shoreline to the 38ft (12m) depth contour at Drake and Gato Canyon (the focus integration sites) varies from ~800ft (240m) to 1,600ft (490m). Water depths at the Small Facility focus areas are shown in Figure 37.
- **Geology.** The geology of the potential integration site locations (Drake/Gato Canyon) is characterized by marine and non-marine sedimentary geologic units. It is a highly active seismic region, potentially subject to strong ground motions. The depth of bedrock and thickness of these marine deposits is not well known in this area and should be further evaluated (California Division of Mines and Geology, 1986; U.S. Department of the Interior, USGS, 2013; CA Geological Survey Information Warehouse).
- **Wave Climate.** Drake, Gato Canyon, and Ellwood Pier are all exposed to Pacific Ocean swell. Relative to the sites further north within the Initial Study Area, the South SB County shoreline is shielded from northerly swell. Santa Barbara Harbor is protected by breakwaters.
- **Air Draft and Height Restrictions.** Ellwood Pier is located within a Federal Aviation Regulation (FAR) Part 77 Surface airspace restricted area. The Part 77 surface height at Ellwood Pier is approximately 510-560ft above mean sea level. See Airspace in Appendix A for further details.

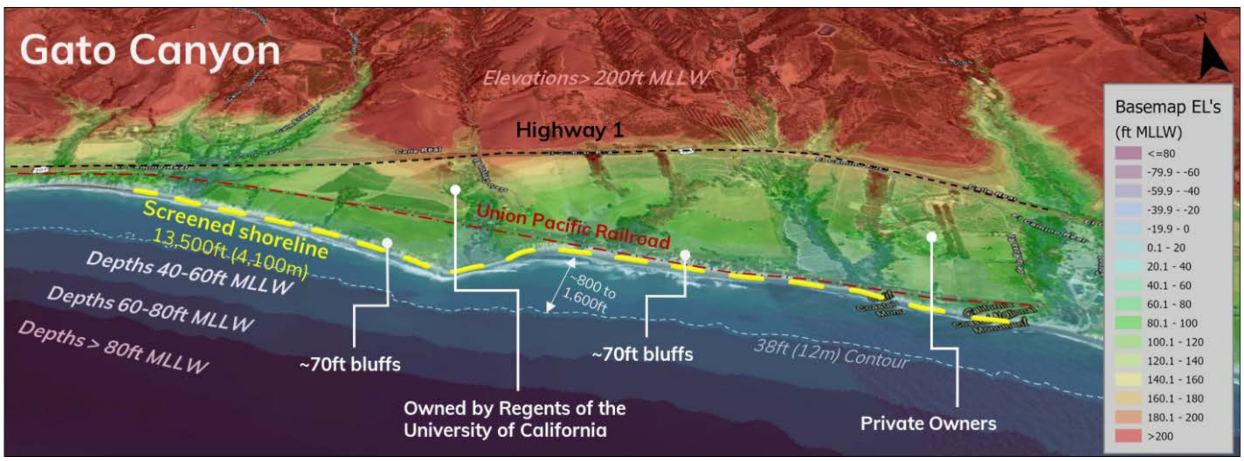


Figure 36. Overview of example Large Facility focus area (Gato Canyon) within South SB County.

	Inner Channel
Project Depth	15ft
Width	300 feet

	Entrance Channel
Project Depth	Varies, 20 to 38ft
Width	250 feet

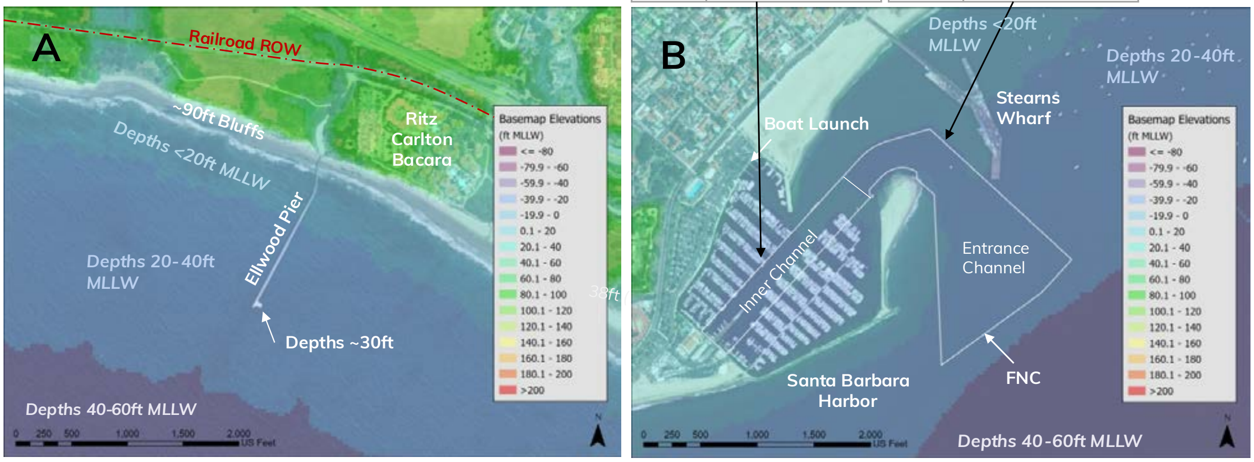


Figure 37. Overview of Small Facility focus areas in South SB County. Plate A: Ellwood Pier; Plate B: SB Harbor and Stearns Wharf.

WATERFRONT INFRASTRUCTURE ASSESSMENT SUMMARY

A gap analysis for the South SB shoreline (including Drake, Gato Canyon, Ellwood Pier, SB Harbor, and Stearns Wharf sites) was conducted and is presented in Appendix C. A summary of the outcomes from the gap analysis as they relate to potential Small or Large FOW Facility development are provided below.

Small Facilities

This region is farther from the Morro Bay Lease Areas (>100 nautical miles) and therefore may be less preferred for siting an OMF or conducting construction staging relative to sites within SLO County. However, there may be a need for development and use of FOW port facilities outside SLO County. There are a number of facilities which could potentially support O&M, with improvements.

- SB Harbor is likely too congested to serve as an OMF without significant changes to current uses.
- Stearns Wharf, if upgraded with new mooring dolphins and localized dredging, could potentially service SOVs and AHTVs; but onshore space for warehouses and offices could be limited due to potential conflicts with recreational uses. Impacts to recreational users would need to be considered and coordinated.
- Ellwood Pier similarly could potentially service vessels that do not require long-term moorage, though a breakwater or wave screen may be required along with onshore upgrades.

Large Facilities

Any integration facility on the South SB Coast would likely require significant land grading or a fully overwater structure, a new offshore breakwater to protect a new wharf, dredging, and efforts to reduce impacts to existing shoreline-adjacent rail and/or road ROWs. There are limited opportunities for development of a Large Facility, though the area near Gato Canyon appears more favorable than Drake, from a technical perspective. However, Gato Canyon is owned by the University of California, and land development has been historically blocked in this area.

6.2.3 REGIONAL SUMMARY

Figure 38 below summarizes the results of the waterfront infrastructure assessment in SB County by highlighting which FOW activities may be able to be conducted at each focus area.

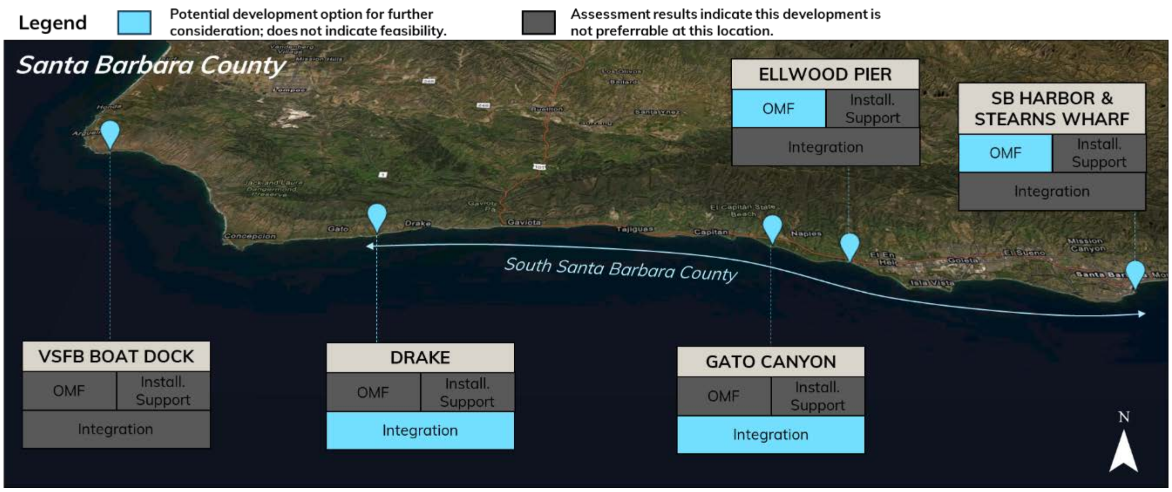


Figure 38. Summary of waterfront infrastructure assessment results in SB County.

6.3 CONSTRUCTION COST ESTIMATES

Planning-level concept construction cost estimates have been prepared to estimate the scale of potential investments required for waterfront infrastructure in the Initial Study Area to support FOW. Costs were developed according to the Class V level estimate scheme of the Association for the Advancement of Cost Estimating (AACE), typically used for concept screening, which aligns with the level of detail considered in this study (e.g., no site investigations, a range of potential sites, and variability in facility requirements). The Class V estimates have an accuracy range of -50% to +100% and include considerations of changes in scope, site conditions, and market conditions. Estimates are in 2022 dollars and were developed based on prior project experience, literature review, and conceptual engineering analysis. Actual costs will vary depending on the size of the FOW project, annual throughput requirements, results of future site investigations, and other project-specific requirements.

Construction cost estimates for the three example facilities, Morro Bay (Small Facility), Diablo Canyon (Large Facility), and SLO Bay (Large Facility) follow. These are intended to be planning-level costs and should not be used for financial investment purposes.

6.3.1 SMALL FACILITIES

Morro Bay

Construction cost estimates for the Small Facility are based on the assumptions the tables below. Total cost will depend heavily on the design vessel and associated harbor dredging.

Table 12. Small Facility cost estimate basis for Morro Bay.

Element	Assumed Parameters
Mobilization and Demobilization	Assume 6% of subtotal.
Channel Dredging	To support safe navigation of larger AHTVs and SOVs, channel deepening to -21ft (-6.4m) MLLW within the mapped horizontal extents of the Main and Navy Channels was assumed. In some areas of the channel, this depth is naturally present. Actual dredge depth and extents require additional engineering analysis and stakeholder/developer engagement. Estimated to be approximately 350,000CY. Does not include maintenance dredging or eelgrass mitigation cost.
Berth Dredging	Dredging of the berth adjacent to the new wharf to approx. -24ft (-7.3m) MLLW. Does not include maintenance dredging or eelgrass mitigation cost.
Waterfront Yard	Includes area between the Embarcadero and the shoreline. Includes site grading, lighting, concrete surfacing.
Pile-Supported Wharf	Concrete deck, supply and install of steel pipe piles, fenders, bollards, lighting, bulkhead, and scour protection.
Onshore Yard	Concrete slab, lighting.
Exclusions	Utilities, fuel dock, onshore facilities landward of the Embarcadero (e.g., building, parking lot).

Table 13. Small Facility conceptual cost estimate summary for Morro Bay.

Element	Cost (2022$)
Mobilization and Demobilization	$1,300,000
Channel Dredging	$7,000,000
Berth Dredging	$200,000
Waterfront Yard	$2,500,000
Pile Supported Wharf	$10,000,000
Conceptual Cost Estimate (Limited Contingency Included)	$21,000,000
Range (-50% to +100%)[16]	$11m-40m

6.3.2 LARGE FACILITIES

Typically, marine terminals take advantage of yard space available adjacent to the waterfront and do not require the entire facility to be constructed overwater. As an example, two recent fixed-bottom OSW port developments — the New Jersey Wind Port and New Bedford Marine Commerce Terminal (Massachusetts) —leveraged existing waterfront yard space and included yard ground improvements and wharf improvements to support OSW activities. The estimated construction cost for Phase One of

[16] Range of -50% to +100% of the estimated value provided in accordance with AACE Class V Cost Estimate scheme to account for potential variation in scope, FOW project definition and technology, site conditions, and market values relative to the basis for the conceptual cost estimate developed in this study.

the New Jersey Wind Port is ~$400 million[17]. While these two ports are for fixed-bottom construction, they are useful indicators for assessing the costs of an FOW facility in California. On the Central Coast, waterfront acreage adjacent to deep water is not available, and there are additional site considerations such as land conservation requiring more overwater construction, which is typically more expensive. Therefore, even with similar wharf lengths and yard sizes, the cost for the developments at Diablo Canyon and in SLO Bay are expected to be greater than the cost for the New Jersey Wind Port.

The capital cost for Diablo Canyon would likely be greater on a per acre basis than SLO Bay because the increased complexity of construction, increased wave exposure, and difficult site access.

Construction cost estimates for the Large Facility are based on the assumptions in Table 14 below and are associated with the site renderings. The estimated costs are presented in Table 15.

Table 14. Large Facility cost estimate basis for Diablo Canyon and SLO Bay.

Element	Assumed Parameters – Diablo	Assumed Parameters – SLO Bay
Mobilization and Demobilization	Assume 6% of subtotal.	Assume 6% of subtotal.
Wharf Structure	Consists of the pile-supported 6,000psf+ wharf structure, ~300ft (91m) wide and ~3,500ft (1,067m) in length to provide enough yard space without pushing the breakwater into depths greater than 100ft (30m). Assumes the need for rock sockets due to shallow bedrock. Remoteness factor due to site access constraints.	Consists of the pile-supported 6,000psf+ wharf structure, ~300ft (91m) wide and 1,500ft (67m) in length. Assumes the need for rock sockets due to shallow bedrock. Note that this facility would likely support buildout of fewer MW per year due to fewer berths.
Overwater Yard Structure	Consists of the pile-supported 80-acre (32 hectare) storage yard. Assumes the need for rock sockets due to shallow bedrock. Remoteness factor due to site access constraints.	Consists of the pile-supported 80-acre (32 hectare) storage yard. Assumes the need for rock sockets due to shallow bedrock.
Utilities and Civils	Includes water, fire protection, curbs, electrical, telecommunication, drainage, signage.	Includes water, fire protection, curbs, electrical, telecommunication, drainage, signage.
Breakwater	~4,000ft (1,200m) length. Assumes caisson breakwater.	~2,000ft (600m) length. Assumes rubble mound breakwater.
Dredging	Limited rock dredging assumed to be required (outcroppings).	Similar.
Exclusions	Roadway improvements, any dredging to support wet storage, land-side connection details and bluff stabilization, onshore building development or additional parking, cranes and equipment, electrical transmission grid upgrades (if needed).	Similar.

[17] Includes the improvement of approximately 65 acres (26 hectare) of waterfront land, 1,280ft (390m) of new purpose-built wharf (6,200psf {30T/m²} live load capacity), berth dredging and seabed improvements, dredging of a new navigation approach channel, a new heavy-haul road, and utilities. The cost presented is estimated and could change. For example, the actual cost for the New Bedford Marine Commerce Terminal was approximately 40% higher than estimated.

Table 15. Large Facility conceptual cost estimate summary for Diablo Canyon and SLO Bay.

Element	Cost - Diablo Canyon (2022$)	Cost - SLO Bay (2022$)
Mobilization and Demobilization	$200,000,000	$140,000,000
Wharf Structure	$850,000,000	$335,000,000
Overwater Yard Structure	$1,900,000,000	$1,620,000,000
Utilities and Civils	$70,000,000	$55,000,000
Breakwater	$470,000,000	$350,000,000
Dredging	$1,000,000	$1,000,000
Conceptual Cost Estimate (Limited Contingency Included)	$3,500,000,000	$2,500,000,000
Range (-50% to +100%)[18]	$1.8b-6.2b	$1.3b-5.0b

[18] Range of -50% to +100% of the estimated value provided in accordance with AACE Class V Cost Estimate scheme to account for potential variation in scope, FOW project definition and technology, site conditions, and market values relative to the basis for the conceptual cost estimate developed in this study.

GOVERNANCE + FINANCE REVIEW

7 GOVERNANCE AND FINANCE REVIEW

There are a range of potential development and governance/operational structure that may be applicable for an offshore wind (OSW) port. The intent of this section is to provide an introduction and overview of those potential structures, as it relates to waterfront infrastructure development on the Central Coast, with example OSW port developments across the U.S.

7.1 INTRODUCTION

Development of port facilities may occur when a market demand is not met by existing infrastructure and a return on the investment in that infrastructure can be justified or may be required for other purposes, such as defense. The return on investment depends on the ability to lease the facility at a rate in a specific period required to recoup the cost of investment. There are several key factors that contribute to the return on investment to construct a port. First, governmental actions to create new OSW lease areas bolster the market's confidence and are necessary to project the utilization opportunity at a port facility. Second, competition in the market to OSW developers are under tight budgets that are often set through their offtake agreements, and the lease fees at the ports must work within the context of the overall budget. Finally, financial support from government policies and programs can reduce the cost to construct a port facility, which can reduce cost of the development, minimize the recovery term for the investment and control concerns of passthrough costs that could potentially increase costs to ratepayers.

Additional economic benefits resulting from development of a port facility also factor into the justification of investment and potential subsidies to facilitate the investment. As such, economic studies should be carried out to evaluate development costs and should also consider the potential future use of the port facility for multiple purposes.

There are various governance and operating models that have been used in the development of OSW support facilities that are being developed or already operational on the U.S. East Coast. BOEM has held 10 competitive lease sales and issued 27 active commercial wind leases in the Atlantic Ocean from the shores of Massachusetts to North Carolina. As a result, many OSW support facilities are in various stages of development on the East Coast. Operations of these facilities will either be from a port authority, a terminal operator, or the developer.

For this study, the governance of these facilities has been parameterized and classified into three categories:

- **Port Authority-Developed Sites:** Port authority-developed sites are projects that public port authorities are developing with state, federal, and private funding. These projects typically remain under the port authority's ownership and governance with leases established with OSW developers and component manufacturers. Examples include the Portsmouth Marine Terminal (VA) and New London State Pier (CT).
- **Public Developer Sites:** Public developer sites typically include a state agency that has a mandate to develop a port facility (often brownfield or greenfield) to support the OSW industry. Funding for these projects is typically from state and federal grants. These facilities are typically managed and operated by the entity that has developed the site. The port facilities are then leased to OSW developers and/or manufacturers. Examples include the New Bedford Marine Commerce Terminal (MA) and the New Jersey Wind Port (NJ).

- **Private/OSW Developer Sites:** Private developer sites are being developed by private entities that see a need for OSW port facilities and are investing to meet market demands. These include private port developers, commercial real estate companies, OEMs, OSW developers, and logistics companies. Typically, an OSW developer does not own and operate port facilities. However, in some cases where OSW developers are providing the majority of funding for the project, they have taken control of the design and construction of the port facilities. The land may remain under port or municipal ownership. Funding may include a combination of private investment and public grant funding. Examples include the Arthur Kill OSW Terminal (NY), the Salem Harbor Wind Terminal (MA), the New Bedford Foss Terminal (MA), the South Brooklyn Marine Terminal (NY), and the Humboldt Bay Harbor District (CA).

There are benefits and challenges to each of these governance structures that should be considered in the early development of the Central Coast FOW port development. Example benefits and challenges are listed below:[19]

- A public developer may have the benefit of a multi-disciplinary board that can be structured for greater collaboration with stakeholders. With stable leadership and funding, projects can be developed ahead of market needs. However, under a public structure, the project's risks may not be distributed.
- Port authorities have an exceptional knowledge and skillset in port operations and ocean conditions. They can have a strong, committed management team and can be a champion to advancing a project forward. Port authorities may however, have more relative challenges in securing access to capital.
- Private developers may have exceptional capabilities to aggregate financial resources. They can also bring innovation and insights from other sectors such as oil and gas and find solutions to complex problems. However, they are likely not to take any action without a strong path to market to recover their investments.

Examples of these port development categories are included in the following sections.[20]

7.2 PORT AUTHORITY DEVELOPED SITES

Connecticut Port Authority: The Port Authority is implementing a plan to improve utilization of the New London State Pier and capture Connecticut's Offshore Wind Vision. The State Pier facility will include heavy-lift capabilities for marshaling and launching OSW turbines. Infrastructure improvements of $157 million will be financed jointly by the Connecticut Port Authority, Ørsted and Eversource. Once construction is complete, Connecticut will continue to own the State Pier, and Ørsted and Eversource will enter into a 10-year sublease agreement with Gateway New London. During periods where Ørsted and Eversource are not using the State Pier, the facility will be marketed to other customers to ensure maximum utilization.

Port of Albany: The Port received a federal grant of $29 million from the Maritime Administration to develop an 81-acre (25 hectare) site suitable for the manufacturing of OSW towers. The Port of Albany is the owner of the property and is working in association with Empire Wind (Equinor) and a joint venture of Marmen/Welcon, who will operate the facility. The manufacturing space will be spread throughout four buildings located in the Town of Bethlehem, and the fifth building will be located within the existing Port District in the City of Albany.

[19] Not intended to be comprehensive.
[20] Sources of information include USDOT (2022), DOE (2022), and experience with public and private agencies.

Virginia Port Authority: The Port Authority received a $20 million grant from the Maritime Administration to create two staging areas for WTGs, monopiles, and other project components at the Portsmouth Marine Terminal. The project will redevelop approximately 72 acres (22 hectare) of the terminal and rebuild 1,500ft (450m) of the existing wharf for heavy-lift capabilities. Dominion Energy will pay $44 million over 10 years to lease the site, to be used as a staging and pre-assembly area for the foundations, and as many as 180 14MW, 800ft+ (244m) turbines to be installed 27mi (43km) off the Virginia Beach coast.

South Jersey Port Corporation (SJPC): SJPC developed the Paulsboro Marine Terminal in New Jersey and leases the facility to Holt Logistics. Holt has subleased an area on the port property to the German company EEW, which will be manufacturing monopiles at a new facility it is constructing on site. The monopiles will support the Ørsted and PSEG Ocean Wind project and are providing funding for the project along with EEW.

7.3 PUBLIC DEVELOPER

Massachusetts Clean Energy Center (MassCEC): MassCEC is a quasi-government state economic development agency dedicated to accelerating the growth of the clean energy sector across the commonwealth to spur job creation, deliver statewide environmental benefits, and secure long-term economic growth for the people of Massachusetts. In support of the Cape Wind project in 2014, MassCEC developed the New Bedford Marine Commerce Terminal (NBMCT) with more than $100 million in state funding. The facility was the first port facility dedicated to support OSW and includes 1,200ft (366m) of berthing and an upland area with heavy-lift and storage capability of over 21 acres (8 hectare). Although the Cape Wind project did not move forward, the site has been leased for the Vineyard Wind and Mayflower Wind projects. These lease agreements commit the facility to full-time OSW work from 2023 into 2027 and are worth more than $32.5 million. Additional investment for additional storage area, logistics facilities, and extended berthing areas have been made. This includes a $15.4 million grant from the Maritime Administration.

New Jersey Economic Development Agency (NJEDA): NJEDA is developing a greenfield port facility specifically for the manufacturing, staging, and deployment of OSW turbines. The site is being developed at the PSE&G Hopes Creek power plant on the Delaware River and will be developed in phases. The first phase will develop a 30-acre (12 hectare) marshalling site and a 25-acre (10 hectare) manufacturing site. The second phase will have an additional 150 acres for marshalling and manufacturing. NJEDA will lease the site to OSW developers and component manufacturers. The total cost of the first phase of the project is estimated to be between $300 and $400 million funded by the State of New Jersey.

7.4 PRIVATE DEVELOPER SITES

Baltimore, Maryland: Tradepoint Atlantic purchased the Sparrows Point iron- and steel-making facility in Baltimore in 2014 with the goal of creating a port and logistics hub in the Chesapeake Bay. The site is a 3,300-acre industrial site that has been converted to a logistics warehousing and seaport facility with water, rail, and highway access. In 2019, Ørsted leased a 115-acre (47 hectare) staging area at Tradepoint Terminals for laydown and assembly of components for Skipjack Wind OSW farm. Improvements will include strengthening ground-bearing capacity. The Ørsted investment is $13.5

million. U.S. Wind has also secured agreements with Tradepoint Atlantic to develop 90 waterfront acres into a new OSW deployment hub, where U.S. Wind will initially invest $77 million via the MarWin project.

Staten Island, New York: Atlantic Offshore Terminals (AOT) is an infrastructure and industrial real estate development company founded in 2018 by a team of energy and infrastructure project developers, investors, and advisors. AOT's principal business is the development of strategic properties serving the U.S. OSW industry. AOT is looking to develop a 32-acre (13 hectare) port facility on Staten Island, south of the Outerbridge crossing for an OSW staging and assembly facility. AOT is securing private equity funding to support the project as well as federal and state grants. In October 2022, AOT received a $42 million grant from the Maritime Administration to fund dredging in support of the new terminal.

Salem, Massachusetts: The Salem Harbor Wind Terminal is a public-private partnership between Crowley and the City of Salem, with Avangrid Renewables serving as the port's anchor tenant for its Commonwealth Wind and Park City Wind projects. The terminal will be a 42-acre (17 hectare) logistics and operations center for turbine preassembly, transportation, staging activities, and storage of assembly components. Crowley Wind Services, the company's business unit dedicated to helping develop clean wind energy resources, will operate the terminal. Development of the port will serve as a base of operations for the worldwide logistics and marine company's marine support to the OSW industry. In October 2022, the Maritime Administration awarded a $34 million grant to support the Salem project.

