OCS Study
BOEM 2023-038

California Floating Offshore Wind Regional Ports Feasibility Analysis

U.S. Department of the Interior

Bureau of Ocean Energy Management

Pacific OCS Region, Camarillo, CA

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ABOUT THE COVER

Photo Description: Floating offshore wind turbines installed at sea and one turbine being towed out for installation.

Photo Credit: Moffatt & Nichol

ACKNOWLEDGMENTS

We would like to thank the following for their time and participation in completing this effort: Bureau of Ocean Energy Management, California State Lands Commission, California Energy Commission, Aspen Environmental Group, Boudreau Associates, LLC, Ecotech Resources, Inc., Harris Environmental Group, Inc., SeaJay Environmental LLC, City of Morro Bay, City of Pittsburg, Crescent City Harbor District, Diablo Canyon Power Plant, Port of Benicia, Port of Hueneme, Port of Humboldt, Port of Long Beach, Port of Los Angeles, Port of Redwood City, Port of Richmond, Port of San Diego, Port San Luis, Port of San Francisco, Port of Oakland, Port of Stockton, and AMPORTS (Antioch).

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List of Abbreviations and Acronyms

AACE	Association for the Advancement of Cost Estimating
AB	Assembly Bill
BOEM	Bureau of Ocean Energy Management
CARB	California Air Resources Board
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CSLC	California State Lands Commission
CTV	Crew transfer vessel
e.g.	*Exempli gratia* (for example)
etc.	et cetera
ft	feet
GW	Gigawatts
i.e.	*id est* (that is)
IDIQ	Indefinite Delivery Indefinite Quantity
M	million
M&N	Moffatt & Nichol
MF	Manufacturing / Fabrication
MW	Megawatt
N/A	Not applicable
NEPA	National Environmental Policy Act
O&M	Operation and Maintenance
OCS	Outer Continental Shelf
OEM	Original equipment manufacturers
psf	pounds per square foot
S&I	Staging and Integration
SOV	Service operations vessel
U.S.	United States
USACE	United States Army Corps of Engineers
WEA	Wind Energy Area
WTG	Wind turbine generator

Executive Summary

The purpose of this report is to further evaluate the feasibility of improvements for California port sites identified in the previous Bureau of Ocean Energy Management (BOEM) study titled *California Floating Offshore Wind Regional Ports Assessment,* BOEM 2023-010 (Moffatt & Nichol 2023). This further evaluation includes cost estimates and project development timelines for the port infrastructure improvements needed for offshore wind industry use.

As part of the State of California Assembly Bill (AB) 525, which set offshore wind planning goals of 2 to 5 gigawatts (GW) by 2030 and 25 GW by 2045, California is developing a strategic plan for offshore wind development (Flint 2022). This report will provide input for the AB 525 Port Readiness Plan, including cost and schedule of port infrastructure upgrades to support the offshore wind industry.

Below is a summary of the evaluated ports, unit cost estimates, and timelines for these port improvement projects. For additional details on the required improvements and cost, refer to **Table 2** through **Table 4.**

Construction cost estimates were developed to an Association for the Advancement of Cost Engineering (AACE) Class 5 level of accuracy. For this level, the typical cost variation is -20% to -50% on the low range and +30% to +100% on the high range. All costs are in 2023 U.S. Dollars, escalation is not included. Cost estimates include all material, labor, and equipment to complete the work and indirect costs such as contractor supervision (general conditions), corporate overhead and profit, and bonds and insurance costs. A project contingency of 50% is applied to cover undefined items due to the level of engineering carried out at this time. Construction cost estimates exclude any above-grade construction (i.e., warehouses and buildings) to facilitate fair cost comparisons as each developer will determine the necessary above-grade construction for each site. In addition, the cost estimates do not include any costs for navigation channel improvements such as widening and deepening or wet storage.

Staging & Integration (S&I) Sites

- Evaluated S&I Ports:
    - Port of Humboldt
    - Port of Los Angeles
    - Port of Long Beach
- S&I Site Cost Range = $700M to $1,110M per 80-acres
- Timeline from Project Planning to Securing Permits and Environmental Approvals = 4 to 10 years
- Timeline for Construction (starts after all permits are acquired) = 4 to 6 years
- Sites need to be ready to begin operations by late 2020s to early 2030s to meet California offshore wind planning goals.

Manufacturing/Fabrication (MF) Sites

The provided costs and timelines are for manufacturing of large components (i.e., floating foundations, tower sections, blades, and nacelles) as they require significant site improvements.