Humboldt, California: In October 2022, Crowley signed an agreement with the Port of Humboldt Bay to exclusively negotiate to be the developer and operator of a terminal to serve as California's first hub to serve OSW energy installations. The agreement focuses on a 98-acre (40 hectare) Phase I development, with options for incorporating adjacent land in additional phases. Per offshore-mag.com, the Port of Humboldt Bay developed a conceptual master plan for site development in 2021 with a grant from the Humboldt County Headwaters Fund. The California Energy Commission granted $10.45 million for conducting technical studies, preliminary design, and pre-permitting activities. Permitting and design are anticipated to be completed in 2024.

New Bedford, Massachusetts: Foss is partnering with Cannon Street Holdings LLC to develop a former Sprague/Eversource 30-acre (12 hectare) site in New Bedford. Per the Foss press release, the site will provide storage and laydown yards for equipment and materials, offer berth facilities for tug and barge operations, and host CTV and SOV support services. It will create new office space for project teams and a marine coordination center for technicians involved in OSW projects.

Bridgeport, Connecticut: Vineyard Wind is redeveloping an 18.3-acre (7.4 hectare) waterfront industrial property in Bridgeport. The Barnum Landing property will be used for critical foundation transition-piece steel fabrication and final outfitting for the Park City Wind project. The level of investment for the project is not specified. Additionally, Vineyard Wind is also developing an O&M terminal on Martha's Vineyard to berth two CTVs, which is expected to employ 40 people. In October 2022, the Bridgeport Port Authority received a $10.5 mill grant from the Maritime Administration to support the project.

Atlantic City, New Jersey: Ørsted plans to locate its construction logistics base, foundation and transition-piece staging port, and OMF in Atlantic City to support the Ocean Wind project. The level of investment for this project is not specified. Ørsted and Eversource are developing a new O&M hub including dockage for a 250ft (76m) SOV, warehouse, and office facility in Port Jefferson, NY. The level of investment for this project is not specified. Ørsted and Eversource are also investing $40 million for port improvements at the Port of Providence, Quonset Business Park, and potentially additional ports in the state to support the Empire Wind project.

New York: Equinor will invest in port upgrades throughout New York for part of its Empire Wind project. Empire Wind proposed to invest $260-$310 million in port upgrades statewide, including the Port of Coeymans for tower fabrication, Homeport Pier on Staten Island, and South Brooklyn Marine Terminal for staging and assembly. The Maritime Administration has also provided $25 million to support the South Brooklyn Marine Terminal project and $29.5 million to support development at the Port of Albany. New York State has provided $40 million from the New York State Energy Research and Development Authority to support construction at the Port of Albany. New York City has committed $57 million to support the transition at South Brooklyn Marine Terminal.

7.5 SUMMARY

Large Facilities

Considering the locations of the potentially more favorable integration sites (offshore of a power plant or offshore of a conservation area within an existing harbor district), they are unlikely to be initiated by a private developer. The port could be the sponsor, or a public developer entity may be appropriate. A public-private partnership could be an option at various stages, similar to Humboldt Bay where the Harbor District initiated redevelopment of the Redwood Marine Terminal (engineering, permitting) and has now entered negotiations with a private entity (Crowley) to lease and develop the site. Alternatively, the port or a public developer entity could develop and then operate and lease the facility, similar to the NJ Wind Port. Additional governance structures could be considered, taking into account site specific considerations, and there are pros and cons to each model.

Small Facilities (O&M, Construction Staging)

These are often developed and operated by private developers (OSW developers, logistics companies). These sites also have a longer-term user lease commitment and lower initial capital expenditure than an integration port. The sites screened for O&M on the Central Coast have a combination of owner types, including port authorities, power plant operators, private companies, universities, state government administrations, and municipalities. Therefore, the appropriate use and development agreements for these sites may be variable.

Funding options should be explored

Due to the significant cost necessary to build FOW port facilities, leveraging funding from multiple sources could support the development of the infrastructure. By packaging funding from federal, state, local and private sectors, the risk of the project can be distributed. Government funding programs can be structured to complement and drive down the cost of private financing.

CONCLUSIONS + NEXT STEPS

8 CONCLUSIONS AND NEXT STEPS

This section provides a summary of study conclusions and recommended next steps.

8.1 CONCLUSIONS

Existing waterfront infrastructure and potential waterfront development areas were assessed relative to the potential for supporting turbine integration, O&M, and installation support (e.g., construction staging). A basis of assessment was developed in coordination with the FOW industry and parallel state and federal studies to develop requirements for the different marine terminal facilities. To focus the study, a systematic screening assessment of both existing waterfront infrastructure and potential waterfront site development areas was conducted in coordination with the Technical Steering Committee. Conceptual engineering and example site renderings were conducted for a short list of potential sites (see Figure 39) to investigate site constraints, site upgrades and development layouts, and the associated estimated conceptual construction costs. A summary of study findings is provided in the subsections below.

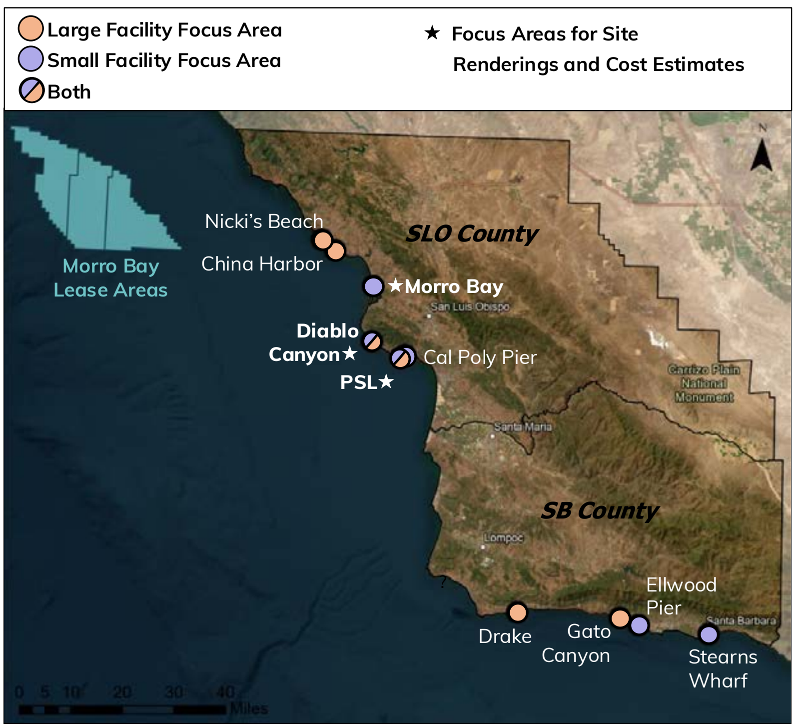


Figure 39. Summary of study focus areas. Purple indicates potential O&M and/or construction staging areas. Orange indicates sites screened for potential integration port development. Bold indicates areas selected for gap analysis, site rendering, and cost estimate development.

8.1.1 GENERAL OUTCOMES

- **A network of ports is likely needed to support the Central Coast FOW industry.** One single site is not likely to support all FOW functions for windfarms offshore the Central Coast, considering the scale of buildout needed to meet state goals for FOW. The importance of proximity to the wind farms varies for different types of FOW port facilities.
- **There is strong FOW developer interest in locating FOW facilities on the Central Coast.** Based on discussions with 10 FOW developers, Small Facilities will be needed within the two-county area to support wind farm operations. There is interest in siting a Large Facility within the study area, especially considering the potential level of FOW buildout needed to meet state goals.
- **SLO and SB Counties could support a variety of FOW functions, with varying levels of complexity and costs.** Small Facilities supporting O&M and installation support (e.g., construction staging, vessel moorage) will require less investment than a potential large new greenfield/brownfield facility to support integration and/or foundation fabrication/assembly. Representative construction costs for developing small and large facilities at example sites within the study area were estimated and are provided in the facility-specific conclusions.
- **Supporting any of these functions along the Central Coast will require significant investments in waterfront infrastructure.** Though the study identified protected lands, critical habitat and endangered species on a site-by-site basis, detailed environmental analysis and review of the permitting framework required for the concepts herein was not conducted as part of this work. These potential projects are complex endeavors with various federal, state and local agency regulatory jurisdictions. Though not addressed within the body of this report, **significant permit coordination and stakeholder engagement will be required for OSW waterfront infrastructure** and are critical aspects of the planning process and project development strategy.

8.1.2 FACILITY-SPECIFIC FINDINGS

Key findings related to options for developing Small and Large Facilities within the study area are presented in the sub-sections below.

SMALL FACILITIES

O&M, Anchor and Mooring Line Staging, Construction Vessel/Barge Staging

With site improvements, there are multiple waterfront infrastructure facilities that may be able to support long-term wind farm O&M or provide installation support during construction. Upgrades at select focus areas may include:

- Morro Bay: Channel and berth dredging, a new wharf, and potentially pier reconfiguration (example shown in Figure 24)
- Diablo Canyon Intake Basin: New mooring floats and potentially leveraging the repurposed intake structure
- Port San Luis: Widening of the pier and new mooring dolphins
- Cal Poly Pier: An expanded structure footprint and new mooring dolphins

The estimated construction cost of these improvements per site range between $11-40 million (2022 dollars), and the use of multiple sites is likely to meet the offshore wind goals for California.

Though farther from the lease areas (>100NM), additional sites in Santa Barbara County could also be utilized for select O&M-related activities such as crew transfer and SOV access, potentially with the following upgrades:

- Ellwood Pier: Upland site development, wave protection (pending intended use and further analysis)
- Stearns Wharf: Localized dredging, mooring dolphins

Upgrades of existing facilities to support O&M can likely be conducted within the timeframe needed to support a potential COD of offshore windfarms of 2030. If channel deepening at Morro Bay is desired, this could be a long-lead item as the channel is maintained by the USACE. Further studies are required to confirm the feasibility at any potential development site.

There are multiple waterfront facilities that could be utilized for installation support. These sites may provide areas for staging of smaller components (such as anchors and mooring lines) or temporary moorage for construction vessels or barges. With varying degrees of improvements, Morro Bay, SLO Bay, and/or the Diablo Canyon intake basin may be able to provide such services.

Table 16. Abbreviated summary of technical benefits and drawbacks for Small Facility development at focus integration sites.

Facility	Benefits	Constraints/Risks
Morro Bay	Natural harbor Proximity to lease areas (~33NM) Opportunity to repurpose obsolete infrastructure Anchorage areas may provide installation support	Navigation channel geometry Environmental sensitivities
Diablo Canyon	Existing harbor (intake basin) Opportunity to leverage decommissioning infrastructure and plans Proximity to lease areas (~36NM)	Existing harbor may not fit larger vessels (SOVs, AHTVs), pending further site investigations and maneuvering analysis Multi-user considerations for operational power plant and port facility
Port San Luis Obispo Harbor District	Existing structure with moderate berth depth (20ft.+) Existing anchorage areas that may be used.	Not a fully protected harbor Timber structure Mixed-use access and parking
Cal Poly Pier	Existing controlled access to deep water Proximity to lease areas (~45NM) Concrete structure Limited access	Wave exposure – long-term moorage may not be possible without additional wave protection Limited upland area Pier modifications may be needed
South SB County (Ellwood Pier, Stearns Wharf)	Ellwood Pier historically used for crew transfer to support oil and gas industry, may be available for use Concrete structure Stearns Wharf historically used to support commercial industry	Distance to lease areas (>100 NM) Structure upgrades and/or wave protection may be needed to provide long-term moorage Upland areas may require change in use

LARGE FACILITIES

Staging and Integration, Foundation Fabrication/Assembly, Component Manufacturing

There is no existing port in the study area that can support integration. New facility development of a large (~100-acre area, 1,500ft wharf) integration facility is likely technically feasible but will cost significantly more and face significantly more permitting complexity than a Small Facility. A screening assessment was undertaken and identified integration focus areas within SLO and SB Counties. Two example sites were selected for further assessment as part of this study (Diablo Canyon and Port San Luis area). A new Large Facility at either site will require installation or extension of a breakwater. Given upland development constraints at both sites, port development would require significant new overwater coverage. Habitat mitigation will very likely be required. The estimated construction cost of site improvements may be in the range of $1.3-6.2 billion, depending on final scope, site investigations, permitting requirements, and engineering details. **These costs are significantly more than port infrastructures proposed on the East Coast because of the complexity of the terrain and port designs that are unique for FOW.** Of the two example sites considered, a new facility in the Port San Luis area would likely cost less due to the existing wave protection and more favorable construction access. **Coordination with stakeholders, regulatory agencies, and landowners is needed to confirm feasibility. Relative to a smaller facility, it will be more challenging to plan, design, permit, and construct a new integration facility. Timing of these processes should be considered in efforts to achieve wind farm COD by 2030.**

Table 17. Abbreviated summary of technical benefits and drawbacks for Large Facility development at focus integration sites.

Facility	Benefits	Constraints/Risks
Point Estero Region (Nicki's Beach, China Harbor)	Some natural wave sheltering at China Harbor	Adjacent to state park Remote area with limited road access and utilities Deep water far offshore
Port San Luis Obispo Harbor District	Existing wave protection to leverage Potential benefits to other users of marine facilities within SLO Bay Existing anchorage areas	Deep water far from shore Environmental sensitivities Limited upland land availability Site egress/ingress limited
Diablo Canyon	Portions of site already zoned for industrial use Deep water relatively close to shore Distance from other residential/tourism activities – limited noise/light impacts	Challenging construction conditions Constraints from continued power plant operation Archaeological/cultural sensitivities
Southern SB (Drake and Gato Canyon)	Deep water relatively close to shore	Distance to lease areas (90-110 NM) Impacts to railroad and/or highway ROW Upgrades to road access and transmission infrastructure may be needed to develop Drake site Land use conflicts (greenfield developments)

OTHER CONSIDERATIONS

- **Wet Storage:** Wet storage area(s) will be needed, regardless of the location of a Large Facility. SLO Bay, or within the construction of a new harbor, appear to be the only areas that have the combination of sufficient water depths and wave protection to support wet storage. Depending on the temporary mooring requirements (e.g., spacing and wave climate), this may be a constraint for the industry.

- **Decommissioning:** Decommissioning of FOW farms was not assessed in detail within this study, but it is assumed that the integration facility would be utilized to support decommissioning as well. This may require planning with future developments.
- **Leveraging Oil and Gas Infrastructure:**
  - The offshore oil platforms are not designed to withstand the large and concentrated loads that originate from the WTG itself and therefore are unlikely to be utilized for generation.
  - The distance from the Morro Bay Lease Areas to the oil platforms is long enough such that it doesn't appear immediately favorable to leverage existing platforms as part of an alternative fuels network (such as H2, ammonia, or other) for the Morro Bay Lease Areas.
  - The decommissioned pipelines making landfall at VSFB are likely to be used for research purposes and are not intended to be used for commercial-scale (e.g., 1GW+) energy facilities. To be used for alternative fuels such as hydrogen, a detailed assessment on the condition and design details would need to be undertaken to determine the scale of upgrades and repairs. The pipelines making landfall at the base were historically for oil rather than gas, and therefore it may be challenging to repurpose those for gas infrastructure. A portion of the existing pipelines could potentially be used as a conduit for an export cable pull-in, but export cables landfall conduits are typically limited in length due to cable strength and pulling tension considerations to about 2km maximum.

8.1.3 WATERFRONT INFRASTRUCTURE DEVELOPMENT

There are a range of potential development and governance/operational structures that may be applicable for OSW waterfront infrastructure. On the Central Coast, a brownfield or greenfield development site will be required for a Large Facility. Considering the potential locations of the more favorable integration sites (offshore of a power plant or offshore of a conservation area and existing port), it is unlikely to be initiated by a private developer. The port could be the sponsor, or a public developer entity may be appropriate. A public-private partnership could be an option at various stages, with pros and cons that vary with project phase. Additional models could be considered taking into account site-specific considerations.

OMFs are often funded, developed, and operated by private developers (OSW developers, logistics companies). The sites screened for O&M on the Central Coast have a combination of owner types, including port authorities, power plant operators, private companies, universities, state government administrations, and municipalities. Therefore, the appropriate use and development agreements for these sites may be variable.

8.2 NEXT STEPS

Potential next steps for the counties of SLO and SB, and the City of Morro Bay include:

- Coordination with ongoing studies such as AB 525's Seaport Infrastructure Readiness Planning and NREL's West Coast Ports Strategy Study to support further analysis and site evaluations to identify preferred development locations. Further analysis to incorporate environmental, social justice, and other critical factors that were not the focus of this study.

- Coordination with winners of the Morro Bay lease auction to better define the need and timeline for both Small and Large Facilities.
- Considering that the potential Large Facility site locations are not onshore, a project sponsor/public developer entity may need to be designated. Coordination with AB 525's Seaport Infrastructure Readiness Plan, the California State Lands Commission, and the California Energy Commission is recommended.
- Depending on the site and scale of upgrades for Small Facilities (e.g., OMFs, construction staging), public and private entity coordination may be required, along with review of applicable waterfront use policies.
- In coordination with the ongoing and planned state-level work to support AB 525, a more detailed but focused Phase 2 of this study should be undertaken to provide local jurisdictions and decision makers with the information needed to recommend if, where, and what development should be pursued. Potential work items for that study phase follow. This study could be funded with the $1 million in state funding that was provided to the County of SLO to further investigate options for integration facility development.

Potential Next Steps to Define Preferred Projects:

Environmental and Permitting:

Early coordination of permitting agencies and engagement with stakeholders will be a vital step so that impacts can be avoided, minimized and mitigated. These considerations should be incorporated into future work to evaluate and identify preferred development locations.

- Identify and engage stakeholders including, but not limited to, tribal representatives, U.S. Army Corps of Engineers (USACE), U.S. Coast Guard (USCG), National Oceanic and Atmospheric Administration, the United States Coast Guard, National Marine Fisheries Service, and the United State Fish and Wildlife Service, as well as California state and local agencies, and commercial and recreational fishing communities
- Initiate informal agency consultation to identify potential environmental constraints and required environmental assessments. Develop permit matrix, including high-level schedule and anticipated lead times
- Initiate cultural and marine resource assessment work that is informed by agency and stakeholder input
- Develop assessment of likely critical-path items based on refined project definition

Economic/Social:

- Coordination with the AB 525 Seaport Infrastructure Readiness Plan and the West Coast Offshore Wind Port Strategy Study being undertaken by the National Renewable Energy Lab
- Continued industry and stakeholder outreach
- Synergies with other industries such as commercial fishing and recreational fishing
- User conflict and marine and onshore traffic conflict assessments
- Workforce development and training assessment
- Refinement of funding options for various project stages

Technical:

- **Site Geometry and Alternatives**: Conduct a comparative alternatives assessment for each activity considering additional non-technical parameters. Refine facility site plans (yard geometry, wharf line elevation, etc.) to refine costs based on results of further investigations

- **Wharf and Berth Orientations and Locations**: Need to be refined based on a detailed coastal engineering analysis to consider maintenance dredging needs
- **Breakwater**: Refine harbor geometry requirements to minimize length and installation depth of breakwater and conduct wave transformation modeling to aid in geometry refinement
- **Downtime**: Conduct metocean downtime assessment to refine downtime assumptions included within throughput modeling
- **Site Investigations**: Conduct extensive subsurface investigation and report prior to refinement of the wharf structure design. Conduct biological resources field surveys. Conduct land/hydrographic surveying within the project area for planning and engineering design work
- **Fabrication**: Refine assessment of the feasibility of fabricating and launching floating foundations on site and/or delivering foundations that have been fabricated elsewhere
- **Wet Storage**: Quantify wet storage capability within San Luis Obispo Bay. Wet storage and staging area orientation and location need to be refined based on a detailed coastal engineering analysis to consider maintenance dredging needs, wave exposure, and other environmental conditions
- **Schedule**: Refine project schedule and identify key milestones needed to meet target development date

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APPENDIX A: SITE CONDITIONS DETAILS

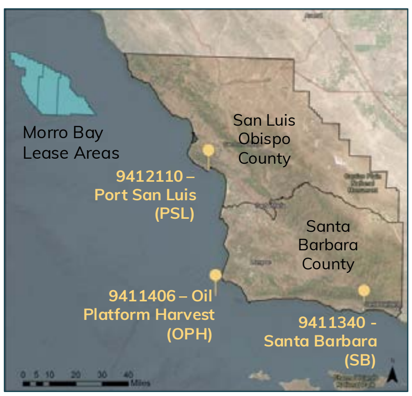
SITE CONDITIONS DETAILS

This appendix contains additional information on site conditions within the study area that was compiled and referenced as the basis for site evaluations during this study.

WATER LEVELS

Water level information is needed to inform conceptual navigation assessments, which were conducted to evaluate what types of vessels or floating devices can safely maneuver in certain areas, and/or what level of dredging may be needed to facilitate different FOW activities.

There are several NOAA water level stations located within the study area. The tidal datums associated with each station and the station location relative to the study area is shown in Figure 40. Based on an initial review, the tidal datums do not vary greatly (order of 1-2 inches {3-5.cm}) throughout the study area. For evaluation of specific port facilities, this study applies the tidal datums from the nearest NOAA station.



Datum	PSL [ft]	OPH [ft]	SB [ft]
HAT	7.08	6.95	7.23
MHHW	5.33	5.22	5.39
MHW	4.62	4.49	4.64
MSL	2.80	2.72	2.78
MLW	1.04	0.99	0.97
NAVD88	0.08	NA	0.13
MLLW	0.00	0.00	0.00
LAT	-2.02	-1.91	-2.05

Figure 40. NOAA Water Level Stations within study area; the associated tidal datums are provided in the table to the right.

WAVE CONDITIONS AND SEASONALITY

Given the energetic wave climate off the Central Coast, it is assumed that FOW at-sea installation activities will likely be limited to months characterized by favorable offshore metocean (wind and wave) conditions. A conceptual sensitivity assessment was conducted based on publicly available wave data to constrain the assumed FOW installation season period for this summary, considering the following:

- Limiting wave height for offshore installation activities: Hs<6.6-8.2ft (2.0-2.5m)
- Wave Information: National Data Buoy Center (NDBC) Station 46028, which is located adjacent to the Morro Bay Lease Areas (see Figure 12).

As shown in Figure 12, wave heights and the risk of at-sea operational downtime is lower during the warmer weather months. It is likely that installation activities will be conducted sometime between

April and November. A more detailed metocean assessment is needed to identify an appropriate installation season. Other FOW activities may be conducted at the port during the offseason to maximize offshore installation throughput during the favorable weather months.

Even during the summer months, a breakwater will be needed to provide wave protection from Pacific Ocean swell for a new integration facility, which could require quayside wave heights below ~1ft (0.3m) to conduct sensitive integration operations. Empirical methods were used to investigate the use of a floating breakwater in lieu of a fixed (full depth) structure. It is likely that the size of a floating breakwater required to attenuate long-period Pacific swell precludes feasibility. Therefore, a fixed breakwater (e.g., caisson or rubblemound structure) will be needed to protect an integration facility along the Pacific Coast.

AIRSPACE

Understanding airspace restrictions is important for siting FOW turbine integration facilities, as turbine tip height can reach up to ~1,100ft (335m) above sea level. The Federal Aviation Regulation (FAR) maps spatially varying height limitations in the vicinity of airports; these surfaces are called FAR Part 77 airspace surfaces (see Figure 41). Mott MacDonald identified seven airports within SLO and SB counties. After reviewing the FAR Part 77 surfaces associated with these airports, it was found that the airspace restrictions associated with three of the seven airports (Oceano County Airport, Vandenberg Space Force Base, and SB Municipal Airport) overlap with the waterfront study area. The Part 77 surfaces for these three airports were digitized and mapped by Mott MacDonald for use in this study.

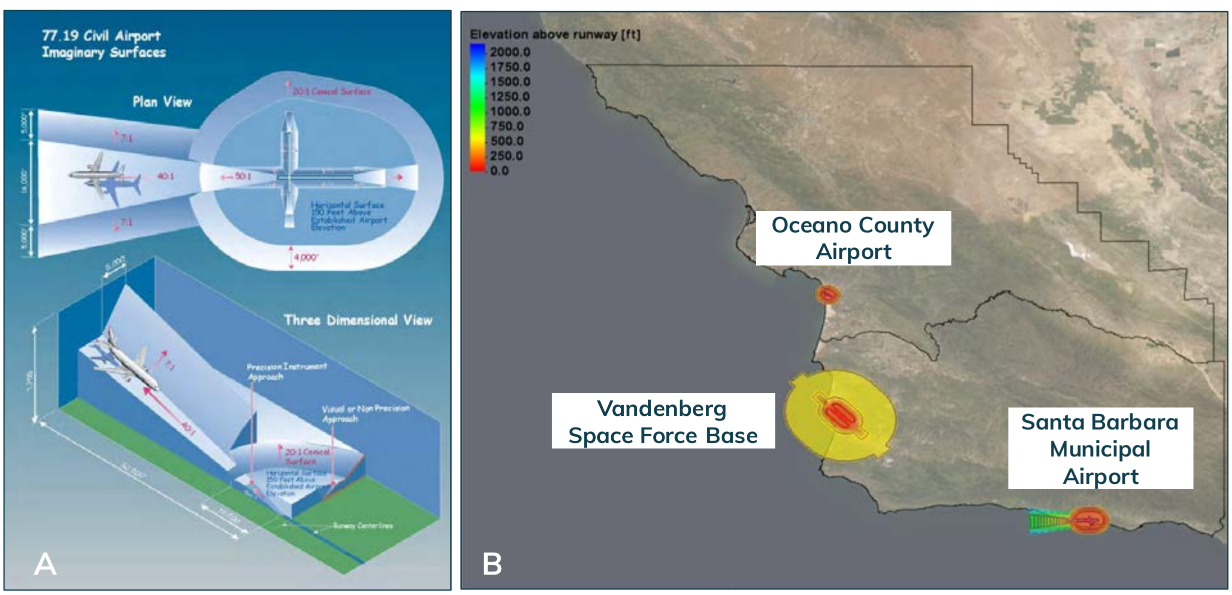


Figure 41. Plate A: example FAR Part 77 airspace surface (SLO County Regional Airport, 2017). Plate B: mapped FAR Part 77 surfaces for airports with restrictions intersecting the study area shoreline; the colors represent the elevation of the Part 77 surface relative to ground level.

ELEVATIONS

Due to the large size of integration facilities (60-100+ acres {12-30+ hectare}), information on upland and in-water elevations throughout the study area is needed to evaluate the need for earthworks or dredging. Mott MacDonald created a project basemap as the basis for assessing water depths (bathymetry) and upland elevations (topography). The project basemap (see Figure 42) was developed by merging the following public elevation data sources into one seamless elevation surface:

- 2008 Santa Barbara DEM (NOAA)
- 2012 Monterey DEM (NOAA)
- 2011 Port San Luis DEM (NOAA)
- 2013 Southern California Coastal Relief Model (NOAA)

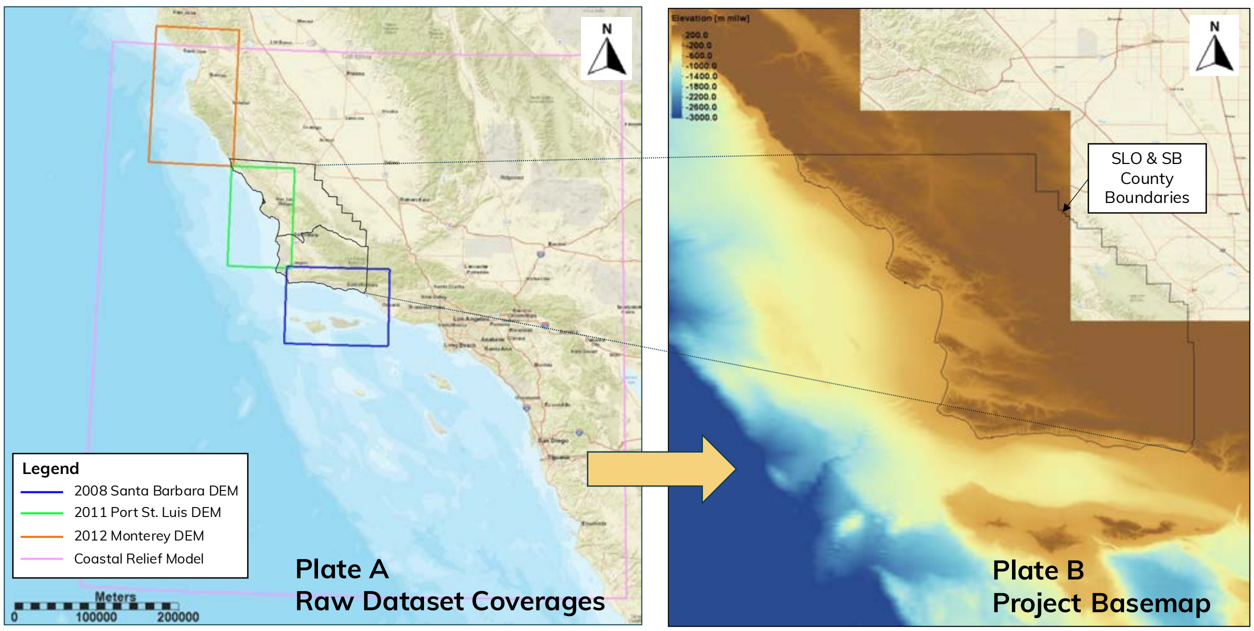


Figure 42. Plate A: coverages of raw, public elevation datasets. Plate B: synthesized project basemap for use in this study.

GEOLOGY

Geologic conditions impact the feasibility and cost of excavation and dredging, structures, and seismic risk and therefore is an important factor in evaluating potential port development sites. Publicly available information was reviewed for specific locations to develop an understanding of geologic site conditions. Qualitative interpretation of information from these sources (e.g., US Geological Survey, California Geological Survey, California Division of Mines and Geology, Dibblee Geological Foundation, etc.) was conducted to characterize focus areas. Information reviewed includes items such as differentiation of active and non-active faults, potential substrate, and approximate depth to bedrock. Additional detail can be found for each geographic focus area within the site-specific sections of the Waterfront Infrastructure Assessment chapter of this report. Detailed site investigations will be needed.

APPENDIX B: SMALL FACILITY SCREENING FRAMEWORK

The table below presents the Existing Facilities Database, the relevant site characteristics that were utilized in the Small Facility screening, and the justification for the Small Facility screening results (see Figure 13).

Table 18. Small Facility screening framework. Screening results for various activities, including crew transfer (CT), CTV moorage (CTV), SOV moorage (SOV), anchor, cable, and mooring storage (SKS).

Existing Facilities			Relevant Site Characteristics				Screening Results	
No.	Existing Facility Name	Existing Infrastructure Type	Limiting Nav. Channel/ Approach Depth	Limiting Nav. Channel/ Approach Width	Current Use	Wave Exposure	Screening Results (CT, CTV, SOV, SKS Storage)	Justification for Screening Out
1	William Randolph Hearst Beach	Pier	6ft (1.8m) at end of pier	NA	Recreational state beach that allows fishing on piers and ocean kayaking	Exposed	-	Exposed; insufficient water depths; recreational use
2	Water Treatment Plant/ Abalone Farm	Water treatment plant, may have small derelict boat ramp	0ft (0m) at end of small boat ramp	NA	Private abalone farm	Exposed	-	Exposed; no moorage infrastructure
3	Cayucos Pier	Pier	4ft (1.2m) at end of pier	NA	Fishing pier well known for night fishing	Exposed	-	Exposed; recreational use, urban area
4	Morro Bay	Morro Bay Breakwaters Small marina	Entrance: 30ft (9.1m) Inner A: 16ft (4.9m) Inner B: 12ft (3.7m)	Entrance: 350ft (107m) Inner A: 350ft (107m) Inner B: 150ft (46m)	Small scale commercial and recreational harbor with vessel slips, piers, ~25 moorings and a developed, mixed-use waterfront	Protected harbor	CT, CTV, SOV, SKS	-
5	Diablo Canyon	Power plant Protected basin	Depths inside basin ~26-33ft (8-10m)	Entrance Width~70-140ft (21-43m)	Breakwater offers protection to the Diablo Canyon Nuclear Power Plant	Protected harbor	CT, CTV, SOV, SKS	Size of SOV and barges will be limited by entrance and harbor sie.
6	Harford Pier and Breakwater	Pier and breakwater	Depths ~10-20ft (3-6m) along pier	NA	Fishing pier with restaurants and fish markets, driving on the pier is allowed	Exposed	CT, CTV, SOV, SKS	-

7	Cal Poly Pier	Research pier with small boat lift	40ft (12m) at end of pier	NA	Marine research facility for Cal Poly; former industrial pier	Semi-exposed	CT, CTV, SOV	No laydown area for upland storage; pier not big enough to support anchor loading
8	Avila Pier	Pier	28ft (8.5m) at end of pier	NA	Suffered major storm damage historically; fishing and passenger wharf; "fair" condition per recent condition assessment	Exposed	-	Exposed; recreational use
9	Pismo Beach Pier	Pier	10ft (3m) at end of pier	NA	Recreational state beach mostly used for sightseeing and tourism purposes	Exposed	-	Exposed, recreational use
10	Vandenberg Space Force Base (VSFB) Boat Dock	RORO berth and breakwater	~10ft (3m) berth depth	NA	Boat/vessel launching area within VSFB, used by the space companies for hardware delivery and recovery activities	Semi-exposed	CT, SKS	Semi-exposed; unsuitable for long-term moorage; limited laydown area adjacent to water, within launch evacuation area. May potentially be used for laydown and construction staging purposes, if can be accommodated in schedule
11	Gaviota Beach	Pier	12ft (3.7m) at end of pier	NA	Unused pier awaiting reconstruction after receiving damage from a severe storm	Exposed	-	Exposed; California State Park
12	Gaviota Substation	Substation		NA	Substation; no waterfront infrastructure	Exposed	-	Exposed; no moorage infrastructure

13	Ellwood Pier	Pier	15ft (4.6m) at end of pier	NA	Pier used for loading and unloading personnel and O&G supplies; owned by CSLC	Exposed	CT, SOV	Exposed, unsuitable for long-term moorage. Weather dependent moorage of SOVs may be possible with upgrades
14	Goleta Pier and Slough	Pier	18ft (5.5m) at end of pier	NA	Fishing pier	Exposed	-	Exposed; recreational use
15	Santa Barbara Harbor	Marina	Entrance: 15ft (4.6m) Inner: 16ft (5m)	Entrance: 300ft (91m) Inner: 16ft (5m)	Private yacht club providing social and recreational activities	Protected harbor	CT	Navigation channel geometry insufficient for SOVs, AHTVs, cable lay vessels; congested harbor – high use; lacks new development opportunities
16	Stearns Wharf	Wharf	18ft (5.5m) at end of pier	NA	Restaurants, parking, Natural History Museum, fishing, recreation	Semi-exposed	CT, SOV	Semi-exposed; recreational use
17	Casitas Pier	Pier	13-27ft (4-8m) at end of pier	NA	Private pier operated by Venoco (energy company); used for transfer of personnel and equipment to service oil platforms; Parking lot used for temporary storage	Exposed	CT	Exposed; unsuitable for long-term moorage

APPENDIX C: WATERFRONT INFRASTRUCTURE ASSESSMENT TECHNICAL APPENDIX

WATERFRONT INFRASTRUCTURE ASSESSMENT TECHNICAL APPENDIX

This Technical Appendix contains details of the waterfront infrastructure assessment that was conducted for selected sites within SLO and SB Counties and accompanies the finding presented in Section 6 Waterfront Infrastructure Assessment. This appendix presents the gap analyses that were conducted for each site. Each gap analysis compares site criteria for various types of FOW facilities to existing site conditions to identify potential upgrades (or "gaps") that will be needed to support each type of FOW activity.

Conceptual navigation assessments were conducted at sites that were selected for developing conceptual development layouts and the associated construction cost estimates. These sites include Morro Bay (Small Facility), Diablo Canyon (Large Facility), and San Luis Obispo Bay (Large Facility). The conceptual navigation analyses were used to inform concept layout development and are presented in this technical appendix.

MORRO BAY

CONCEPTUAL NAVIGATION ASSESSMENT

The subsections below contain conceptual engineering that was conducted to evaluate the need for dredging or navigation channel modifications to accommodate an OMF or SKS staging in Morro Bay.

MARINE TERMINAL BERTH

Vessel berths will require sufficient water depth so that under keel clearance (UKC, the gap between the bottom of the vessel and the seabed) is maintained at a wide range of water levels. For the smaller O&M vessels, the water depth in the harbor is sufficient. Deeper draft SOVs and AHTVs would require increased water depth (e.g., dredging). As shown in the Basis of Assessment (see Figure 6 and Figure 7), vessel draft for smaller SOV and AHTVs could be on the order of 14-16ft (4.3-4.9m), while medium and larger vessels could have drafts of 20-25ft (6.1-7.6m). Table 19 shows conservative, conceptual berth depths for a range of vessel drafts, assuming a design low-water level of Lowest Astronomical Tide (LAT). Berth dredging is likely required relative to the apparent existing water depths (~15ft {4.6m} MLLW) alongside the proposed wharf, though details may vary based on the design vessel and design water level. Dredging in this area may require eelgrass mitigation, depending on the specific dredge prism.

Table 19. Conceptual berth dredging elevations for various vessel drafts.

Vessel Draft	Design Water Level	UKC (10%)	Concept Berth Elev.
10ft (3.0m)	-2ft (-0.6m) MLLW [LAT]	1.0ft (0.3m)	~13ft (-4.0m) MLLW
12ft (3.7m)	-2ft (-0.6m) MLLW [LAT]	1.2ft (0.4m)	~15ft (-4.6m) MLLW
15ft (4.6m)	-2ft (-0.6m) MLLW [LAT]	1.5ft (0.5m)	-18.5ft (-5.6m) MLLW
20ft (6.1m)	-2ft (-0.6m) MLLW [LAT]	2.0ft (0.6m)	-24ft (-7.3m) MLLW
24ft (7.3m)	-2ft (-0.6m) MLLW [LAT]	2.4ft (0.7m)	-28.4ft (-8.7m) MLLW

NAVIGATION CHANNEL

As noted in Porter and Phillips (2020), "*Navigation infrastructure is intended to provide a safe, efficient, environmentally sound, and cost-effective waterway for ships and other vessels to access the harbor*." At present the longest ship to "turn around" in the harbor is the Yaquina (hopper dredge) at 200ft (61m), with a draft ranging between ~9ft (2.7m) and 16ft (4.9m). While SOVs and AHTVs may be more maneuverable than this vessel, if the USACE channel dredging footprint is increased to the full width of the channel, a larger vessel could turn around. Based on review of the authorized channel dimensions, relative to the recent dredge extents, the turning basin could be increased to approximately 600-700ft (183-213m), relative to the apparent turning basin diameter (based on review of recent bathymetry data) of ~400ft (122m). This change would potentially impact the mapped eelgrass area within the south side of the Navy Channel (which is currently not dredged).

Per PIANC (2014), "*Channel geometry may impose limitations on times and durations when the channel can be used safely for various device geometries and vessels; however, an adequate level of safety should be maintained for all navigation activities. The economic analysis is a trade-off between investment, availability, and efficiency, and not between investment and risk, because recommended safety requirements must always be maintained. The depth of port approach channels is determined by a number of components, which are related to the water level, channel bottom and the ship, as well as seamanship and the risk of human error.*"

Depending on the vessel particulars, such an increase in the effective turning basin could potentially accommodate up to an LOA of around 300ft (91m), but draft may start to become the limiting factor to maintain safe navigation for vessels. The design depth in the navigation channel does not likely need to be as deep as the design depth of the berth to accommodate the same vessels, as vessels do not need to access the channel at extreme low water.[21] Secondly, the harbor also naturally maintains much of its depth along the north shoreline. For shallower-draft SOVs and AHTVs (typically shorter length), a change in the authorized channel depth may not be required, as shown in Table 20 below (developed based on guidance in PIANC, 2014). However, for the medium and larger SOVs and AHTVs, channel deepening may be required to consistently provide navigable water depths within the Main and Navy Channel (and a higher facility operability).[22] As previously mentioned, USACE's analysis of sediment cores to a depth of -25ft MLLW within the FNC indicate the presence of poorly graded sand and did not encounter bedrock. The Entrance Channel (30ft {9m} MLLW) is unlikely to require a change in dredge depth, though a more detailed study should be conducted to constrain the upper envelope of

[21] Though CTVs and SATVs that enter the harbor on a more consistent basis should have a lower design water level than vessels calling less frequently, represented in the table by a lower water level.

[22] As the existing authorized depths are 16ft (4.9m) MLLW, though details may vary based on the design vessel and design water level.

the design draft considering bar conditions and shoaling patterns (not conducted as part of this study).

Table 20. Conceptual channel dredging elevations for various vessel drafts.

Vessel Draft	Design Water Level	UKC	Concept Channel Elev.
10ft (3.0m)	0.0ft MLLW [MLLW]	2.3ft (0.7m)	-12.3ft (-3.8m) MLLW
12ft (3.7m)	0.0ft MLLW [MLLW]	2.5ft (0.8m)	-14.5ft (-4.4m) MLLW
15ft (4.6m)	2.8ft (0.9m) MLLW [MSL]	2.8ft (0.9m)	-15.0ft (-4.5m) MLLW
20ft (6.1m)	2.8ft (0.9m) MLLW [MSL]	3.3ft (1.0m)	-20.5ft (-6.3m) MLLW
24ft (7.3m)	2.8ft (0.9m) MLLW [MSL]	3.7ft (1.1m)	-24.9ft (-7.6m) MLLW

GAP ANALYSIS

Table 21 summarizes the gap analysis conducted to identify potential upgrades needed to enable FOW support activities to be performed in Morro Bay.

Table 21. Gap analysis for Morro Bay.

Activity	Gaps/Potential Upgrades
OMF	**New Wharf.** A new 500-1,000psf (2-5T/m^2) wharf is needed to support moorage of larger vessels (SOVs or SATVs) and equipment transfer. The area of the existing finger floats and floating docks may be leveraged to support CTVs and crew transfer. **Upland Area.** Vacant waterfront space is currently limited in Morro Bay. The repurposing of exiting waterfront parcels to create the required storage and laydown space will be needed. A change in local zoning laws may be required to support development. **Dredging.** Depending on the specific O&M vessel fleet, deepening of dredging depths within the FNC may be needed to provide navigable depths for vessel maneuvering and long-term moorage at the new wharf. Dredging would be required to accommodate medium and large size SOVs **Fueling.** Upgrades to the existing fuel dock may be needed to support an increase in demand.
Construction Support	**Upland Area.** Vacant waterfront space is currently limited in Morro Bay. Existing waterfront parcels will need to be re-purposed to support temporary upland storage during construction, such as the decommissioned intake building, but could also provide benefits to other users. **Dredging.** The size of vessel able to safely enter and maneuver within Morro Bay may be limited to ~200ft without modifications to navigation channel geometries, which is on the small end of AHTVs. To accommodate larger AHTVs, which may be preferred, channel deepening and increased dredging within the existing FNC is required.

DIABLO CANYON

GAP ANALYSIS

A gap analysis was conducted to identify key “gaps” in existing infrastructure that were identified by comparing facility requirements for various FOW activities to existing site conditions. The gap analysis for Diablo Canyon is presented in Table 22.

Table 22. Gap analysis for Diablo Canyon.

Activity	Gaps/Potential Upgrades
Integration	**New High-Capacity Wharf.** A new ≥6,000psf (30T/m²) wharf will be needed. **Localized Dredging.** Localized dredging may be needed to remove rocky outcroppings or other obstructions. **New Breakwater.** A new breakwater will be needed to protect the integration berth from Pacific Ocean swell. Exact breakwater length will be dependent on the season in which integration activities are expected to occur, and the limiting wave height for integration activities. **New Storage Yard.** A flat storage yard (60-100 acres {12-30 hectare}) will be needed for storage and maneuvering of WTG components. **Wet Storage.** Wet storage locations will need to be identified, but do not necessarily need to be sited at the integration facility. **Sinking Basin.** If foundations are delivered on a semi-submersible vessel, the breakwater may need to be designed to accommodate a sinking basin for float off of foundations.
OMF	**New Finger Floats and/or Wharf.** Floating and/or fixed docks are needed to accommodate moorage and crew transfer for O&M vessels. Note that the intake structure will be converted into a wharf to support power plant decommissioning activities, which could be utilized for vessel moorage and/or staging. The basin has been utilized previously by barges (See Figure 28, courtesy of PG&E). **SOV Access and Maneuvering.** The existing intake basin marina can likely accommodate CTVs and SATVs without reconfiguration of the breakwater. Further analysis is needed to evaluate whether SOVs can safely enter and maneuver within the intake basin without breakwater configuration and/or dredging. Conceptual-level assessment indicates the marina may be able to accommodate smaller SOVs with tight navigation tolerances, but a detailed maneuvering assessment is needed to confirm.

CONCEPTUAL NAVIGATION ASSESSMENT

The breakwater in the example concept layout (Figure 31) is in water depths around 100ft (30m). A caisson structure is assumed to be preferred over a rubblemound or armor unit structure, considering the water depths for installation. Though west coast experience with caisson breakwaters is limited, there is precedent for a construction at similar depths along the Pacific West Coast at Costa Azul. The example breakwater's offset from the wharf was selected to provide enough room for maneuvering of the large floating foundations within the harbor. An assumed distance of 3X the beam between the quayside and the breakwater was assumed at this concept level (per DNVGL 2015), but detailed analysis and numerical modeling will be needed to refine breakwater orientation and alignment, which could include a change in type and may determine a detached breakwater is sufficient.

SAN LUIS OBISPO BAY

GAP ANALYSIS

A gap analysis was conducted to compare existing conditions within SLO Bay to the requirements for various FOW facilities (as presented in the Basis of Assessment). The gaps in existing infrastructure needed for supporting FOW activities are summarized below in Table 23.

Table 23. Gap analysis for SLO Bay.

Activity	Gaps/Potential Upgrades
Integration	**New High-Capacity Wharf.** A new ≥6,000psf (30T/m²) wharf will be needed to support the industry in the long-term. **New Breakwater or Breakwater Extension.** Wave protection is likely be needed shelter the integration berth. This may consist of an extension to the existing structure or a new detached breakwater, pending further analysis. Additional analysis needed to confirm. **New Storage Yard.** A flat storage yard (60-100 acres {12-30 hectare}) will be needed for storage and maneuvering of WTG components. Given the lack of flat, upland area, the storage yard would likely be supported by a new, pile-supported overwater structure. **Wet Storage.** Wet storage locations will need to be identified, and there may be opportunities to temporarily store foundations with SLO Bay. **Sinking Basin.** If foundations are delivered on a semi-submersible vessel, the bay may be able to provide sufficient water depths (depending on strategy and foundation).
OMF	**New Breakwater or Breakwater Extension.** Additional wave protection will be needed to provide all-weather safe harbor for small craft vessels within SLO Bay. **New Finger Floats and/or Wharf Upgrades.** Upgrades or new floating and/or fixed docks may be needed to support long-term O&M vessel moorage and equipment transfer. **New Storage Yard.** An upland area (2-10+ acres {1-4+ hectare}) for equipment storage, office space, parking, etc. will be needed. **Dredging.** Dredging may be needed, depending on site location and intended use. Though at present there is no small craft harbor, there are multiple potential options to support O&M beyond this purpose, similar to historical uses. • The Cal Poly Pier, which was a historical berth for deep draft oil tankers, may be a favorable option considering water depths, controlled access, and structure type (concrete). Localized widening of the pier head may be required to accommodate the transfer of equipment and goods. Additional onshore facilities would also likely be required with access to the pier. No structural analysis was completed to confirm live load capacity of the existing structure. • The Harford Pier has historically accommodated recreation, fishing, and USCG vessels (up to 150ft) and could potentially serve as a temporary mooring site to support crew and equipment transfer and office space. This would likely require a number of upgrades, including improved vessel access to the pier, security gates, localized dredging, new mooring and breasting dolphins, and potentially widening and/or reinforcing the pier. Harford Pier could be extended to its historic length, which would provide deeper draft access and may reduce conflicts with existing uses. No structural analysis was completed to confirm live load capacity of the existing structure.

CONCEPTUAL NAVIGATION ASSESSMENT

This section contains conceptual engineering considerations for a new or extended breakwater, commentary on potential impacts to existing navigation in SLO Bay, and potential uses of existing anchorage areas.

BREAKWATER

The SLO breakwater provides protection against the waves from the west (the primary wave direction) but does not provide and is not intended to provide the same protection for the southernly directed swell. Assuming a limiting sea state condition for integration activities of Hs < 1ft (0.3m), the existing breakwater may be sufficient for waves out of the west (depending on offshore wave height and period) but does not provide adequate sheltering from the southern swell. Cursory wave modeling aligns with USACE qualitative assessment in that the swell propagates into the harbor and in the area of the example marine terminal.

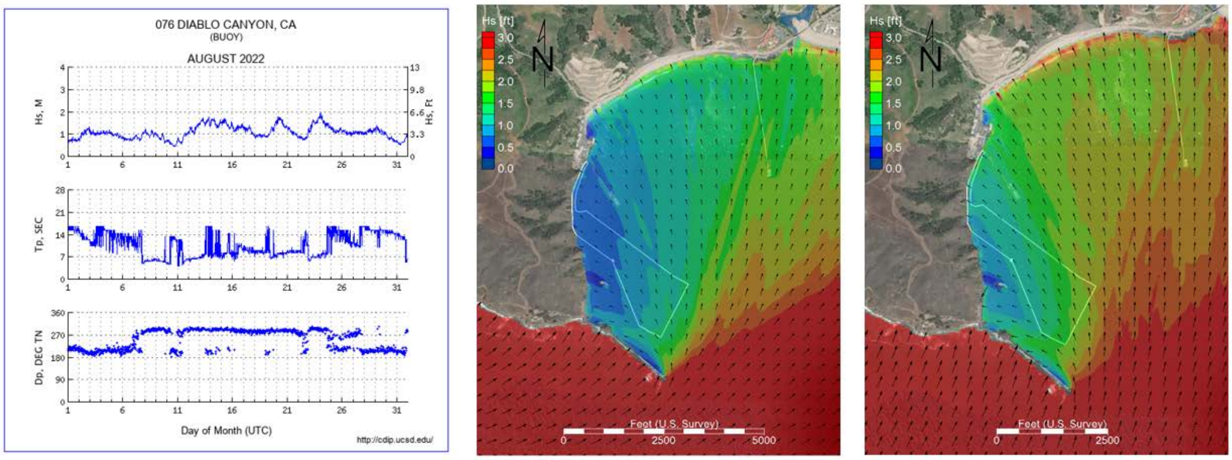


Figure 43. Left: Recorded wave conditions offshore Diablo Canyon in August 2022; Middle: SWAN wave model of typical summer wave height out of the W/NW (3.3ft {1m} offshore Hs); Right: SWAN wave model of typical summer wave height out of the S/SW (3.3ft {1m} offshore Hs). Note that phase-resolved wave modeling should be conducted to capture additional physics, including diffraction in lee of breakwater. These results should be considered as "non conservative."

Either a new detached breakwater or an extension of the existing breakwater is needed to provide shelter for swell out the S/SW. A detailed analysis should be conducted to confirm the need for and extent of a breakwater:

- Waves from this direction occur approximately 10-20% of the time year-round, and ~30-40% of the time between May-October.
- As shown in Figure 43, there are multi-week periods of time where the swell direction is consistently out of the west (at the buoy offshore of Diablo Canyon, local wave conditions may differ), which the existing breakwater may provide sufficient protection against either in its present condition or with a short extension.
- If the marine terminal were moved closer to the breakwater, it would result in better shelter to the marine terminal, and therefore a reduced need or length of a breakwater. However, mapped aquatic vegetation has recently been recorded adjacent to the breakwater, and so this area was avoided as part of this example concept.
- If the breakwater length needed is reduced relative to the example site concept shown in Figure 33, it would result in significant capital expenditure savings and other potential benefits and needs to be investigated further.