- Evaluated MF Sites:
    - Port of Humboldt
    - Port of Stockton
    - Port of Benicia
    - Port of Richmond
    - Port of San Francisco
    - Port of Oakland
    - Port of Redwood City

    - Port of Los Angeles
    - Port of Long Beach
    - Port of San Diego
    - Antioch
    - Pittsburg

- MF Site Cost Range = $275M to $375M per 40-acres
- Timeline from Project Planning to Securing Permits and Environmental Approvals = 4 to 8 years
- Timeline for Construction (starts after all permits are acquired) = 4 to 5 years
- Sites need to be ready to begin operations by early to mid-2030s to meet California offshore wind planning goals.

Operations & Maintenance (O&M) Sites

- Evaluated O&M Sites:
    - Crescent City Harbor District
    - Port of Humboldt
    - City of Morro Bay
    - Diablo Canyon Power Plant
    - Port San Luis
    - Port of Hueneme
- O&M Site Cost Range = $0M to $52M per 2 to 10-acres
- Timeline from Project Planning to Securing Permits and Environmental Approvals = 4 to 7 years
- Timeline for Construction (starts after all permits are acquired) = 3 years
- Sites need to be ready to begin operations by late 2020s to early 2030s to meet California offshore wind planning goals.

Project Development Process & Timing

The typical timeline to secure all required permits and approvals for these types of port projects could be considerably longer than the timeline that has been identified to meet California's AB 525 offshore wind planning goals of 2 to 5 GW by 2030 and 25 GW by 2045. Projects developed on the coast of California of similar size and scale to the proposed sites considered in this study have taken from 3 to over 10 years from project planning to securing all permits and environmental approvals for construction. Considering the regulatory environment in California, the window for securing all required approvals could range from **4 to 10 years for S&I sites, 4 to 8 years for MF sites, and 4 to 7 years for O&M sites**. Development of facilities within existing ports and in areas with existing industrial land uses may be permitted more quickly, but controversial projects that result in legal challenges to the agency approvals and the adequacy of the environmental documents relied upon may require longer timeframes.

Strategies for expediting the processes for environmental review and permitting can be developed through legislative action, or through direct agreements with agencies or the applicants. While each strategy would need to be based on site-specific conditions for each project, the following approaches could help streamline the environmental review and permitting process, and may limit the timeframe for legal challenges to projects after approval:

- Early development of mitigation programs and strategies through coordination with resource agencies.
- Early initiation of community engagement and outreach to identify project effects, alternatives, and mitigation and develop community support. An effective outreach and involvement program that considers community concerns may lead to more effective mitigation presented in the environmental documents and may reduce the risk of legal challenges after project approval. This

type of community engagement also provides opportunities to define and address environmental justice issues and leverage investments that could provide local jobs and expand community resources.

- Development of a legislative program similar to that defined in the Judicial Streamlining provisions of California's Environmental Leadership Development Program, as defined in Senate Bill 7 (Atkins, 2021) that would apply to seaport developments supporting offshore wind could reduce the timeframe for legal challenges to agency decisions and environmental documents.

1 Introduction

The purpose of this report is to further evaluate the feasibility of improvements for California port sites identified in the previous Bureau of Ocean Energy Management (BOEM) study titled *California Floating Offshore Wind Regional Ports Assessment,* BOEM 2023-010 (Moffatt & Nichol 2023). This further evaluation includes cost estimates and project development timelines for the port infrastructure improvements needed for offshore wind industry use.

As part of State of California Assembly Bill (AB) 525, which set offshore wind planning goals of 2 to 5 gigawatts (GW) by 2030 and 25 GW by 2045, California is developing a strategic plan for offshore wind development (Flint 2022). This report will provide input for the AB 525 Port Readiness Plan, including cost and schedule of port infrastructure upgrades to support the offshore wind industry.

To date, BOEM has identified two offshore wind energy areas (WEA) off the state of California, the Humboldt WEA and Morro Bay WEA. On December 6, 2022, BOEM held Pacific Wind Lease Sale 1 (PACW-1) for five lease areas, two within the Humboldt WEA and three within the Morro Bay WEA (BOEM 2022). The size of each lease area ranges from 63,338 to 80,418 acres and the estimated potential installation capacity of each lease area ranges from 769 to 976 megawatts (MW) (refer to **Figure 1**). On December 7, 2022, the lease sale ended and five provisional winners were announced: RWE Offshore Wind Holdings, LLC; California North Floating LLC; Equinor Wind US LLC; Central California Offshore Wind LLC; and Invenergy California Offshore LLC.