NAVIGATION IMPACTS

A navigation risk assessment was not conducted as part of this study. The effect of a large-scale port facility such as an integration facility on existing navigation should be assessed. It should be noted that the example integration facility interferes with the existing access channel and channel markers leading to the Harford Pier. Reconfiguration of the access channel would be needed and should be further investigated at a future design phase.

ANCHORAGE AREAS

There are several anchorage areas for temporary moorings within SLO Bay (see Figure 32). These areas may be able to be utilized for temporary storage of vessels and barges during construction. Coordination with the harbor district will be needed to identify suitable areas based on capacity and existing use. If a new marine terminal is constructed, relocation of a portion these anchorage areas may be required, if possible.

ALTERNATE INTEGRATION METHODS

Integration via jack-up vessel in the lee of the existing breakwater (in lieu of quayside integration at a new marine terminal) utilizing feeder barges may be an option but requires further analysis of wave conditions and definition of the specific foundation geometry (relative to existing depths) to determine feasibility. The throughput rate (number of WTGs installed per season) for integration via jack-up vessel may be lower than integration at a dedicated port facility. Areas for offsite WTG component storage would need to be identified.

SOUTH SANTA BARBARA COUNTY

GAP ANALYSIS

A gap analysis was conducted for facilities within SB County. The site conditions and existing facilities were compared to requirements for supporting FOW facilities within the bay. The results are presented in Table 24.

Table 24. Gap analysis for South SB County.

Activity	Gaps/Potential Upgrades
Integration	***<u>Drake and Gato Canyon Focus Areas</u>*** **New High-Capacity Wharf.** A new ≥6,000psf (30T/m^2) wharf will be needed. **New Breakwater.** A new breakwater will be needed to protect the integration berth from Pacific Ocean swell. **New Storage Yard.** A flat storage yard (60-100 acres {12-30 hectare}) will be needed for storage and maneuvering of WTG components. Depending on the site, the yard may be sited upland, overwater, or a combination. **Wet Storage.** Wet storage locations will need to be identified but will likely not be sited at the integration facility in this region due to the shallower water depths. **Sinking Basin.** If foundations are delivered on a semi-submersible vessel, the breakwater should be designed to accommodate a sinking basin for float off of foundations. **ROW Reconfiguration.** Depending on the site, the railroad or highway ROW may need to be adjusted to accommodate a new integration facility.
OMF	***<u>Ellwood Pier, SB Harbor/Stearns Wharf and Vandenberg Boat Dock Focus Areas</u>*** **Distance to Morro Bay Lease Areas.** The South SB County shoreline is more 100mi (160km) from the Morro Bay lease areas and is therefore less favorable for siting an OMF or other small construction support facility relative to sites in SLO County. The transit distance is likely too long for siting CTV moorage, since these vessels typically go to the wind farm and back within a day. **O&M Vessel Moorage.** SB Harbor is likely too congested to support O&M or construction support activities without a significant change in use, as confirmed during stakeholder discussions. Stearns Wharf may be able to support SOV and/or AHTV moorage with wharf upgrades (e.g., new mooring dolphins), localized dredging, and a change in use for portions of the pier. No structural analysis was completed to confirm live load capacity of the existing structure. Warehouse space to support windfarm operations may be limited on the wharf. Ellwood Pier may be able to support temporary moorage of SOVs or other vessels to support and crew/equipment transfer but may experience operational downtime without installation of a wave screen or breakwater. Onshore development would likely be required. No structural analysis was completed to confirm live load capacity of the existing structure. The Vandenberg boat dock is analyzed separately in Volume II. Given its location within a launch evacuation area, it is unlikely suitable for hosting a long-term OMF facility. However, depending on the level of upgrades conducted to support commercial space, the dock may be able to provide temporary support (e.g., crew transfer, upland staging of SKS), though vessel draft in the harbor will likely be limited.

Volume II: Space

EXECUTIVE SUMMARY

10 EXECUTIVE SUMMARY

The Regional Economic Action Coalition (REACH) commissioned the Central Coast Emerging Industries Waterfront Siting and Infrastructure Study to evaluate the technical opportunities and technical limitations for developing waterfront infrastructure in San Luis Obispo (SLO) and Santa Barbara (SB) Counties to support the future floating offshore wind (FOW) and space industries. This report (Volume II) is focused on the waterfront infrastructure at Vandenberg Space Force Base (VSFB) and infrastructure improvement options and constraints for better serving the growing space sector. A conceptual engineering assessment was conducted to evaluate waterfront infrastructure relative to existing and potential future needs.

The space industry is estimated to grow by three-fold within the next decade, and VSFB is well positioned to be the West Coast hub for commercial and military space operations (REACH, 2021). However, investments in infrastructure are needed to help realize the VSFB Commercial Space Master Plan's vision of building VSFB as a thriving space enterprise to enable advances in space exploration and strengthen the Central Coast region.

At present, users operate at a semi-protected barge berth on the south end of the base (herein referred to as the VSFB boat dock). Due to the large size and weight of certain rocket components, they must be delivered to the base via marine transport (by vessel or barge). This dock is the only waterfront infrastructure on the base that may be used for offload of space rocket components, therefore, the dock is a key element supporting operations at VSFB. After offload, components are transported by heavy-haul trailers to nearby space launch complexes.

The dock experiences significant operational downtime due to waves and tides, causing delays and challenges for present users and potential future users. Key findings of the study are summarized below:

- **VSFB boat dock operations are presently significantly limited.** A 3-day offload operation under ideal conditions can take more than 30 days to complete due to shallow water depths combined with exposure to Pacific Ocean swell. This means that water levels are too shallow for harbor operations ~80% of the time.
- **Waterfront facility upgrades to meet the needs of space launch complex users appear feasible**, with varying levels of complexity and construction cost depending on the scenario.
- **To add harbor capabilities, harbor reconfiguration and expansion is needed**. The following site improvements should be considered:
    - **Channel deepening (dredging).** The shallow water depths in the harbor are a main driver of downtime at the facility, resulting in very limited windows for delivery of rocket components.
    - **Channel widening (dredging).** The existing channel widths are narrow relative to the vessels using the channel and the wave exposure at site, contributing to operational challenges. Channel widening is needed to support larger vessels (such as the SpaceX autonomous droneship recovery vessel) for current and potential future users.
    - **Various assets in the harbor**. For example, fenders and dolphins. These assets will continue to deteriorate and will eventually need replacement.

  - **New aids to navigation.** The lack of proper navigation aids and lights contributes to limiting operational windows.
- **A formal condition assessment of waterfront infrastructure is needed**, including above and below water, to confirm the condition and capabilities of existing infrastructure.
- **Environmental considerations:** Multiple analyses and assessment have previously been conducted in the area as a result of the existing infrastructure and operations.
  - The site contains multiple endangered species, marine mammal habitat, marine mammal haul-outs, and essential fish habitat. Infrastructure upgrades conducted in this area should be developed in such a way to avoid, minimize, and mitigate impacts on marine resources.
  - Dredging is currently permitted, and a new permit is in the process of being issued. There are not presently any limitations on time-of-year restrictions. Any changes will require a restart of the permitting process.

Two scales of upgrade scenarios were developed to assess potential infrastructure needed to meet facility requirements associated with following goals:

1. Significantly improve reliability of existing operations for the vessel fleet that currently accesses the harbor.
2. Enable long-term vessel moorage to support flight recovery operations and potential future users. Significantly improve reliability of existing operations for the vessel fleet that currently accesses the harbor.

A summary of the key components of each upgrade scenario is provided below.

SCENARIO 1 — IMPROVE EXISTING HARBOR. Conceptual construction cost for the upgrades is estimated to be between $5-22 million (pending site investigations). Potential upgrades are listed below:

- Deepening of the harbor by 5ft (1.5m) to 15ft (4.6m) Mean Lower Low Water (MLLW) and an extension of the channel would significantly improve access to the harbor (increasing favorable tide/wave conditions likely by a factor of 3-4x). Dredging is likely a combination of mechanical dredging and confined blasting.
- Localized widening of the channel (~20-60ft) would provide increased operability in addition to the deepening. Alternatively (or in combination with) a short extension of the breakwater would improve reliability of operations.
- Navigation aids should be installed to mark the channel. New shore lighting would provide the ability to conduct operations at night.
- New fenders such as donut fenders for the existing dolphins are likely needed.
- A small boat hoist could be installed to support VSFB operations, but a new boat ramp appears challenging without excavation of the hill below the Vandenberg Boat House.

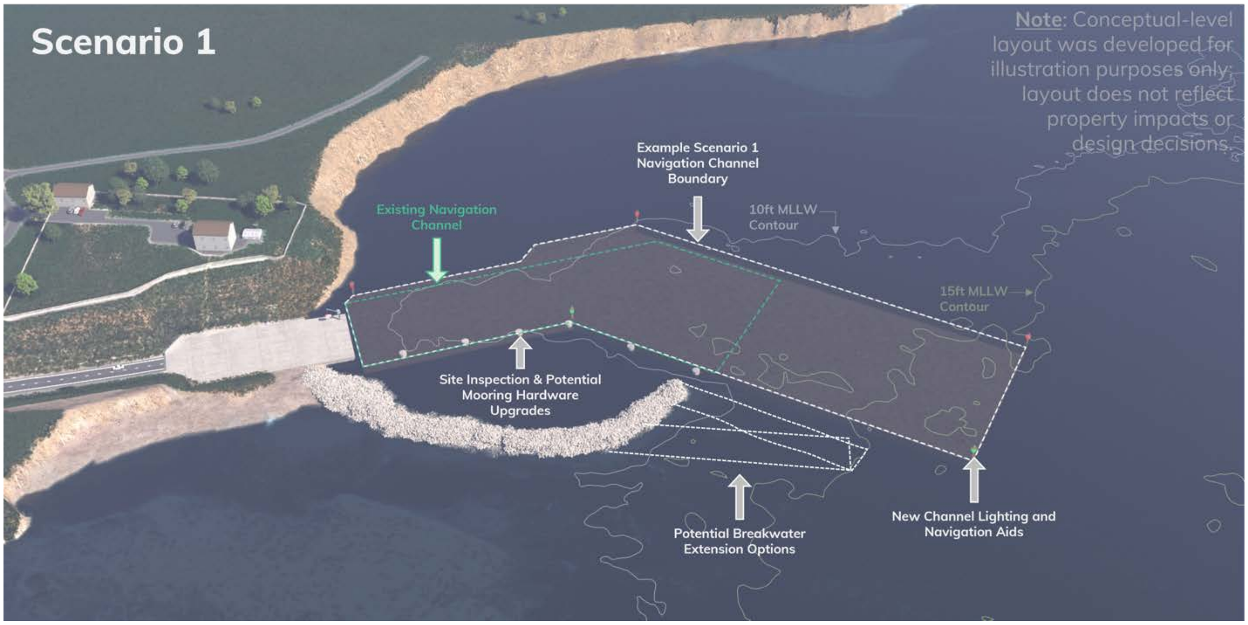


Figure 44. Rendering of VSFB boat dock facility with Scenario 1 concept upgrades.

SCENARIO 2 — RECONFIGURE HARBOR FOR NEW ACTIVITIES. Conceptual construction cost for the upgrades is estimated to be between $60-240 million (pending site investigations). Potential upgrades are listed below:

- A reconfiguration/expansion of the harbor. An expanded harbor will require a new breakwater, a significantly larger dredged area, construction of a new wharf, new navigation aids, and mooring dolphins and fenders.
- The new breakwater will likely need to be installed seaward of its existing location, with the existing breakwater demolished.
- A pile-supported wharf may be installed behind the breakwater to provide permanent moorage for vessels. A new wharf will likely need to be constructed seaward of the existing wharf.
- The minimum dredge depth may be similar to Scenario 1 (15ft {5.6m} MLLW) or greater (20ft {6.1m} MLLW), depending on confirmed vessel drafts, but the channel width will need to be wider (likely in the range of 450-600ft {137-183m} wide) to accommodate recovery vessels and allow for long-term moorage.
- A narrow boat ramp could be installed to the north of the new wharf if the harbor is reconfigured but could result in shifting the new breakwater seaward if excavation of the hill is not desired.
- Scenario 2 upgrades would facilitate harbor use by a wider range of vessels. The facility would support military, government and commercial space use. The facility could potentially be utilized to support other industries, such as FOW (e.g., temporary crew transfer operations) or other defense-related activities.

Figure 45. Rendering of VSFB boat dock facility with Scenario 2 concept upgrades.

10.1 NEXT STEPS

- General
    - REACH should coordinate results with Vandenberg Memorandum of Understanding (MOU) group and ongoing infrastructure planning workstream to prioritize projects and explore potential federal, state, local and private-sector funding opportunities.
    - As launch frequency increases, use plans and conflict assessment planning should be conducted among users.
- Technical
    - Prior to further site concept development, development and execution of a site investigation and condition assessment program above and below water is needed.
    - A detailed coastal engineering assessment and downtime assessment is needed to refine breakwater extents.
    - Mooring and berthing analysis should be conducted for the existing piles to determine whether replacement is needed.
    - A soil-structure analysis based on desired dredge depth should be conducted to determine if/what modifications are required for Scenario 1 or 2.
    - Construction phasing assessment should be conducted to assess impact on throughput during construction.
- Environmental
    - Initiate informal agency consultation to confirm potential environmental constraints and environmental assessments required.

11 ACRONYMS AND ABBREVIATIONS

The acronyms and terms in the table below are defined within the body of the report and summarized here for reference.

Acronym/Term	Definition
ATONs	Aids to Navigation
BMPs	Best Management Practices
cm	centimeters
CM	Cubic Meters
CoNED	Coastal National Elevation Database
CY	Cubic Yards
DOD	Department of Defense
FOW	Floating Offshore Wind
ft	feet
ILL	Impact Limit Line
in	inches
km	kilometers
LA/LB	Los Angeles / Long Beach
LAT	Lowest Astronomical Tide
LOA	Length Overall
m	meter or million
mi	miles
MHW	Mean High Water
MHHW	Mean Higher High Water
MLW	Mean Low Water
MLLW	Mean Lower Low Water
MOU	Memorandum of Understanding
MSL	Mean Sea Level
MPA	Marine Protected Area
MSL	Mean Sea Level
N	North
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
psf	pounds per square foot
PSL	Port San Luis
REACH	Regional Economic Action Coalition
RFI	Request For Information
RoRo	Roll On–Roll Off
S	South
SB	Santa Barbara
SLD 30	Space Launch Delta 30
SLO	San Luis Obispo
SLR	Sea Level Rise
SPMT	Self-Propelled Modular Transporter
T/m^2	Ton per meter squared
UKC	Under Keel Clearance
ULA	United Launch Alliance
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
VSFB	Vandenberg Space Force Base
W	West

INTRODUCTION

12 INTRODUCTION

The Regional Economic Action Coalition (REACH) commissioned the Central Coast Emerging Industries Waterfront Siting and Infrastructure Study to evaluate opportunities and constraints for developing waterfront infrastructure in San Luis Obispo (SLO) and Santa Barbara (SB) Counties to support the future floating offshore wind (FOW) and space industries. Volume II of this report is focused on the waterfront facilities at Vandenberg Space Force Base (VSFB) and infrastructure improvement options for better serving the growing space sector.

The space industry is estimated to grow by three-fold within the next decade, and VSFB is well positioned to be the West Coast hub for commercial and military space operations (REACH, 2021). However, investments in infrastructure are needed to help realize the VSFB Commercial Space Master Plan's vision of building VSFB as a thriving space enterprise to enable advances in space exploration and strengthen the Central Coast region. A new technical park is being planned at VSFB to support the growth of the space industry, but there has been no detailed assessment on options for improving waterfront infrastructure to better serve both current and future space needs.

The VSFB waterfront infrastructure available to space users consists of a semi-protected barge berth on the south end of the base, herein referred to as the VSFB boat dock (see Figure 46). Elements of the boat dock facility are deteriorating, and current users experience significant operational downtime. This study evaluates the existing VSFB facility and assesses the constraints and what infrastructure upgrades are likely needed to meet the needs of current users and the needs of the potential future industry.

This report volume outlines present operational challenges, site conditions, development constraints, an overview of potential development scenarios, and planning level costs. A figure of the existing site is below.

Figure 46. Location of VSFB within the study area.

BASIS OF ASSESSMENT

13 BASIS OF ASSESSMENT

Mott MacDonald coordinated with REACH, VSFB staff, and other space stakeholders to outline the basis for the space waterfront infrastructure assessment. This included input from several current and potential future users of the VSFB Boat Dock. The subsections below outline the basis and assumptions for assessing existing infrastructure and developing conceptual upgrades for various operational scenarios.

13.1 STUDY METHODOLOGY

A summary of the processes followed to conduct the space waterfront infrastructure assessment is provided below.

Data Compilation. This conceptual-level study was based on public information and input from various stakeholders (see list below). No new data collection or site investigations were conducted. Information was gathered through the following methods:

- Literature review and assessment of public information;
- Request for information (RFI) responses from relevant space dock users and VSFB staff; it should be noted that detailed, user-specific information was provided and incorporated into this study, but is not included within this public report;
- Virtual discussions with VSFB staff; and
- On-site and virtual discussions with marine contractors/tug operators operating at the VSFB boat dock facility to gather first-hand accounts of site constraints and challenges.

Feedback and Technical Review. Meetings with the Technical Steering Committee were held monthly to share technical updates and solicit feedback. Periodic discussions were held with VSFB staff to confirm assumptions and understanding throughout the study. A technical review of this report was conducted by VSFB staff.

Site Visit. The Mott MacDonald and REACH project team visited the VSFB Boat Dock facility on Aug. 18, 2022, to discuss site constraints and challenges with VSFB staff, take photos, and document site observations. No detailed inspections were performed.

Basis of Concept Design. The Basis of Analysis was developed based on information compiled through the data gathering pathways listed above. Based on feedback from VSFB staff and current/potential future dock users, two development scenarios were defined within the Basis of Concept Design: Minor Upgrade Scenario (Scenario 1) and Major Upgrade Scenario (Scenario 2).

Space Waterfront Infrastructure Assessment. Conceptual design was conducted based on the facility requirements and site constraints contained within the Basis of Concept Design to develop likely infrastructure upgrades needed to support both operational scenarios considered in this study. It should be noted that future work will be needed to refine and document environmental sensitivities and construction methods to minimize impact on aquatic vegetation, pinnipeds, other marine mammals, and critical habitats. The concept upgrade designs presented in this volume are intended to reflect the scale of development and investment needed under each scenario and are not meant to meet the needs of specific project proposals. Planning-level (Class V level) cost estimates were developed for each upgrade scenario but will need to be refined based on site investigations and regulatory requirements.

13.2 STUDY AREA

The current VSFB boat dock location (Figure 47) will be the focus of the space infrastructure assessment. As coordinated with VSFB staff, the current dock location is preferred relative to other alternative segments of shoreline within the base for waterfront infrastructure development.

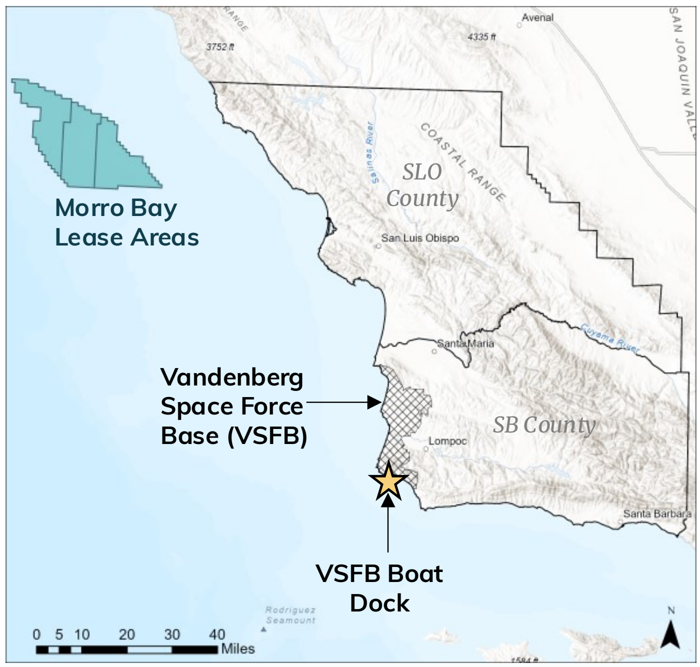


Figure 47. VSFB boat dock location within study area.

13.3 OPERATIONS OVERVIEW

13.3.1 CURRENT USE

The VSFB boat dock facilitates space hardware deliveries and supports offshore flight hardware recovery. Space "hardware" refers to elements such as large rocket components, boosters, recovered launch stages, etc. The existing dock accommodates RoRo (roll on-roll off) loading, meaning that components are rolled off of barges and onto the dock. Components are then transported via truck to their final destination elsewhere on the base. United Launch Alliance's (ULA's) *R/S Rocketship* cargo vessel is one of several vessels that use the dock. The *R/S Rocketship's* size relative to the VSFB Boat Dock facility is shown in Figure 49, Figure 55 and Figure 56.

Figure 48. VSFB boat dock site context and example heavy haul route to a space launch complex.

13.3.2 OFFLOADING CAPABILITIES

The current dock was designed to accommodate RoRo cargo transfer. There are no heavy-duty cranes (or broadside access) to facilitate lifting equipment off of vessels.

13.3.3 DANGER ZONE

The dock is located within the impact limit line (ILL) of the majority of VSFB launches and is subject to the evacuation of all non-essential personnel. Specific evacuation area maps are published by Space Launch Delta 30 (SLD 30) and the U.S. Coast Guard (USCG) before each launch based on the rocket trajectory. If the dock falls within the evacuation zone, then the area must be evacuated prior to launch.

13.4 SITE CONDITIONS

The key elements of the VSFB Boat Dock facility are summarized in Figure 49, and current challenges at the facility are summarized in Figure 55. Select ground photos are provided in Table 25. Further detail on each of these elements is provided in the subsections below.

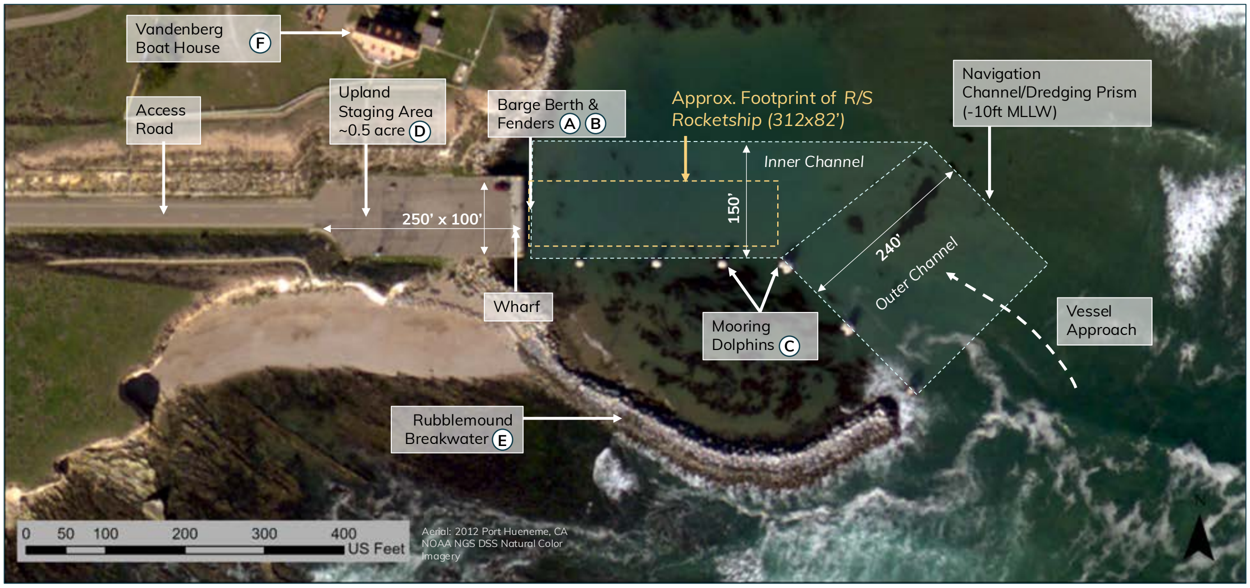


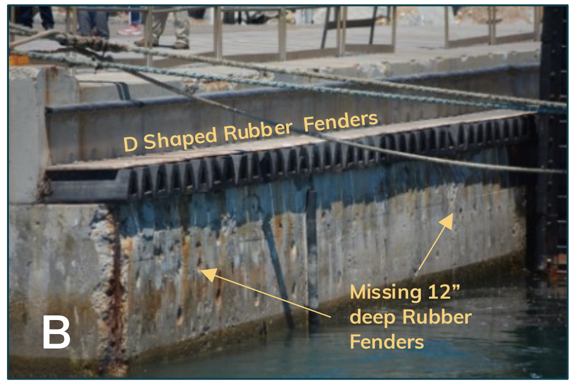
Figure 49. VSFB boat dock existing infrastructure elements. Letters A-F correspond to the associated ground photos in Table 25.

13.4.1 ELEVATIONS

Site elevations at Vandenberg dock within the dredging prism were provided by a series of condition and post-dredge surveys conducted in 2020 and 2021. Outside of the dredging prism, elevations were provided by a 2017 U.S. Geological Survey (USGS) Coastal National Elevation Database (CoNED) topobathy dataset. Figure 56 shows a map of site elevations.

Table 25. VSFB Boat Dock ground photos, taken during a site visit conducted Aug. 18, 2022.

Tug moored at barge berth (looking south).



Quay wall and fenders (looking northwest).

Mooring dolphins (looking east).

Upland staging area (looking west).

Rubblemound breakwater (looking southeast).

Historic Vandenberg Boat House (looking north).

13.4.2 WATER LEVELS

For this study, the tidal datums associated with this site are given by NOAA Station 9411406 Oil Platform Harvest, located approximately 7.3 mi (12 km) offshore the project site. The great diurnal tidal range (difference between Mean Higher High Water {MHHW} and Mean Lower Low Water {MLLW}) is 5.2ft.

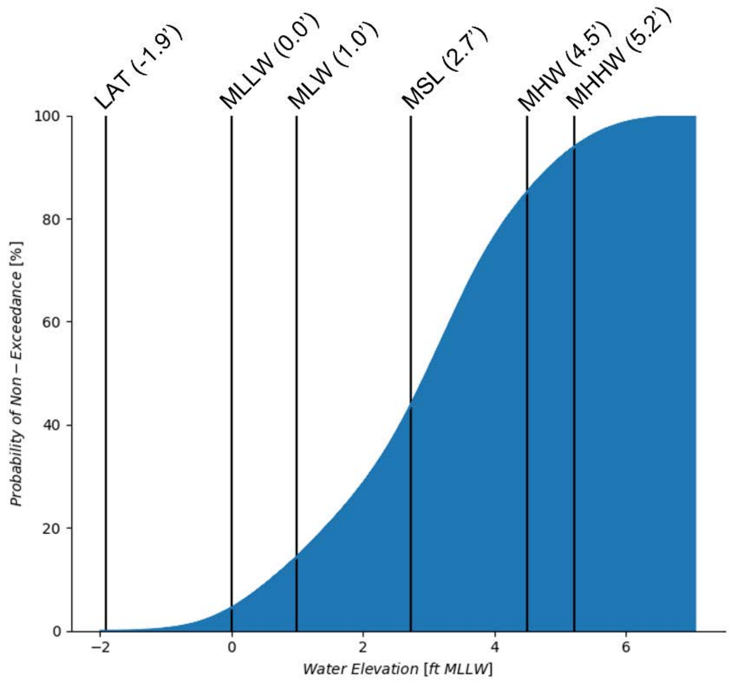


Figure 50. Water level datums and probability of non-exceedance plot for NOAA Station 9411406 Oil Platform Harvest.

13.4.3 NAVIGATION CHANNEL

A dredged channel is maintained to provide vessel and barge access to the dock. Dredge reports indicate the material removed is predominately sand. A summary of key channel parameters is provided in Table 26. Based on review of existing survey data the channel appears to be subject to sedimentation, with the most recent maintenance dredge event occurring in August 2022. The existing channel is the “minimum viable” geometry for the vessels and barges delivering components according to VSFB and is subject to significant downtime (see Operations and Challenges subsection) due to insufficient water depths and weather.

Table 26. Summary of navigation channel parameters.

Parameter	Authorized Value	Observations
Channel Length	~650ft (198m)	Based on prism provided within ULA (2021)
Inner Channel Depth	10ft (3m) +2ft (0.6m) overdrege[23]	The various surveys reviewed indicate depth varies over time and within the channel. Post-dredge, water depths are typically 11-12ft (3.4-3.7m) MLLW, with elevations closer to 10ft (3m) MLLW, or below, around the edges. With siltation, channel depths decrease, resulting in a narrow portion of the channel with depths greater than the design elevation of 10ft (3m).
Outer Channel Depth		Similar to the inner channel the water depths depend on recency to dredging. Based on available data, water depths appear to be typically between ~10-11ft (3.0-3.4m) with elevations closer to 10ft (3m) MLLW or below around the edges. Near the outer (southern) edge of the channel the dredged channel meets the natural 12ft (3.7m) contour.
Inner Channel Width	150ft (46m)	There is limited area outside the channel that is as deep as the authorized depth, and therefore the space outside the dredge channel is not typically used. The channel transitions at an approximate 45° angle from the outer portion of the channel. No additional width for the bend exists (resulting in narrower effective width due to the turning).
Outer Channel Width	240ft (73m)	There is limited area outside the channel that is as deep as the authorized depth, and therefore the space outside the dredge channel is not typically used.
Channel Substrate	97% sand, 3% clay – above bedrock	Depth to bedrock and hardness of the bedrock is not known. As would be expected, maintenance dredging does not include any rock dredging.

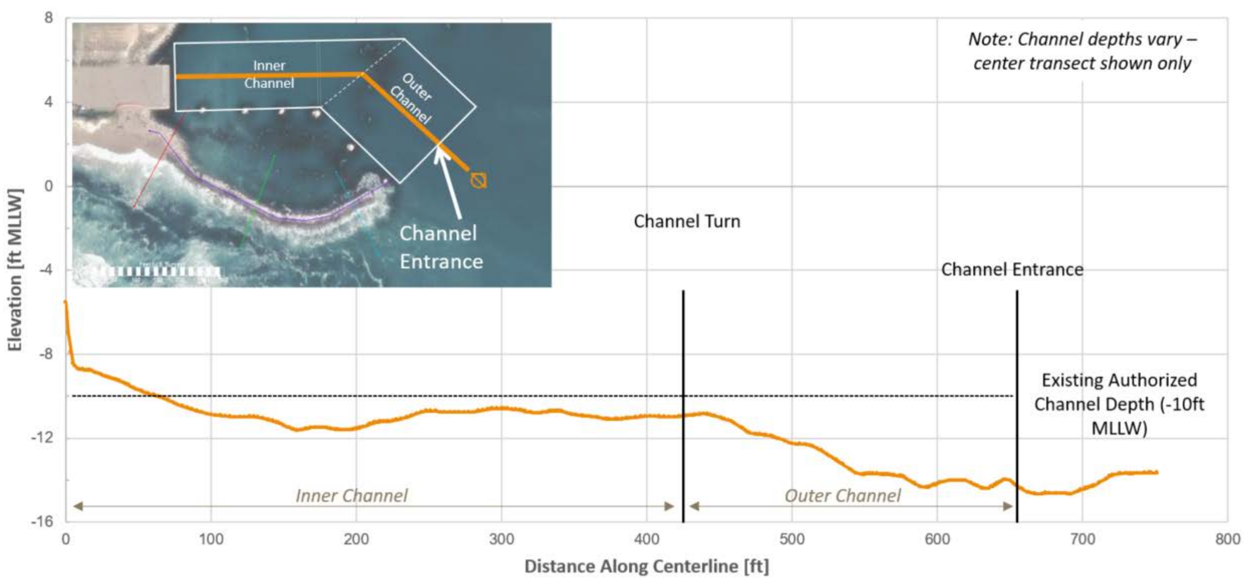


Figure 51. Elevation profile through existing navigation channel centerline.

[23] Overdredge is included to allow for construction tolerances and sedimentation in the channel between dredge events.

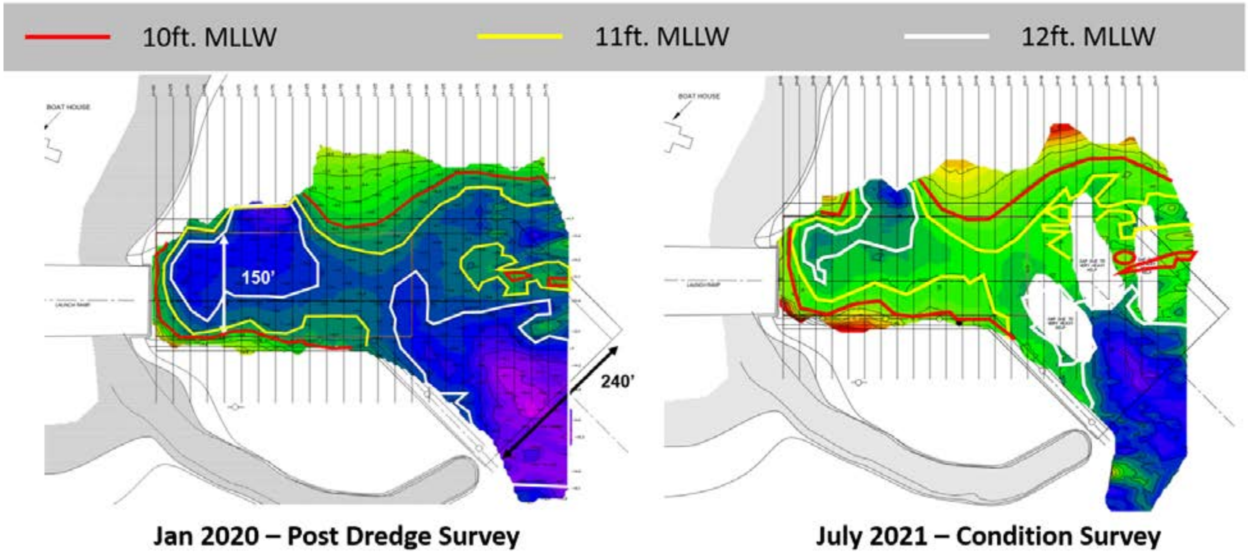


Figure 52. Evidence of sedimentation between January 2020 Post-Dredge Survey (left) and July 2021 Condition Survey (right).

13.4.4 WHARF AND QUAY WALL

The wharf is a 100ft (30.5m) long reinforced concrete quay wall structure consisting of "lip" superstructure and unknown foundation. The lip superstructure extends 10ft 2in (3.1m) landward from the recessed face of the quay wall with two single bitt bollards attached at both ends of the wharf. Embedment depth and anchorage of the foundation into the substrate are unknown in addition to the type of soil that the quay wall is retaining. Based on the photos taken during the Aug. 18, 2022, site visit, the following damage and deterioration was observed: the superstructure exhibits spalling on the corners, along the top, and along the seaward face with exposed reinforcement bars. Exposed reinforcement appears to be heavily corroded.

13.4.5 RUBBER FENDERS

Based on the photos taken during the Aug. 18, 2022, site visit, the rubber fenders shown in May 28, 2003, as-builts appear to be mostly missing but have been replaced with a row of D-shaped fenders mounted on top of the seat of the quay wall using a steel plate and bolts and projecting out approximately 6in (15cm) from the quay wall face. See Table 25B.

13.4.6 BOLLARDS

Based on the photos taken during the Aug. 18, 2022, site visit, bollards appear to have up to 25-percent coating loss and are corroding where the bare steel is exposed. South bollard foundation has corner spalls without exposed reinforcing.

13.4.7 MOORING DOLPHINS

Five mooring dolphins line the south end of the approach channel dredging prism (see Table 25C).

According to VSFB staff, the dolphins have significant rust and corrosion, including holes in the steel below the waterline. Based on a review of the photos, the existing rubber elements are attached to chains, anchored vertically and horizontally at each pile. These rubber elements do not appear to absorb significant energy (except for the fenders on one pile at the eastern end), but rather act as "bumpers/cushions" between the vessel's hull and the steel pile. The steel monopile appears to be acting as the "fender," where the pile would deflect to absorb the vessel's berthing energy at impact.

Each pile has a single-bitt bollard, which appears to be mounted on a concrete foundation; the steel pile is filled with concrete. A ladder is attached to each of the piles.

13.4.8 UPLAND STAGING AREA

A 250ft x 100ft (76m x 31m), half-acre paved upland staging area is located landwards of the berth. See Table 25D.

13.4.9 WHARF LIGHTING AND POWER

The upland staging area is fitted with six 45ft (14m) high mast floodlights around the perimeter. A 300kV pad-mounted transformer is located in the northwest corner of the paved area (Boeing, 2003). According to VSFB staff, outages of power and lighting are recurring.

13.5 RUBBLEMOUND BREAKWATER

A ~470ft (143m) long rubblemound breakwater provides some level of wave protection to the berthing area (See Table 25E). The breakwater was reviewed on site but not inspected in great detail. No as-builts were available. Based on on-site observations, the rock appeared to be of granite material with an estimated D50 of 6ft (1.8m) and estimated crest width of ~18ft (5.5m). The breakwater crest elevation appeared to be similar to the upland staging area (approximately 12- 14ft {3.7-4.3m} MLLW, with variations) and fairly uniform. Localized areas of apparent damage and displaced rock were observed but overall condition appears to be "fair" to "good." On a relatively calm day (swell under ~3ft {1m}), and a water level of 3.5ft MLLW (above MSL, below MHW), crashing waves were observed spraying the crest of the revetment (see Figure 53). Lidar data was available in the area to plot the variability of the crest elevation along the top of the breakwater (see Figure 54).

13.5.1 NAVIGATION AIDS

The harbor lacks lighting and accurate navigation beacons.

Figure 53. Plate A: Rubblemound breakwater crest (looking northwest). Plate B: Breakwater crest and wave crashing (looking southeast).

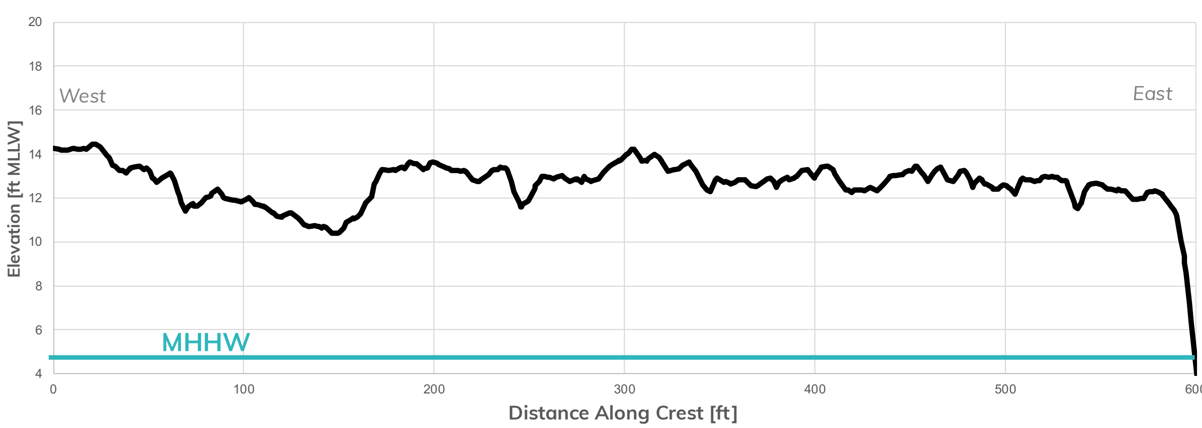


Figure 54. Elevation profile along crest of breakwater, based on USGS CoNED (2017) dataset.

13.5.2 HISTORIC SENSITIVITIES

The Vandenberg Boat House is a historic USCG building that sits upon a hill north of the upland staging area. This building is to be preserved. See Table 25F.

13.5.3 ENVIRONMENTAL

- A new permit is in the process of being issued for up to 10,000 cubic yards (CY) of maintenance dredging of the existing channel. This material is disposed of at an upland disposal site. Any changes to the dredge prism or volume would require a restart of the permitting process.
- The maintenance program description also includes removal of kelp from the dredge area. In consultation with agencies, it was determined that essential fish habitat and habitats of particular concern would not be adversely affected, provided best management and minimization measures are implemented.
- There are no present limitations on work windows for the maintenance dredging process, but any changes to the project could result in a different work window.
- Any changes in the project would require extensive consultation with agencies.
- Below is an abbreviated summary of prior analysis and assessments in the area of study:
    - An analysis of Essential Fish Habitat was prepared in support of the Final Environmental Assessment for Harbor Activities Associated with the Delta IV/Evolved Expendable Launch Vehicle.
    - In 2001, the U.S. Fish and Wildlife Service released a biological opinion regarding potential adverse effects of the program. This included six endangered species in the area. In 2009, black abalone was listed as an endangered species.
    - In 2014 the following was found as part of "Issuance of Regulations and a Letter of Authorization to the U.S. Air Force to Take Marine Mammals Incidental to Launches, Aircraft and Helicopter Operations, and Harbor Activities at Vandenberg Air Force Base, California."[24]
        - The marine mammals most likely to be disturbed incidental to the conduct of launch, aircraft, and helicopter operations from VSFB launch complexes and Delta Mariner operations, cargo unloading activities, and harbor maintenance dredging in support of the Delta IV/EELV launch activity on South VSFB are primarily California sea lions, northern elephant seals, Pacific harbor seals, and to a lesser extent northern fur seals and the eastern distinct population segment (DPS) of the Steller sea lion. None of these species are listed as threatened or endangered under the Endangered Species Act.
    - Also reported in and around site are southern sea otters within the harbor and marine mammal haul-outs, including elephant seals on the adjacent beach.
    - Kelp planted to the south of the mooring dolphins was provided as mitigation for dredging of the channel.
- No cultural resources have been included as part of the existing maintenance program but may require additional review with an expanded project footprint.

13.6 SITE CONSTRAINTS

Conceptual upgrades at the VSFB dock are subject to the following site constraints:

- Expansion of dredge limits is allowable, though will require new permits;

[24] https://media.fisheries.noaa.gov/dam-migration/vafb_2014rule_ea_opr1.pdf

- Pocket beach to remain;
- Historic house and existing slope to remain;
- Avoid submerged aquatic vegetation as possible, not a hard constraint;
- Breakwater may be modified/replaced;
- The dredgeability of the harbor will require further site investigation. Depending on depth to bedrock and the strength properties of the rock, rock blasting may be required.
- Minimize new overwater coverage as possible.

13.7 OPERATIONS AND CHALLENGES

Mott MacDonald developed an understanding of (1) current and anticipated operations and challenges and (2) preferred operations with facility upgrades, based on discussions and RFIs with relevant dock users and VSFB staff. A summary is provided in the sections below, with an overview of current challenges at the VSFB boat dock presented in Figure 55.

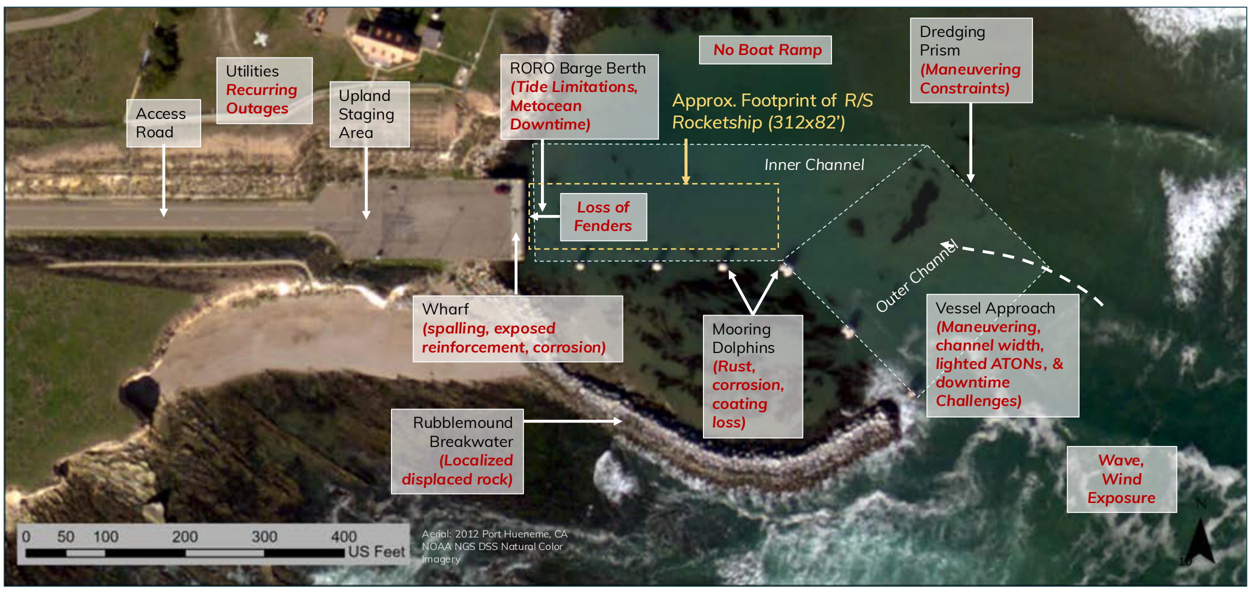


Figure 55. Summary of current challenges at VSFB boat dock.

13.7.1 FACILITY USES

This section summarizes the primary uses of the VSFB boat dock facility.

EXISTING HARDWARE DELIVERY OPERATIONS

Current Operations. ULA's *R/S Rocketship* is a cargo vessel that delivers boosters to VSFB for select launch systems. It is used to transport hardware from ULA's production facility in Decatur, Alabama, to Cape Canaveral, Florida, and VSFB.

Current Design Vessel. The *R/S Rocketship*'s parameters are provided below.

- Length Overall (LOA): 312ft (95m)
- Beam: 82ft (25m)

- Draft: 12ft (3.7m)

Operational Metocean Criteria. Based on discussions with the marine contractor responsible for ULA's unloading operations, activities at the VSFB boat dock are subject to the following thresholds:

- Significant wave height (Hs) ≤4ft (1.2m), see Figure 57.
- Water level elevation ≥ 4ft (1.2m) MLLW; note that water levels exceed 4ft MLLW only ~20% of the time (see Figure 50), and typically only for a few hours. This means that water levels are too shallow for harbor operations ~80% of the time.
- Wind speed ≤ 20 knots.

Downtime. Unloading operations at the dock are limited to higher water levels and calmer metocean (wind and wave) conditions, which can lead to significant downtime delays. Documentation shows that under preferred weather conditions, unloading operations can require three calendar days. However, given downtime challenges at the site due to high winds and/or high swells, operations have taken up to nine working days to complete. When accounting for additional downtime spent waiting for tidal windows, operations have taken up to 30 calendar days. Causes of downtime include:

- Daylight: The harbor lacks lighting and navigational beacons, limiting vessel maneuvering operations primarily to daylight hours.
- Water levels: As shown in Figure 56, existing depths at berth facilitate unloading only at higher water levels. There is insufficient under-keel clearance at lower water levels to conduct unloading activities throughout the tidal cycle.
- Winds and waves: Operational downtime at the dock has been recorded due to high winds and/or high swells, which affect the ability to safely maneuver into the harbor and berth at the dock. Vessel maneuvering to approach the berth is limited to stricter downtime criteria due to the tight navigational tolerances associated with the navigation channel width.

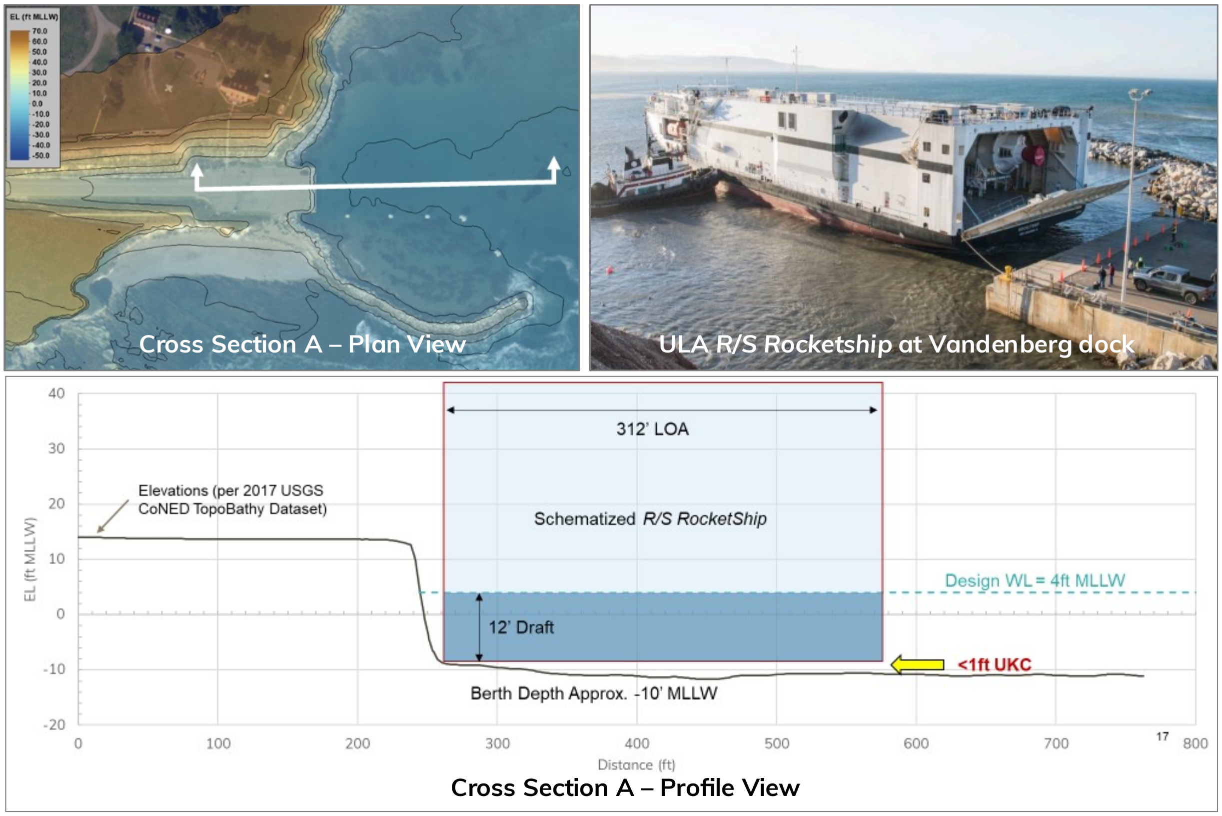


Figure 56. Cross section showing berth depths at Vandenberg boat dock.

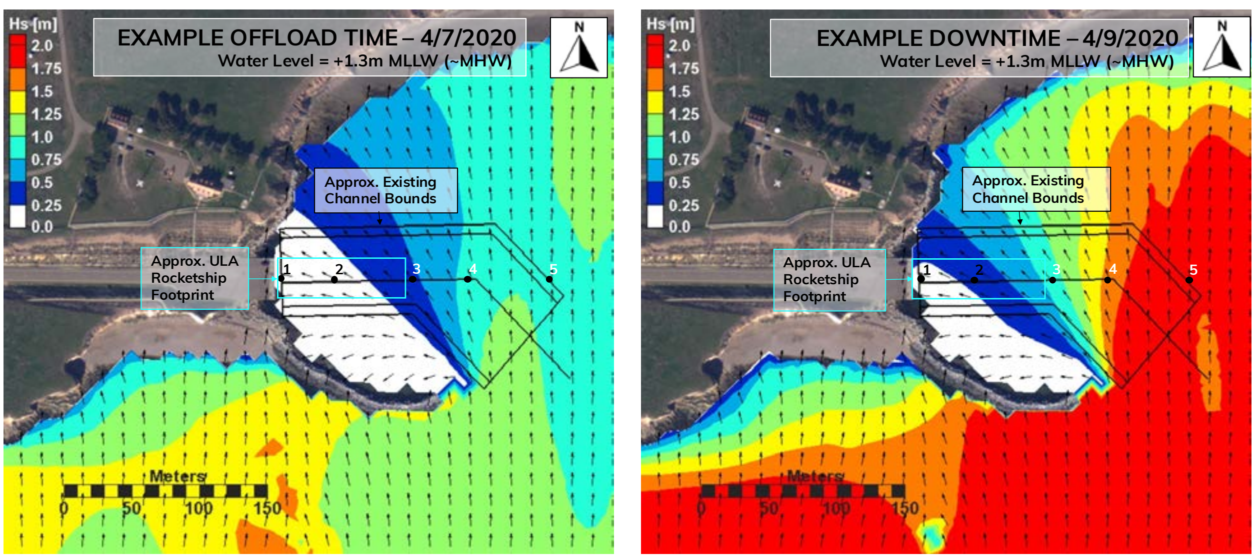


Figure 57. Results of numerical modeling conducted by Mott MacDonald to test the sensitivity of wave heights in the VSFB harbor under different wave and water level conditions. The results are consistent with documentation that records 4/7/2020 as a successful offloading operations day, whereas wave conditions on 4/9/2020 precluded offloading operations.

Preferred Scenario. Upgrades to the existing waterfront facility are desired to reduce operational downtime by improving dock access and operability. By improving dock access (e.g., channel dredging, improved aids to navigation, lighting, etc.), ULA can conduct more reliable and efficient unloading operations at VSFB.

FLIGHT RECOVERY AND POTENTIAL FUTURE USERS

Current Operations. Space hardware recovered by Space X's recovery vessel (an autonomous droneship) is transported to and unloaded at the Port of Los Angeles (LA), as shown in Figure 58, since the recovery vessel cannot safely maneuver and dock at VSFB — the navigation channel is too narrow, and there is no broadside moorage available. Hardware is transferred from the recovery vessel to a smaller barge at LA for transport to the VSFB boat dock, adding an additional 3-4 days to operations.

Figure 58. SpaceX operations at Port of LA. Plate A shows space hardware being unloaded off of the recovery vessel via crane. Plate B shows a plan view of the recovery vessel moored adjacent to a smaller barge. Hardware is unloaded off of the recovery vessel at LA and transported to the smaller barge for marine transport to VSFB.

Current Design Vessel. SpaceX presently uses a barge for transport and unloading at VSFB. The assumed barge parameters are 210ft (64m) LOA; 72ft (22m) beam; 10ft (3m) max. draft. The barge is supported by tugs with a limiting draft of 10-12ft (3.0-3.7m).

Operational Metocean Criteria. SpaceX's harbor approach and offloading operations are subject to the following criteria:

- Water Level Elevation: Assumed similar to ULA (≥4ft {1.2m} MLLW; ~80% downtime).
- Waves: Hs≤ 4ft (1.2m) from a southerly direction; Hs≤6ft (1.8m) from a westerly direction.

Downtime. Flight recovery operations at VSFB boat dock are also subject to significant metocean downtime. Despite monitoring offshore buoys and forecasting models, there have been cases where hardware is transported north from LA/LB, but the vessel must turn around upon arriving at Vandenberg due to unsafe metocean conditions.

Preferred Scenario. The goal is to have the ability to unload hardware directly from recovery vessels at Vandenberg, which would save time, fuel, and money. This would require broadside moorage, a quayside crane, and a wharf with enough bearing capacity to support the offload of recovered flight hardware. It would be preferred that the VSFB facility could accommodate long-term moorage of the potential future design vessels listed below, which would obviate the need for vessels to leave the harbor at lower water levels. A larger upland storage area to facilitate storage and staging of equipment is also preferred to support future operations.

Potential Future Design Vessels. The assumed upgrade scenario to meet the preferred needs of current flight recovery efforts and potential future users includes moorage for three vessels at VSFB: a recovery vessel and two support vessels. The assumed vessel parameters are below:

- Recovery vessel: 300ft (91m) LOA; 180ft (55m) beam; 12-16ft (3.7-4.9m) draft
- Support vessels (x2): 165ft (50m) LOA, 36ft (11m) beam, 10ft (3.3m) draft

VANDENBERG SPACE FORCE BASE PERSONNEL

Current Operations. The VSFB boat dock is utilized year-round by VSFB personnel and retirees for recreational activities, including fishing, boating, surfing, diving, walking, and camping. The Vandenberg Boat House (see Table 25F) is used occasionally to host meetings and social events. There is no boat ramp at the current facility, which means that smaller support vessels need to either travel to Santa Barbara or Avila Harbors or be lifted in and out of the water at Vandenberg using cranes on the dock.

Preferred Scenario. It is desired to provide a boat launch for use of trailerable vessels (26ft {7.9m} or less) and jet skis. This would provide more convenient options for smaller vessels to enter/exit the water and would also support the VSFB Fire Department’s search and rescue activities. Jet-ski launching may be via hoist or boat ramp, such as the examples in Figure 59.

Figure 59. Vessel and jet-ski launching options: boat ramp (left) or hoist (right).

13.7.2 POTENTIAL FUTURE OPERATIONS AND CHALLENGES

Part of VSFB’s Commercial Space Master Plan is to construct a new commercial park to accommodate more frequent launches (likely increasing to 35-50 launches per year) and the overall growth of the space industry. Potential future changes to the use of the VSFB boat dock facility may include:

- New users: some space entities have expressed interest in utilizing Vandenberg facilities but have not yet committed to VSFB.
- New vessels: different vessels may have a need to use the site to accommodate delivery of larger components and/or rockets.
- Use conflicts: managing user conflicts at the dock may become necessary with an increasing number of users and increasing frequency of use.

13.8 SPACE STUDY ASSUMPTIONS AND EXCLUSIONS

The space waterfront infrastructure assessment was based on the following study assumptions:

- This study focused on the existing VSFB boat dock area;
- Potential infrastructure upgrades and developments were generated at a pre-feasibility assessment level;
- The study was based on prior project experience, public information, and input from relevant stakeholders. Our database of existing site conditions is limited to relevant characteristics based on readily available public information and is not intended to be comprehensive;
- Developments in the emerging space industry may allow for differences in envisioned dock use, vessel dimensions, and component geometries beyond those considered in this study;
- Navigation assessments were conducted at a conceptual level only; vessel-specific maneuverability and operational details were not included and will need to be investigated at a later project phase;
- Preliminary environmental and regulatory considerations were developed to inform site screening and outline potential regulatory constraints for development in various locations. This study did not include a comprehensive environmental impact assessment;
- Waterfront infrastructure concept schematic development did not include detailed engineering calculations; concepts were developed at planning-level based on review of site conditions and likely loading criteria; and
- Limited 2D numerical metocean modeling was conducted to simulate nearshore wave conditions and inform potential harbor upgrades.
- Study exclusions:
    - Vessel simulations were not completed as part of this study.
    - Navigation channel sedimentation rates were not analyzed as part of this study.
    - Detailed condition assessments, inspections, surveys, and new data collection were not performed.
    - Detailed geotechnical or structural analysis was not conducted.
    - Disposal options for dredged material were not assessed; open-water disposal was assumed for cost estimating purposes.
    - Detailed construction schedules were not developed.
    - Phased construction options and considerations were not included at this stage.

SPACE WATERFRONT INFRASTRUCTURE ASSESSMENT

14 SPACE WATERFRONT INFRASTRUCTURE ASSESSMENT

The waterfront infrastructure assessment contains further investigation of the preferred development scenarios by site users. This chapter contains a gap assessment to outline qualitatively the upgrades required for the existing site (Figure 60), and then provides a more detailed look at the potential upgrades for two different development scenarios. These include: Scenario 1, intended to improve operability of the existing harbor; and Scenario 2, intended to expand facility capabilities by reconfiguring the harbor. This section presents the basis for concept upgrades developed for each scenario as well as associated 3D-site layout renderings and conceptual construction cost estimates.

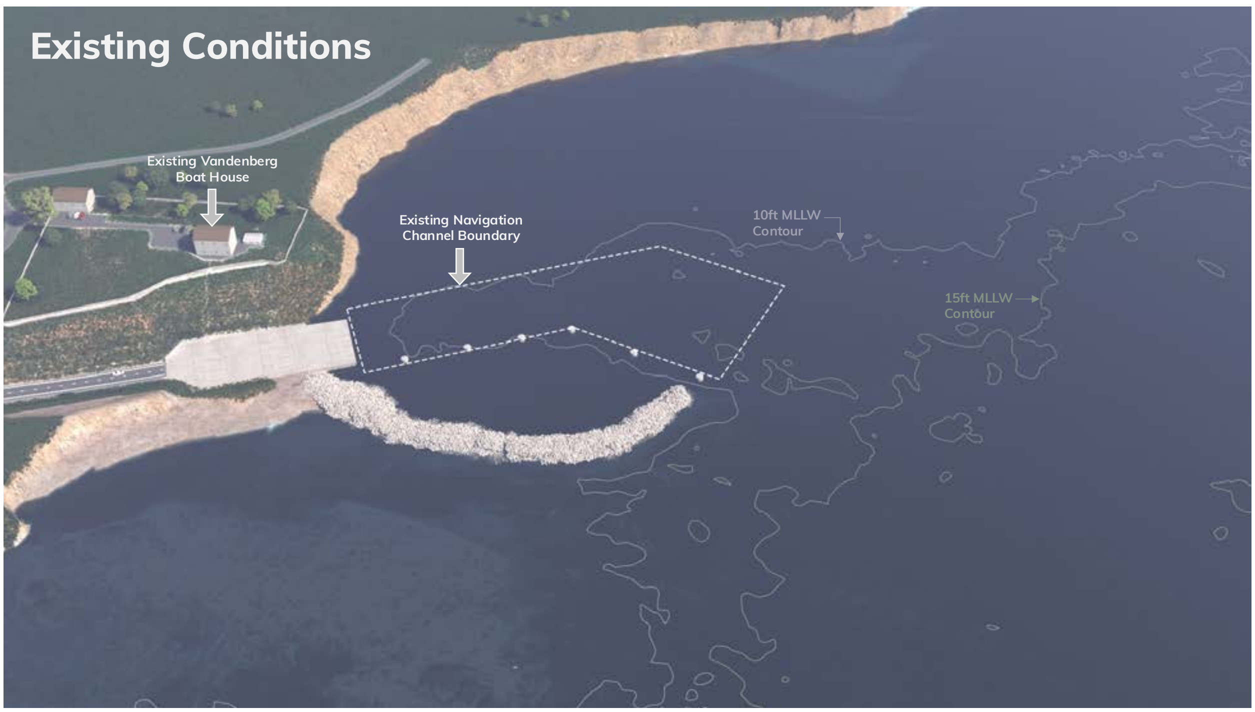


Figure 60. Existing conditions, oblique view.

14.1 GAP ANALYSIS

Section 13.7 Operations and Challenges outlined current operations and challenges for current users of the VSFB boat dock facility. A gap analysis was conducted to compare existing facility conditions to preferred capabilities for various users. This gap analysis forms the basis for development of facility upgrade scenarios later as part of the waterfront infrastructure assessment.

Table 27. Gap assessment summary for current operations and potential future use of the VSFB boat dock facility.

User	Gaps/Potential Upgrades Needed
Existing Hardware Delivery Operations	**Navigation Channel Geometry.** Dredging of a deeper harbor and entrance channel is needed to allow for use of the dock at high tide. Widening of the existing navigation channel would also likely reduce downtime and allow for operations in a wider range of sea states. **Wave Protection.** The existing rubblemound structure provides protection at the berth during *R/S Rocketship* offloading and limited protection at the entrance to the harbor. A short extension of the breakwater (in alignment with channel orientation) may provide value. **Mooring Dolphins and Fenders.** The condition of several assets is deteriorating, and upgrades are likely required. Detailed inspection and monitoring of condition should be conducted. **Navigation Aids.** Limited at present. Navigation aids are recommended. Present lighting does not allow for night operations. **Onshore Staging Area.** Limited size at present but sufficient for current operations. There is limited space to expand staging area on the waterfront between the beach and the historic boat house and slope. Expanded staging area would likely need to occur up the hill at the existing storage area approximately 1,000ft (330m) to the west. **Lighting.** Improved shore lighting is needed; existing lights are not sufficient for conducting nighttime operations.
Flight Recovery and Potential Future Operations	**Moorage.** A new berth is needed to accommodate broadside moorage of a recovery vessel. It would be preferred to have long-term moorage for several vessels, as depth restrictions at the current facility enable access only at higher water levels. **Wharf.** A new wharf with a bearing capacity of 1,200psf (5.9T/m^2) is needed to support quayside offloading and staging activities. To support moorage of the recovery vessel and two support vessels, a wharf length of ~ 1,000ft (330m) is assumed to be preferred. **Navigation Channel Geometry.** Dredging of a significantly expanded, deeper harbor will be required to accommodate larger vessels and provide more reliable operational windows. **Wave Protection.** A new breakwater (length TBD) is needed to protect the reconfigured harbor. Improved wave protection would also allow long-term (all-weather) moorage at the reconfigured facility. **Upland Storage Area.** A larger storage area is needed to facilitate quayside storage and staging activities. A storage yard of 1.5 acres (0.6 hectare) is assumed to be preferred. **Navigation Aids.** New aids to navigation and lighting will be needed to provide safe navigation at the reconfigured facility.

14.2 FACILITY UPGRADE SCENARIOS

Based on the results of the gap analysis, the potential gaps/upgrades were organized into two potential upgrade scenarios. The two upgrade scenarios considered in this study include:

Scenario 1: ***Improve Existing Harbor to Support Current Operations***. Smaller-scale upgrades to existing infrastructure; upgrade or replace elements in place; intended to reduce downtime and improve current operations for current users; not intended to support significant change in facility use.

Scenario 1 Objectives:

- VSFB: Small craft launching.
- ULA Hardware Delivery: Similar operations to those conducted at present, with reduced downtime due to waves/water levels and ability to operate at night.
- Current Flight Recovery and Potential Future Users: Similar operations to those conducted at present, with reduced downtime due to waves/water levels and ability to operate at night.

Scenario 2: ***Reconfigure Harbor to Support Direct Flight Recovery and Potential Future Users.*** Larger-scale site upgrades; may include reconfiguration of the harbor and/or changes in site layout; intended to support larger variety of vessels; intended to support improved and more efficient flight recovery operations and increased use of the waterfront facility by existing and potential future users.

Scenario 2 Objectives:

- VSFB: Small craft launching.
- ULA Hardware Delivery: Similar operations to those conducted at present, with reduced downtime due to waves/water levels and ability to operate at night.
- Current Flight Recovery and Potential Future Users: Long-term moorage; additional flexibility for future vessels/barges that may utilize/berth within harbor.

14.3 FACILITY UPGRADES DEVELOPMENT

This section outlines the assumptions and conceptual engineering considerations that formed the basis of the concept site layouts and construction cost estimates for each upgrade scenario. This section is organized by waterfront facility element. For each element, the basis of the concept design and conceptual engineering design considerations for each scenario are provided.

14.3.1 NAVIGATION

BASIS OF CONCEPT DESIGN

Conceptual dredging upgrades were developed with consideration for the following:

- The present harbor is too small for the SpaceX autonomous vessel to enter the harbor (vessel is wider than existing Inner Channel).
- A turning basin is not required for the *R/S Rocketship* or SpaceX autonomous vessel.
- Design Vessels
    - Scenario 1: existing vessel fleet
        - Design Draft: 12ft (3.7m)
        - Design Width: 82ft (25m)
    - Scenario 2: existing vessel fleet plus recovery vessel plus support vessels
        - Design Draft: 12ft-16ft (3.7-4.9m); note that the draft of the recovery vessel needs to be confirmed. The final draft will impact dredging volumes and construction costs for Scenario 2.
        - Design Width: 180ft (55m)

Mott MacDonald conducted a conceptual analysis of navigation channel geometry (width/depth) using several guidelines for sizing of navigation approach channels for both Inner and Outer Channels.

SCENARIO 1

Channel Depths

A range of estimated water depths for the design draft of 12ft (3.7m) was assessed for a selection of design water levels. At present the "design" water level is 4ft (1.2m) MLLW, which is not met 80% of the time.

Inner Channel Depth. The most conservative water depth to design for, which is unusual for a navigation channel but not for a berth where vessels are permanently moored, is lowest astronomical tide (LAT). At the design water level, there must be enough water depth to accommodate the draft of the vessel and the under keel clearance (UKC) to account for vessel motion, seabed variability, and other factors. A summary of conceptual required channel depths for operations at various water levels is shown in Table 28. An inner channel depth of between 13ft and 16ft (4.0 to 4.9m) is likely required (not including overdredge) to significantly reduce water level downtime for a 12ft (3.7m) vessel, which is the design draft for Scenario 1. These depths align with anecdotal estimates by users than an additional 3ft (0.9m) in the harbor would provide a significant increase in operability.

Outer Channel Depth. The water depth needed in outer channels is typically greater than that of inner channels to accommodate larger motions due to environmental conditions, such as swell. The estimated range of water depths required for safe navigation in the outer channel is summarized in the table below. An outer channel depth of between 15-18ft (4.6–5.5m) is likely required (not including overdredge) to significantly reduce water level downtime for a 12ft (3.7m) design draft.

Table 28. Conceptual inner channel depths to facilitate navigation for 12ft (3.7m) vessel draft at various water levels and associated likelihood of water level downtime.

Desired Minimum Water Level	WSEL (MLLW)	Downtime Due to Tides	Inner Channel Depth Lower Range	Inner Channel Depth Upper Range
LAT	-2.0ft (0.6m)	0	16ft (4.9m) MLLW	17.5ft (5.3m) MLLW
MLLW	0.0ft (0.0m)	~5%	14ft (4.3m) MLLW	15.5ft (4.7m) MLLW
MLW	1.0ft (0.3m)	~15%	13ft (4.0m) MLLW	14.5ft (4.4m) MLLW
MSL	2.7ft (0.8m)	~45%	11.3ft (3.4m) MLLW	12.8ft (3.9m) MLLW
Present Limit	4.0ft (1.2m)	~80%	10ft (3.0m) MLLW	11.5ft (3.5m) MLLW

Table 29. Conceptual outer channel depths to facilitate navigation for 12ft (3.7m) vessel draft at various water levels and associated likelihood of water level downtime.

Desired Minimum Water Level	WSEL (MLLW)	Downtime Due to Tides	Outer Channel Depth Lower Range	Outer Channel Depth Upper Range
LAT	-2.0ft (0.6m)	0	18ft (5.5m) MLLW	19.5ft (5.9m) MLLW
MLLW	0.0ft (0.0m)	~5%	16 ft (4.9m) MLLW	17.5ft (5.3m) MLLW
MLW	1.0ft (0.3m)	~15%	15ft (4.6m) MLLW	16.5ft (5.0m) MLLW
MSL	2.7ft (0.8m)	~45%	13.3ft (4.1m) MLLW	14.8ft (4.5m) MLLW
Present Limit	4.0ft (1.2m)	~80%	12ft (3.7m) MLLW	13.5ft (4.1m) MLLW

Application to Site: The desired range of water depths at site appears to be between 13-16ft (4-4.9m) in the inner channel and 15-18ft (4.6-5.5m) in the outer channel. Because the channel is being deepened, it needs to “daylight” or meet the natural depth contour, which requires lengthening of the channel.[25]

On the low end of the recommended design depth range for the outer channel, -15ft (-4.6m) MLLW, the natural depth contour is approximately 230ft (70m) seaward of the existing channel, as shown in Figure 61. A channel depth of 15ft (4.6m) MLLW would likely provide adequate water depths for the presently active vessel fleet in the outer channel between 15-45% of the time, depending on the preferred UKC. The -18ft (-5.5m) MLLW contour is a significant distance from the outer edge of the existing outer channel (~400ft {122m}), as shown in Figure 62.

For the inner channel, it may be desired for vessels to stay within the harbor during low tide. A 15ft (4.6m) MLLW water depth within the harbor would provide adequate water depths in the inner channel approximately 90-95% of the time.

Takeaways: 15ft (4.6m) MLLW channel depth (5ft {1.5m} deeper than present) appears to provide significant improvement to operations for the existing fleet, both for inner and outer channels.[26] This would significantly reduce downtime and the need to exit the harbor at low tide. The effect of channel dredging on the breakwater must be assessed. Because the channel would require elongation, a wider

[25] The present channel daylights at approximately the natural 12ft (3.7m) contour.
[26] A tradeoff analysis should be conducted to select a preferred depth. Assessment conducted only to the level needed to provide a basis for a Class V cost estimate.

channel is likely preferred as there is a higher exposure level to environmental forces outside the existing breakwater.

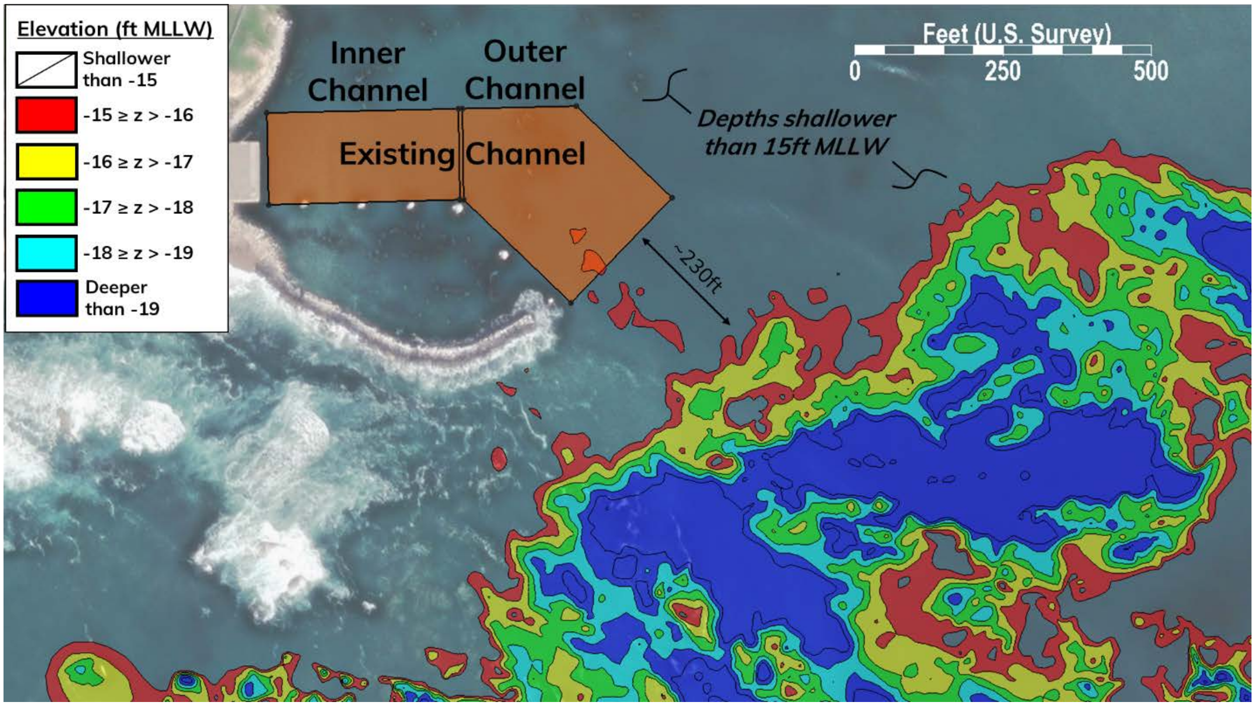


Figure 61. Elevation colormap at VSFB boat dock. Areas with no color represent depths shallower than 15ft (4.6m) MLLW.

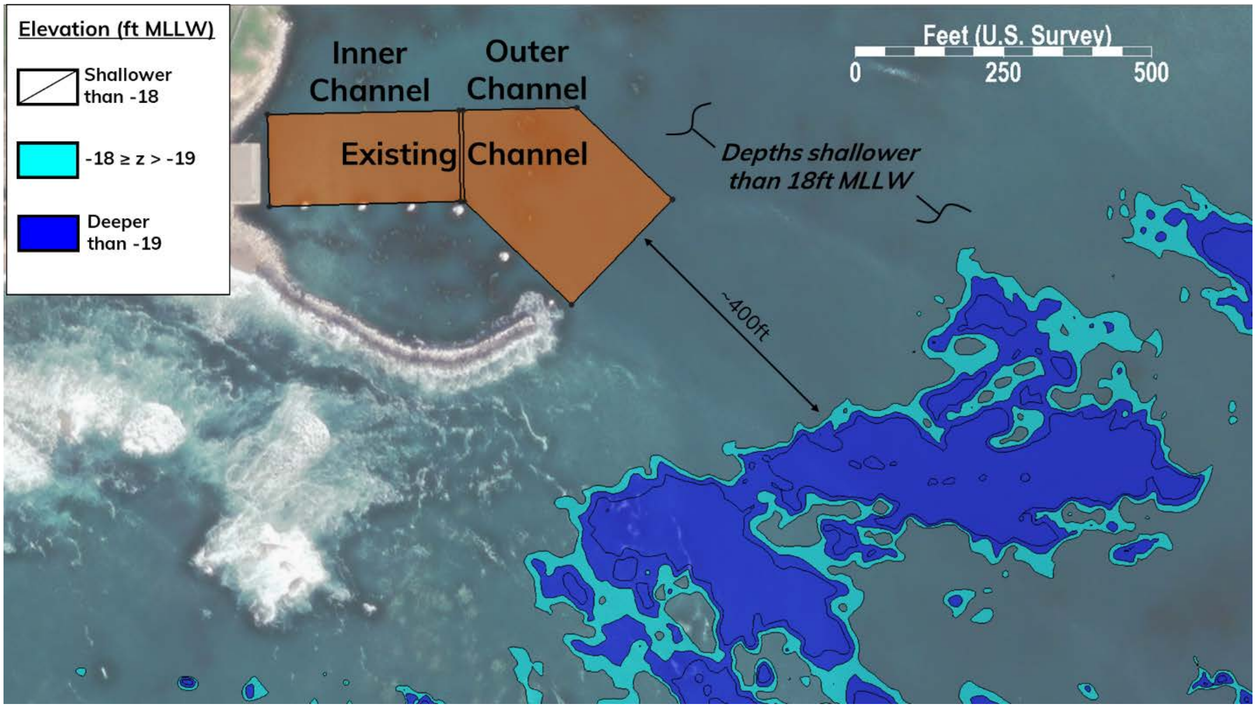


Figure 62. Elevation colormap at VSFB boat dock. Areas with no color represent depths shallower than 18ft (5.5m) MLLW.

Channel Widths

Inner Channel Width. The existing inner channel width is narrower than conceptually recommended widths for consistent use of the waterway under conditions other than "ideal." This assessment aligns with input and feedback from users. If designed considering the geometry of the vessels and barges using the channel, current water depths, and the lack of navigation aids, the inner channel width would likely be on the order of ~100ft (30m) wider than existing. Additional width can be needed at low UKC due to "sluggish" response of the vessel, should it veer off course.

Outer Channel Width. Outer channels are typically wider than inner channels to accommodate a greater range of environmental conditions. Similar to the inner channel, the conceptually recommended width for the outer channel is wider than the existing channel. If designed now for its present depth and lack of navigation aids, the channel would likely be on the order of 50-100ft (15-30m) wider than existing.

Application to Site: Given existing site elevations, deepening the navigation channel will also require a longer channel (as noted in the previous section) and may also require a wider channel footprint. An assessment was conducted to evaluate the preferred channel dimensions, give the design vessels for each scenario, based on several conceptual methods (USACE 2006, PIANC 2014, DNV-GL 2015). The methods were applied assuming improved navigation aids and increased water depths within the harbor. Note that unlike water depths, the effect of a wider channel on operability cannot be directly computed without a more robust probabilistic analysis and engagement with users.

Table 30. Ranges of conceptual channel width upgrades for the inner and outer channel for Scenario 1.

Channel Area	Existing Width	Concept Width [Low Range]	Concept Width [High Range]
Inner Channel	150ft (46m)	164ft (50m)	216ft (66m)
Outer Channel	240ft (73m)	270ft (82m)	311ft (95m)

Scenario 1 Conceptual Navigation Channel Geometry

An example refined dredge prism for Scenario 1 was developed based on the takeaways in the prior sections. This concept includes a widened channel in the area of the turn[27] and slight adjustments to the inner and outer channel widths. The associated volume of dredged material, not including side slopes, is approximately 45,000CY, assuming a new harbor depth of 15ft (4.6m) MLLW. If deepened further to 18ft (5.5m) MLLW, an additional 30,000CY would likely be required to be dredged. Without geotechnical boring or sufficient geophysical information, the volume of material that is bedrock versus other substrate such as sand or clay cannot be estimated.

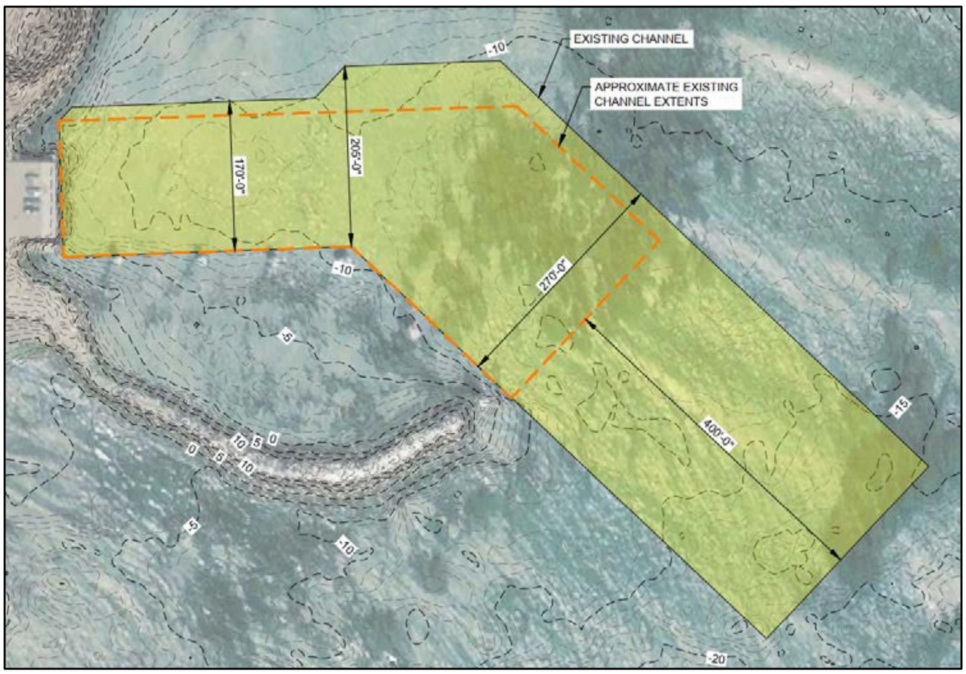


Figure 63. Example refined dredge prism for Scenario 1 overlaid on existing depths. Contours represent elevations in feet relative to MLLW.

[27] Assumed to be channel width +0.5 x Beam of Design Vessel = 205ft (62.5m).

SCENARIO 2

Channel Depths

A range of estimated water depths for a design draft range of 12-16ft (3.7m-4.9m) was assessed for a selection of design water levels. A range was provided considering potential different vessels/users that may access the harbor.[28] This assessment builds off the analysis conducted for Scenario 1.

Inner Channel Depth. Table 31 outlines the potential inner channel depth required for a 16ft (4.9m) draft vessel. Considering a range of vessel draft between 12 and 16ft (3.7-4.9m), an inner channel depth between 13ft-20ft (4.0-6.1m) is likely required.

Outer Channel Depth. Table 32 outlines the potential outer channel depths required for a 16ft (4.9m) draft vessel. To enable new operations (e.g., direct offloading from a recovery vessel), outer channel depths of around 15-22ft (4.6-6.7m) may be needed.

Application to Site: The desired range of water depths at site appears to be between 13-20ft (4.0-6.1m) MLLW in the inner channel and 15-22ft (4.6-6.7m) MLLW in the outer channel. The channel requires shifting to the east to accommodate the new breakwater and reconfigured harbor. In this area, there is a natural shoal that would either require avoidance or dredging.

Takeaways: A 20ft (6.1m) MLLW channel depth (10ft {3m} deeper than present) both for the outer channel and inner channel may be required to facilitate harbor reconfiguration, but these depths are highly dependent on vessel details. only [29]

Table 31. Conceptual inner channel depths to facilitate navigation for 16ft (4.9m) vessel draft at various water levels and associated likelihood of water level downtime.

Desired Minimum Water Level	WSEL (MLLW)	Downtime Due to Tides	Inner Channel Depth Lower Range	Inner Channel Depth Upper Range
LAT	-2.0ft (0.6m)	0	20ft (6.1m) MLLW	21.5 (6.6m) MLLW
MLLW	0.0ft (0.0m)	~5%	18 (5.5m) MLLW	19.5 (5.9m) MLLW
MLW	1.0ft (0.3m)	~15%	17 (5.2m) MLLW	18.5 (5.6m) MLLW
MSL	2.7ft (0.8m)	~45%	15.3 (4.7m) MLLW	16.8 (5.1m) MLLW
Present Limit	4.0ft (1.2m)	~80%	14 (4.3m) MLLW	15.5 (4.7m) MLLW

Table 32. Conceptual outer channel depths to facilitate navigation for 16ft (4.9m) vessel draft at various water levels and associated likelihood of water level downtime.

Desired Minimum Water Level	WSEL (MLLW)	Downtime Due to Tides	Outer Channel Depth Lower Range	Outer Channel Depth Upper Range
LAT	-2.0ft (0.6m)	0	22 (6.7m) MLLW	23.5 (7.2m) MLLW
MLLW	0.0ft (0.0m)	~5%	20 (6.1m) MLLW	21.5 (6.6m) MLLW
MLW	1.0ft (0.3m)	~15%	19 (5.8m) MLLW	20.5 (6.3m) MLLW
MSL	2.7ft (0.8m)	~45%	17.3 (5.3m) MLLW	18.8 (5.7m) MLLW
Present Limit	4.0ft (1.2m)	~80%	16 (4.9m) MLLW	17.5 (5.3m) MLLW

Channel Width

The width required for a recovery vessel will be greater than the existing channel due to the width of the vessel (180ft {55m}). The conceptual minimum channel width is between 360-450ft (110-137m),

[28] Conceptual engineering analysis requires revisions if design vessel parameters (such as draft) are revised.
[29] A tradeoff analysis should be conducted to select a preferred depth. Assessment conducted only to the level needed to provide a basis for a Class V cost estimate.

but depending on the wave climate and maneuverability of the vessel, a wider channel may be required. To be conservative, this assessment assumes an outer channel width of 540ft (165m), or 3x the vessel beam, consistent with guidance from DNV-GL (2016). This may vary depending on the final orientation and extent of the breakwater.

The inner channel conceptual geometry is governed by providing maneuvering area for a recovery vessel and preserving access to the RoRo berth (see Figure 64). Determining the specific harbor and channel dimensions warrants additional analysis and maritime transport industry input.

Scenario 2 Conceptual Navigation Channel Geometry

An example dredge prism for Scenario 2 was developed based on the takeaways in the prior sections (see Figure 64). Seaward extent of the channel will depend on the final depth selected. Similarly, dredge volume is highly dependent on dredge depth, as shown in Figure 65. Estimated harbor dredge depths and the associated dredging volumes are listed in the table below.

Table 33. Estimated dredging volumes for various harbor depths.

Imperial Units			Metric Units		
Harbor Dredge Depth	Depth Increase, Relative to Existing	Estimated Dredging Volume	Harbor Dredge Depth	Depth Increase, Relative to Existing	Estimated Dredging Volume
15ft MLLW	5ft	160,000 CY	4.6m	1.5m	122,000 CM
18ft MLLW	8ft	260,000 CY	5.5m	2.4m	199,000 CM
20ft MLLW	10ft	360,000 CY	6.1m	3.0m	275,000 CM
38ft MLLW[30]	28ft	1,200,000 CY	11.6m	8.5m	917,000 CM

Without geotechnical boring or sufficient geophysical information, the volume of material that is bedrock versus other substrate such as sand or clay cannot be estimated.

[30] At the request of stakeholders, a sensitivity assessment was conducted to evaluate the possibility of further deepening the horizontal dredge prism developed for Scenario 2 to -38ft. MLLW. This would allow for a greater number and type of vessels to access the harbor.

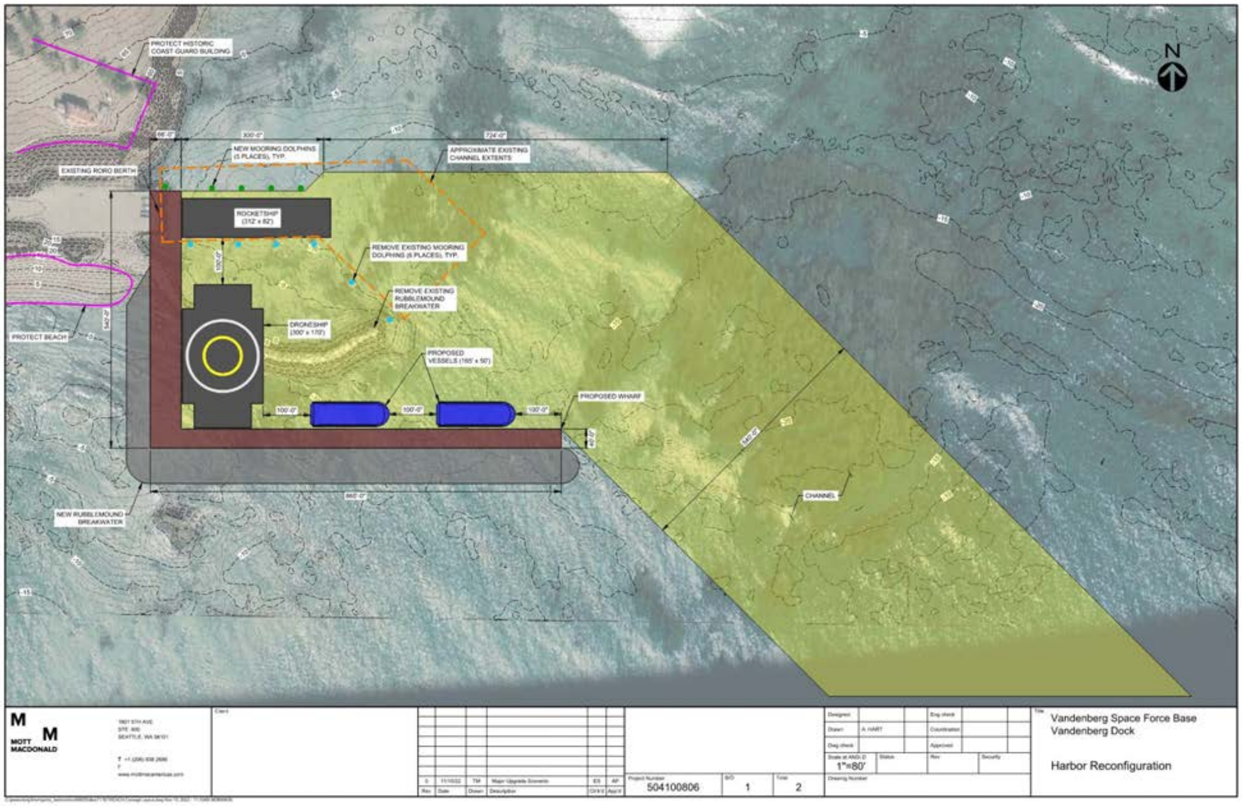


Figure 64. Conceptual site layout of navigation channel and new wharf and breakwater for Scenario 2.

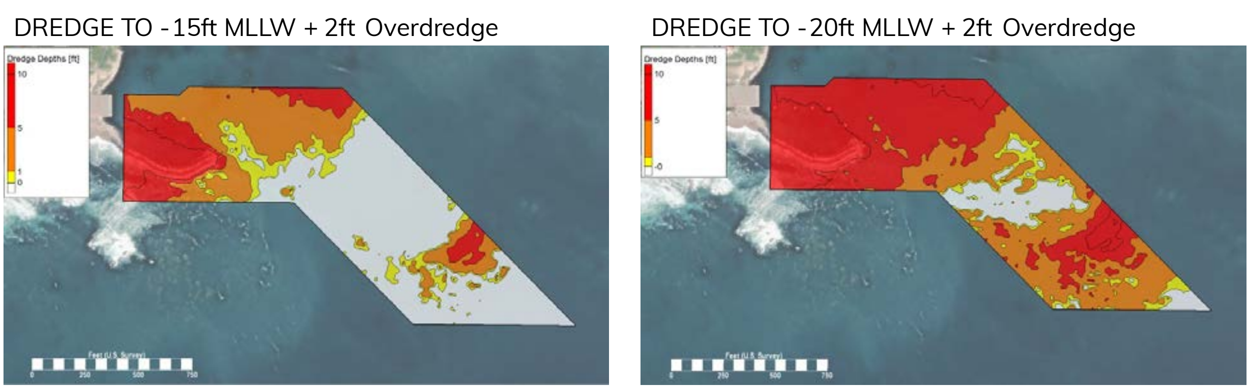


Figure 65. Example dredge depths to achieve 15ft (4.6m) MLLW (left) and 20ft (6.0m) MLLW (right). Estimated dredging volumes are 160,000CY and 400,000CY, respectively.

CONSTRUCTION METHODOLOGY

The method of dredging depends on the type of material being dredged, the volume of the material, the disposal method, environmental considerations, and other site constraints such as equipment access. Historically, dredging at VSFB has consisted of mechanical excavation of primarily sand material and upland disposal, with de-watering occurring at the wharf. The dredging required to deepen the harbor will include a quantity of material that is an order of magnitude more than previous maintenance efforts and may consist of both sandy material and rock. The sand is anticipated to be removed with mechanical means, similar to prior maintenance works (though a suitable disposal site needs to be identified). If encountered, bedrock will likely require confined blasting and mechanical removal. Such removal techniques have been utilized previously by USACE. The Department of Defense (DOD) has specifications on how underwater rock blasting for dredging should be conducted (UFGS, 2021). These specifications include requirements for testing, blasting, material removal, and environmental mitigation measures/best management practices (BMPs). The cost of dredging rock depends on the rock properties, including hardness.

14.3.2 WHARF AND QUAY WALL

BASIS OF CONCEPT DESIGN

The following assumptions provide the basis for the conceptual design of the wharf:

- **Moorage and Offloading Capacity.**
    - **Scenario 1**. No change; maintain existing RoRo berth.
        - **Bearing Capacity.** The existing wharf bearing capacity is sufficient for supporting current operations. Localized repairs may be recommended to extend lifetime of wharf structure, pending results of a detailed site inspection.
        - **Length.** The existing wharf length is sufficient to support existing operations.
    - **Scenario 2.** The wharf should be designed to simultaneously accommodate the following:
        - RoRo berth;
        - Long-term, broadside moorage for recovery vessel;
        - Long-term moorage for two support vessels;
        - A new, longer wharf is needed to accommodate broadside berthing, alternate unloading methods, and long-term moorage for several vessels/users; total berthing length needed for all three vessels (recovery vessel ptwo support vessels) is ~1,000ft (305m), but crane access not required for full length of the wharf;
        - A new wharf with a bearing capacity ≥1,200psf (5.9T/m^2) is required to support crawler crane lifts and other future quayside operations. The wharf structure type recommended for this site will be determined based on geotechnical and structural analysis in a future phase of work;
        - Support vessels do not require high-capacity wharf for berthing and may be berthed at a lighter duty wharf with mooring dolphin; and
        - Offloading hardware from the recovery vessel may be conducted via crane at the RoRo berth or at the recovery vessel berth.
- **Upland Maneuvering.**
    - **Scenario 1.** Maintain existing upland storage yard area.
    - **Scenario 2.** The new wharf must provide space for crane and self-propelled modular transporters (SPMTs) for transport of boosters; assume ~60ft (18m) in width.
- **Berth Depth.** The risks and engineering considerations for dredging in front of the existing RoRo quay wall apply to both **Scenario 1** and **Scenario 2** upgrade scenarios. Some current and potential future users have expressed a preferred berth depth of 38ft (11.6m) MLLW (~26ft {7.9m} deeper

than existing dredge depth). This level of dredging requires extensive geotechnical investigation and assessment to determine feasibility and potential risks to existing infrastructure. The level of dredging required to provide a deep draft berth depth of 38ft (11.6m) is beyond the scope of upgrades considered in this study. The engineering considerations and risks noted below are intended to constrain the dredging extents assumed for the two upgrade scenarios considered in this study.

CONCEPTUAL ENGINEERING DESIGN CONSIDERATIONS

Scenario 1

- No significant changes to the wharf and quay wall are proposed as part of Scenario 1. A comprehensive structural condition assessment should be conducted to confirm the need for maintenance or upgrades to support existing operations.

Scenario 2

- **Structure Type:** Based on preliminary review of available site information, it was assumed that the new wharf would be a pile-supported structure with a concrete deck. For cost estimation purposes, it is assumed that piles will require rock anchors, such as a rock socket. The wharf structure type recommended for this site will need to be confirmed based on site investigations and further analysis in a future phase of work.

The following considerations for berth dredging in front of the existing RoRo quay wall apply to both **Scenario 1 and Scenario 2**:

- Embedment depth and anchorage of the foundation into the substrate are unknown in addition to the type of soil the quay wall is retaining. Based on the limited site visit and limited data provided, the existing structure appears to be a cast-in-place bulkhead either anchored directly to bedrock or encapsulating sheet piles that are embedded in the substrate. Both the as-built structure design details and existing soil in front of and behind the quay wall are needed to assess dredge depth adjacent to the quay wall.
- Absent adequate as-built structure information and depending on the soils in front of the quay wall, we recommend that the increased depth dredge prism be kept a minimum of 4ft (1.2m) from the face of the quay wall and that the slope of the soil be no steeper than a ratio of 2 (horizontal) to 1 (vertical), assuming static, unliquifiable soils.
- Further investigation:
  - Accurate as-built information;
  - Surrounding soil type and properties;
  - Scour analysis; and
  - Soil-structure analysis based on desired dredge depth to determine if/what modifications are required.

14.3.3 BREAKWATER AND OVERTOPPING

BASIS OF CONCEPT DESIGN

- Operations currently limited by wave heights between 4-6ft (1.2-1.8m); see Basis of Assessment.

- Wave-induced downtime impacts harbor approach and maneuvering more so than quayside offloading operations.

CONCEPTUAL ENGINEERING DESIGN CONSIDERATIONS

Wave Protection

Scenario 1. If the channel is lengthened in accordance with the concept Scenario 1 modifications, a short breakwater extension to the southeast may be warranted to enhance wave protection for harbor approach and maneuvering. More detailed wave modeling is needed to confirm the increase in operability, considering an already increased harbor depth.

Scenario 2. The existing breakwater is replaced with a new breakwater located further seawards to protect the larger, reconfigured facility. The length and configuration of the breakwater will be determined in a future design phase but will need to be long enough to provide protection to the new, longer wharf. Enhanced wave protection will also enable long-term (all weather) moorage and safe harbor.

Overtopping

Wave overtopping over the breakwater has been reported by harbor users. The occurrence and volume of wave overtopping is based on the water level, wave climate (height and period), and breakwater structure type and geometry. High volumes of overtopping can result in damage to the structure.

A conceptual engineering assessment was conducted to assess the crest height of the existing breakwater and its potential susceptibility to damage due to overtopping, both at present water levels and with sea level rise (SLR). No extreme wave modeling was conducted. The modeling that was conducted as part of this study includes sensitivity testing only. Calculations are based on USACE guidance for run-up and overtopping of rubblemound structures. The following findings are applicable to the existing structure (**Scenario 1**) and should be considered in design of any new wave protection structure at the facility (**Scenario 2**).

- Overtopping appears to occur at present but based on limited visual inspection does not appear to be significantly damaging the structure. In elevated wave climate events, structural elements directly landward of the crest of the structure may start to see damage, verified by the exposure and wasting of bolts of the existing bollards on the breakwater.
- With SLR, based on review of the crest of the existing breakwater, the rate and volume of overtopping is likely to increase. Depending on the increase in SLR, the amount of overtopping will increase the rate of structural deterioration and start of damage to the structure.
- A more detailed assessment is recommended in a following step to assess the condition of the breakwater relative to the anticipated service life of the structure and vulnerability to SLR.

14.3.4 MOORING HARDWARE AND AIDS TO NAVIGATION

BASIS OF CONCEPT DESIGN

- ULA's *R/S Rocketship* requires use of breasting/mooring dolphins; the breasting/mooring dolphins may be placed on either side of the vessel (e.g., may be move to north side of channel).

- Mooring dolphins have significant rust and corrosion below the waterline (per VSFB staff); the expected lifespan prior to need for renovation and replacement is unknown.
- Feedback from the *R/S Rocketship* operator lists the following as preferred upgrades:
    - Fixed connection points on mooring cells for Yokohama fenders;
    - Repair current fendering on mooring cells (chains supporting current fendering is wasted and fendering is falling and hanging off the cells);
    - Elevated walkway between existing mooring cells (major safety improvement for shore-side personnel working vessel lines); and
    - Inspect and repair bollard foundation bolts; (current bolts wasting).

CONCEPTUAL ENGINEERING DESIGN CONSIDERATIONS

Scenario 1. New aids to navigation (ATONs) and shore lighting are needed to improve navigational safety for harbor approach and to support nighttime operations.

Commentary on potential upgrades is provided below:

Fenders on Mooring Dolphins. Installing Yokohama-type fenders could be an option; however, these fenders are typically installed against a flat surface that can support the fender's compressed footprint. Installing Yokohama-type fenders would require the installation of a steel frame at each of the piles. If Yokohama-type fenders are installed, foam-filled-type fenders such as SeaGuard foam filled, should be evaluated as a potential alternative.

Other fender options that would require fewer modifications to the existing piles include "donut fenders" and laminated pile wrap fenders, such as the pile wrap system Schuyler Model 153. Both systems would rely on the pile's capacity to absorb the berthing energy. Donut fenders (Figure 66) cover the full pile circumference and rise and fall with the water level. The donut fender is also able to rotate about the pile, reducing friction forces on the pile and spreading out the wear. Laminated pile wrap fenders (Figure 67) are a viable alternative to donut fenders for this application. Laminated pile wrap fenders could provide a lower-cost alternative. These fenders can be manufactured to any vertical length, and the extent of the "wrap" around the pile's circumference cab be customized, so that attachments (e.g., ladders and gangways) can be directly installed to the pile.

Figure 66. "Donut fenders" on single pile.

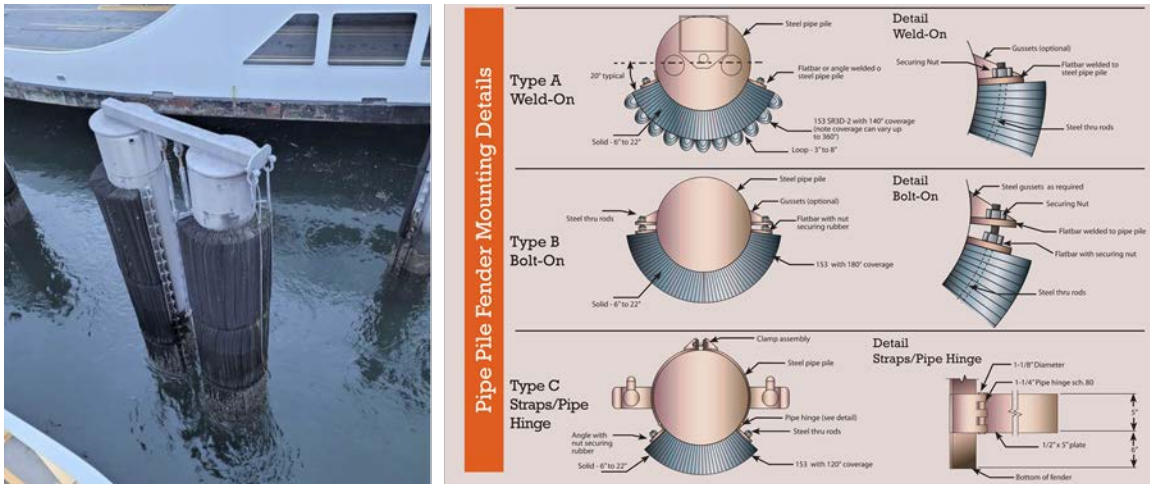


Figure 67. Laminated pile wrap fenders.

Mooring Dolphins Condition. While surface rust is normal, holes on the pile indicate a durability issue. It is recommended that a site assessment be performed, to include thickness measurements and damage identification along and around the pile to understand the level of deterioration.

Elevated Walkway. Elevated walkways from pile to pile are possible, but because the piles deflect at vessel impact, gangways should be designed to support lateral movement of the piles.

Bollards. Bollards are typically installed with "cast-in-place" anchors at the time of concrete installation, or "through" anchors if there's access from below the foundation, such as an elevated deck. Repairing bollard foundation bolts, as it appears, could only be done by replacing the bolt(s) and using epoxy adhesive. Post-installed anchors for mooring bollards are not a typical solution due to the nature of loading and would likely require a structural repair. Performing a structural repair would include demolishing the bollards, removing the existing concrete plug, and repouring a reinforced concrete plug with cast-in-place anchors. Adding a steel plate cap, battered piles, and support frame to the monopiles such that the piles act as a frame could be further investigated to determine whether this should be considered as a viable alternative.

Further Investigation. The following are recommended to better inform upgrades to existing mooring hardware:

- A condition assessment of the piles should also be performed, to include thickness measurements at splash zone and at mudline and to identify any structural damage along the piles. This information is critical to determining the remaining life of the pile;
- Mooring load demand as well as berthing load demand on the piles should be analyzed. Mooring load may control the pile analysis; and
- A vertical geometric evaluation of the vessel should be performed to determine the vertical extents of a new fender system.

Scenario 2. New mooring dolphins and fenders will be needed to accommodate moorage at the reconfigured facility. New ATONs and shore lighting will be needed to provide safe navigational conditions and enable nighttime operations at the reconfigured facility.

14.3.5 BOAT LAUNCH

BASIS OF CONCEPT DESIGN

The basis for boat launch upgrades and costs were based on the following assumptions (based on California Department of Parks and Recreation, 2021) for both scenarios:

- Head of Ramp Elevation: Existing wharf/yard elevation;
- Toe of Ramp Elevation: 3ft (0.9m) below MLLW;
- Ramp slope: 12-15%;
- Single ramp, minimum ramp width: 16ft (4.9m)-20ft (6.1m), depending on length;
- Ramp Material: Cast in place or pre-cast concrete; crushed rock may also be suitable, depending on wave climate;
- Boarding floats: Not required; and
- Design vessels: Jet-skis, zodiacs, rigid hulled inflatable boats (RHIBs).

CONCEPTUAL ENGINEERING DESIGN CONSIDERATIONS

Scenario 1. The apparent preferred location to integrate a new boat ramp would be to construct it just north of the existing berth. To allow for adequate operability of the boat ramp under most expected water levels, the boat ramp will need to be approximately 115ft (35m) long. Considering the boat ramp length, the width may need to be increased to 20ft (6m) based on the California guidelines (California Department of Parks and Recreation, 2021) along with an additional 90ft (27m) for the boat ramp approach (see Figure 68). Based on the lidar ground surface elevations, construction of a new boat ramp would likely require excavation with installation of retention features into the adjacent hill. If excavation is not preferred, a boat or jet-ski hoist on the north side of the wharf with ladder access may be preferred as a lower-cost option.

Scenario 2. For Scenario 2, a boat ramp could potentially be integrated into the existing wharf footprint during harbor reconfiguration so that excavation and retention features would not be needed. However, this may result in the breakwater and dredge prism being shifted seaward.

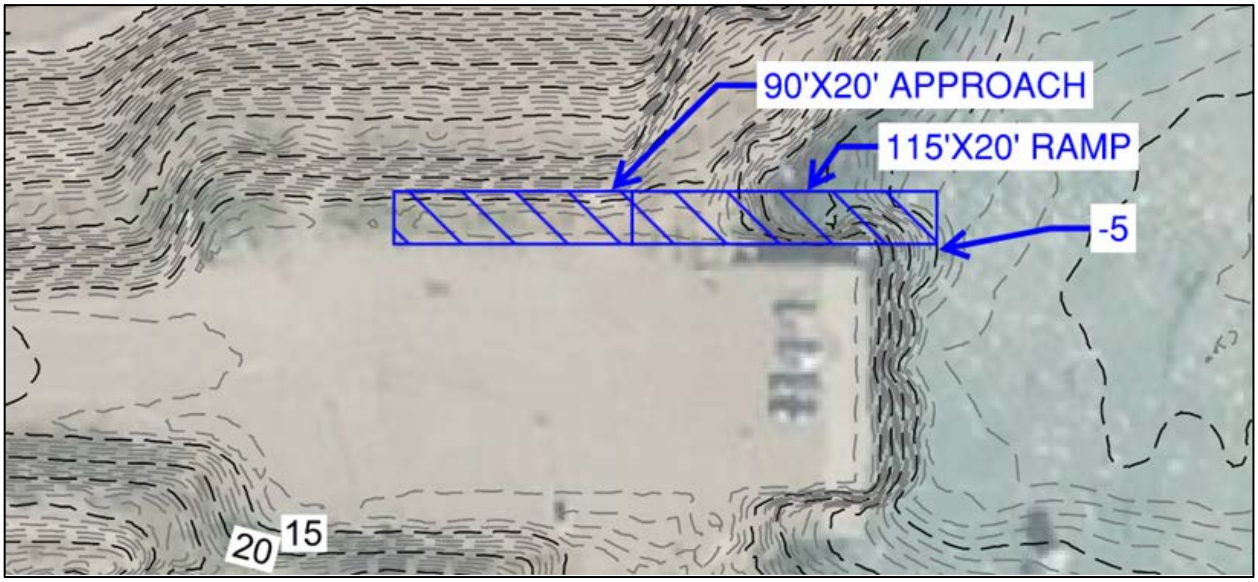


Figure 68. Conceptual new boat ramp alignment at VSFB boat dock.

14.4 EXAMPLE SITE DEVELOPMENT RENDERINGS

The following renderings were developed based on 2D schematics considering user input and conceptual engineering analysis. Notes for each are included below.

Scenario 1

- Includes localized channel widening and deepening to 15ft (4.6m) MLLW (not shown).
- A breakwater extension may be needed, but more detailed analysis will be required. Example potential alignments are shown.
- No structural improvements to the existing wharf or breakwater.

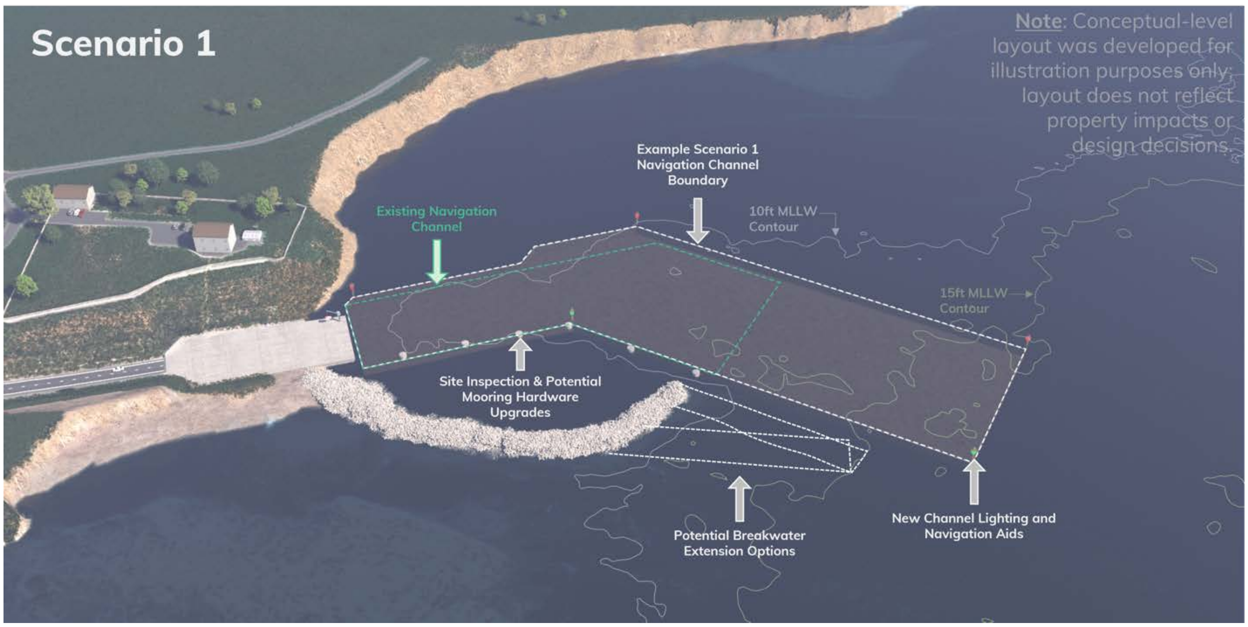


Figure 69. Rendering of VSFB boat dock with Scenario 1 concept upgrades.

Scenario 2

- Includes an expansion of the navigation channel (not shown) and harbor deepening (not shown).
- In this example, the recovery vessel offloads at the RoRo berth when it arrives, but its permanent moorage berth is to the south to allow for the *R/S Rocketship* to offload when not active.
- Final dimensioning will require user input — including the distance required between the docked recovery vessel and the *R/S Rocketship* when offloading.
- A new pile-supported wharf is assumed to be constructed seaward of the existing wharf to minimize footprint on the existing adjacent beach. This wharf is assumed to be ~ 66ft (20m) in width to allow for crane access (also the minimum pier width per UFC (2017).
- The support vessels are moored at a lower-capacity pile supported wharf in the lee of the new breakwater. This wharf is anticipated to be ~40ft (12.2m) in width to accommodate a fire lane, bollards and bullrails, and gangway landing areas.
- Due to the wave climate (swell), it is likely preferred that the new breakwater is installed first to provide a protected harbor for construction.
- A breakwater extension in alignment with the outer navigation channel may be needed, but more detailed analysis will be required. Example potential alignment shown.

Figure 70. Rendering of VSFB boat dock facility with Scenario 2 upgrades.

14.5 CONSTRUCTION COST ESTIMATES

Planning-level concept construction cost estimates have been prepared to estimate the scale of potential construction costs for waterfront infrastructure in the study area to support space. Costs were developed according to a Class V level estimate scheme of the Association for the Advancement of Cost Estimating, typically used for concept screening, which aligns with the level of detail considered in this study (e.g., no site investigations and variability in facility requirements). The Class V estimates have a range of -50% to +100% and include considerations of changes in scope, site conditions, and market conditions. Estimates were developed based on prior project experience, literature review, and conceptual engineering analysis. Actual costs will vary, depending on the industry needs, results of future site investigations, and other project-specific requirements.

Construction cost estimates for the two example development scenarios are provided in the tables below. These are intended to be planning-level costs and should not be used for financial investment purposes. Actual cost will depend heavily on site investigations and data collection, design vessels, and extent of harbor dredging/blasting. The following are not included:

- Engineering and permitting costs;
- Roadway upgrades or onshore storage area expansions (if needed); and
- Utility upgrades outside the wharf area.

14.5.1 SCENARIO 1

The assumptions that provided the basis for the construction cost estimate for Scenario 1 are provided in Table 34. Table 35 contains the estimated conceptual construction cost estimate.

Table 34. Conceptual construction cost estimate assumptions for Scenario 1 upgrades.

Element	Assumed Parameters
Mobilization and Demobilization	Assume 6% of subtotal.
Channel Dredging	Assumes deepening to 15ft (4.6m) plus a 2ft (0.6m) pay volume of overdredge. Includes localized widening of the channel and extension to the -15ft (4.6m) depth contour. Assumes primarily rock dredging (confined blasting and excavation).
Aids to Navigation	Includes supply and install cost of the pile, dayboards, and lighting.
Wharf and Dolphin Hardware Upgrades	Includes new fenders on each of the five dolphins. No structural improvements estimated at this time. Includes 100 linear feet of fender replacement on the wharf. Includes supply and install cost of small hoist intended for jet-skis or inflatable boats such as zodiacs. Includes onshore lighting improvements.
Breakwater Extension	Not included at this time, pending wave modeling and coordination with users.

Table 35. Scenario 1 conceptual construction cost estimate.

Element	Cost Estimate
Mobilization and Demobilization	$500,000
Channel Dredging	$9,000,000
Aids to Navigation	$250,000
Wharf and Dolphin Hardware Upgrades	$1,000,000
Conceptual Cost Estimate (Limited Contingency Included)	*$11,000,000*
Range (-50% to +100%)	$5.5m to $22m

14.5.2 SCENARIO 2

The construction cost estimate for Scenario 2 upgrades is presented in Table 37, below. The assumptions for each cost element are provided in Table 36.

Table 36. Conceptual construction cost estimate assumptions for Scenario 2 upgrades.

Element	Assumed Parameters
Mobilization and Demobilization	Assume 6% of subtotal.
Channel Dredging	Assumes deepening to 15ft (5.5m) plus a 2f (0.6m) pay volume of overdredge. Includes localized widening of the channel and extension to the natural -15ft (6.1m) depth contour. Assumes primarily rock dredging (confined blasting and excavation). Assumes a channel width of 540ft (165m). Total volume ~160,000CY.
Wharf Construction	Includes supply and installation of a new pile supported wharf — total length ~1,400ft (427m) and approximately 70,000sf. Includes cost of rock sockets, 2ft. thick reinforced concrete deck, and approximately 150 new piles.
On-site Utilities and Civils	Includes curbs, signage, and on-site utilities such as new electrical lines and lighting.
Breakwater Demolition and Construction	Demolition and disposal of the existing breakwater and installation of new breakwater. Re-use of rock not assumed but may be feasible.
Aids to Navigation	Private aids to navigation. Includes supply and install cost of the pile, dayboards, and lighting.
Wharf and Dolphin Hardware Upgrades	Includes new dolphins. Assumes new donut fenders on each of the dolphins. Assumes new fenders for the wharf. Includes supply and install cost of small hoist intended for jet-skis or inflatable boats such as zodiacs. Cost for a boat launch not included.

Table 37. Scenario 2 conceptual construction cost estimate.

Element	Cost Estimate
Mobilization and Demobilization	$7,000,000
Channel Dredging	$40,000,000
Wharf Construction	$24,000,000
On-site Utilities and Civils	$2,000,000
Breakwater Demolition and Construction	$40,000,000
Aids to Navigation	$300,000
Wharf and Dolphin Hardware Upgrades	$6,000,000
Conceptual Cost Estimate (Limited Contingency Included)	*$120,000,000*
Range (-50% to +100%)	$60m to $240m

CONCLUSIONS AND NEXT STEPS

15 CONCLUSIONS AND NEXT STEPS

A conceptual technical study was conducted by Mott MacDonald to evaluate the opportunities and technical limitations for waterfront infrastructure to support present operations and future increased launch operations at VSFB. The VSFB boat dock is the only facility on the base that supports sealift operations to transfer heavy components from vessel or barge to landside transport vehicles. At present, there are technical limitations on how and when the VSFB boat dock can support both present and anticipated future needs. These limitations include:

- **Insufficient water depth in the harbor limits operations to high tide only.** A 3-day offload operation under ideal conditions can take more than 30 days to complete due to limited harbor depth and exposure to Pacific Ocean swell. The harbor is presently dredged on an as-needed basis, but even when dredged, sealift operations can be conducted only at high tide and when wave conditions allow.
- **Operations can be conducted only in daylight hours.** Daytime operations further limit the operational windows available.
- **Condition of mooring and berthing hardware in the harbor is deteriorating.** Components may be reaching the end of their useful life. Component conditions further limit the sea-state during which operations can be conducted.
- **The harbor is undersized relative to potential future vessel needs.** The harbor is too small to allow permanent moorage of vessels or of autonomous rocket booster vessels.

To address these limitations, work conducted as part of this study included compilation of available site information, a site visit, interviews with VSFB staff, coordination with marine transport contractors, and conceptual engineering analysis. There are multiple data and information gaps that need to be addressed as a future phase prior to selection of a development concept. Development and execution of a site investigation program is recommended as part of a next step. These gaps are:

- **Existing Structures**: The structures were originally constructed to support the Space Shuttle program, and original as-built drawings are not available. Prior to design of any improvements or repairs, site investigation and development of as-built drawings will be required.
- **Condition Assessment**: A detailed condition assessment, above and below water, needs to be conducted to estimate the current structural capacity and life of existing structures. Results of the condition assessment may significantly affect construction cost estimates.
- **Geotechnical Conditions:** It is generally understood that veneer of sand overlays bedrock in this area; however, no subsurface borings are available. Therefore, depth to bedrock is not known, nor are the rock parameters such as unconfined compressive strength and rock quality designation. A subsurface investigation program and subsequent analysis is needed to refine cost estimates and confirm feasibility.
- **Wave Conditions**: A detailed wave modeling assessment is needed to refine the need for extending the existing breakwater and/or refining the breakwater length needed if the harbor is to be expanded.

15.1 SITE UPGRADE SCENARIOS

In coordination with the Technical Steering Committee, two example scenarios were developed to provide improved serviceability for existing operations and to support anticipated increases in launch frequency. These scenarios are summarized below in Table 38. Table 39 shows detailed considerations.

Table 38. Scenario summary.

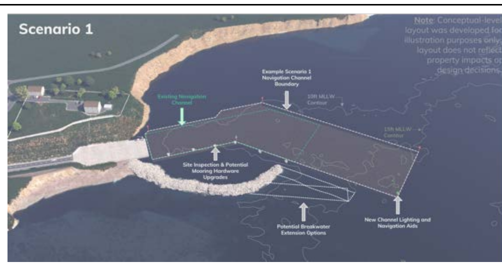
	Scenario 1	Scenario 2
Objectives	Reduce downtime for current users, supporting increased launch frequency; operational windows would likely increase by a factor of 3-4x. Obviate the need for vessels to leave harbor at low tide. Improve small craft vessel access.	Reduce downtime for current users, supporting increased launch frequency; operational windows would likely increase by a factor of 3-4x or more. More efficient recovery operations, direct offloading from recovery vessel (depending on user). Permanent moorage options. Broadside moorage and lift-off offloading capabilities. Improved small craft vessel access.
Upgrades Needed to Meet Objectives	**Dredging:** Deepening of harbor by approximately 5ft (1.5m), seawards extension of the channel and localized widening of the channel is likely required. **Breakwater:** A short (~200ft {61m}) extension of the existing breakwater may be needed. **Wharf:** A detailed condition assessment should be conducted. **Aids to Navigation:** New pile-supported dayboards with lights. **Berthing Hardware:** Replacement likely needed, pending condition assessment. Mooring dolphin structures may require replacement for long-term use. **Boat Launch:** A small boat hoist could be installed to support VSFB operations. A new boat launch to meet state guidelines likely requires grading of the hillside.	**Dredging:** Deepening of harbor by approximately 5ft, and a significant expansion of the dredged area. **Breakwater:** A new breakwater will need to be installed seaward of its existing location, with the existing breakwater demolished or repurposed. **Wharf:** A new structure is needed to provide permanent moorage for vessels and to allow for larger vessels/barges to dock. **Berthing Hardware:** Relocation and replacement (pending condition assessment) of mooring dolphins will likely be needed to accommodate vessel maneuvering within the harbor. **Boat Launch:** A small boat hoist could be installed to support VSFB operations. A narrow boat ramp could be installed to the north of the new wharf.
Estimated Class V Const. Cost	$5.5-22m	$55-220m
Concept Visualization		

Table 39. Upgrade considerations.

Topic	Considerations
Dredging	• For both scenarios, a combination of mechanical dredging of sand and confined blasting of rock is likely required. The need for confined rock blasting will depend on the characteristics of the rock on site. • Present maintenance dredging is of primarily sand. It is understood that bedrock is just below the present dredge prism. • Dredging of bedrock via confined blasting is more expensive than dredging of sand. Depth of bedrock is not known, which greatly affects cost. • Confined blasting may include mitigation measures such as minimizing the charge requirements, bubble curtains, and acoustic deterrents.[31]
Breakwater	• The breakwater provides wave protection for vessels at berth, as well as for vessels entering the harbor. • The need for extension of the current breakwater and the length/orientation of a new breakwater require more detailed numerical wave modeling coupled with downtime analysis to refine.
Wharf	• The present wharf is a reinforced concrete quay wall structure; however, because full as-builts are not available and no condition assessment was conducted, the capacity of the existing wharf is not known. • New wharf structures are assumed to be pile supported, with a concrete deck designed to seismic engineering standards. • Shallow depth to bedrock will likely necessitate use of rock anchors for the piles, such as rock-sockets or other. • For Scenario 2, the new rock breakwater would likely need to be constructed prior to installation of the new wharf structure to provide a protected harbor for construction. • New structures have been conceptually designed as part of this work to allow for vessel and emergency services access. Refinement of geometry is required upon a refined basis of design in later phases.
Aids to Navigation	• Aids to navigation (ATONs) are structures intended to assist a vessel operator to determine position or safe course, or to warn of dangers or obstructions to navigation. The primary objective is to mark navigable channels and waterways, obstructions adjacent to these waterways, and obstructions in areas of general navigation that may not be anticipated. • Present ATONs are reported to be lacking. • Poor ATONs reduce the conditions in which safe travel through a navigation channel can be conducted. To improve the operability of the harbor, additional ATONs are recommended.
Berthing Hardware	• Existing fenders on the mooring dolphins do not appear to absorb much energy during berthing activities. The fender structures also appear corroded, and replacement may be needed (pending a condition assessment). • Fenders on the existing wharf may need replacement, pending a detailed condition assessment relative to desired asset lifespan.
Small-Craft Vessel Launching	• Launching of small vessels such as zodiacs or jet-skis to support base activities may be conducted with a hoist or a boat ramp. • The present harbor is limited on shoreline space and would likely require grading of the hill to the north in order to fit a new boat launch. • Location of a boat hoist needs to be coordinated with other site users and would also require installation of a ladder for access.

15.2 INDUSTRY SYNERGIES

Due to launch evacuation protocols, the site is unlikely to be used as a permanent FOW facility, either for large operations such as wind turbine integration, or for smaller functions such as supporting wind farm operations and maintenance. The site may be able to support temporary activities, e.g., crew transfer or mooring line or anchor storage/staging.

[31] International Association of Dredging Companies (2016), Facts About Underwater Drilling and Blasting

Current booster recovery operations leverage a small port network (Port of Long Beach together with the VSFB boat dock). If a new large FOW port is constructed in SLO or SB Counties, that facility may be able to be integrated into the network of ports used to support the space industry.

15.3 NEXT STEPS

Recommended next steps for further analysis are provided below.

- General
  - REACH should coordinate results with Vandenberg Memorandum of Understanding (MOU) group and ongoing infrastructure planning workstream to prioritize projects and explore potential federal, state, local and private sector funding opportunities.
  - As launch frequency increases, use plans and conflict assessment planning should be conducted between users.
- Technical
  - Prior to further site concept development, development and execution of a site investigation and condition assessment program above and below water is needed. This may include:
    - Geophysical and geotechnical investigation and report
    - Development of as-built plans
    - Structural condition assessment in accordance with ASCE Manual of Practice 130
    - Land/hydrographic surveying within the project area for planning and engineering design work
  - A detailed coastal engineering assessment and downtime assessment is needed to refine breakwater extents and to refine the dredge prism.
  - Mooring and berthing analysis should be conducted for the existing piles to determine if replacement is needed.
  - Soil-structure analysis should be conducted based on desired dredge depth to determine if/what modifications are required for Scenario 1 or 2.
  - Construction phasing assessment should be conducted to assess impact on throughput during construction.
  - A refined basis of concept design needs to be developed among users, to confirm activities, design vessels, and operations.
  - A comparative alternatives assessment considering additional non-technical parameters should be conducted.
  - Facility site plans need to be refined to refine costs based on results of further investigations.
  - Wharf and berth orientations and locations need to be refined based on a detailed coastal engineering analysis to consider maintenance dredging needs.
- Environmental
  - Initiate informal agency consultation to identify potential environmental constraints and environmental assessments required. Develop permit matrix, including high-level schedule and anticipated lead times. Note that a multi-year permitting process should be expected for either scenario presented.

16 VOLUME II REFERENCES

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