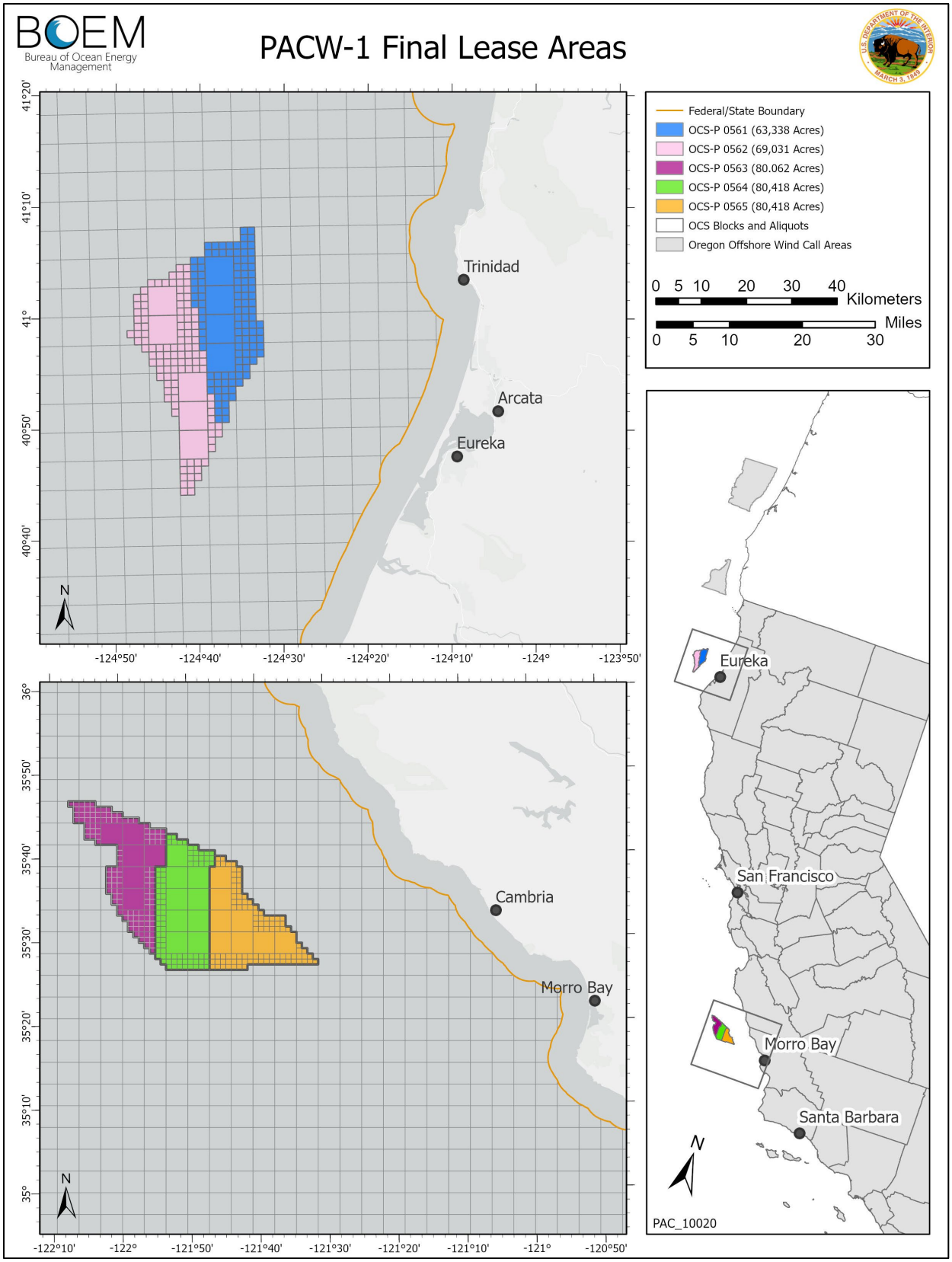

Figure 1. California final lease areas (BOEM 2022)

2 Offshore Wind Port Site Types

This section provides an overview of the various offshore wind port site types that are needed to stage, assemble, and provide ongoing operations and maintenance of the wind turbines for the offshore wind industry. In addition, this section will provide a brief overview of the results from the previous BOEM study, *California Floating Offshore Wind Regional Ports Assessment* (Moffatt & Nichol 2023), to provide context for the ports sites that are further assessed in this report.

This study includes the following primary port sites for the offshore wind industry:

- **Staging and Integration (S&I) Site:** a site to receive, stage, and store offshore wind components and to assemble the floating turbine system for towing to the offshore wind area.
- **Manufacturing/Fabrication (MF) Site:** a port site located on a navigable waterway that receives raw materials via road, rail, or waterborne transport and creates larger components in the offshore wind supply chain. This site typically includes factory and/or warehouse buildings and space for storage of completed components.
- **Operation and Maintenance (O&M) Site:** a base of wind farm operations with warehouses/offices, spare part storage, and a marine facility to support vessel provisioning and refueling/charging for the following O&M vessels during the operational period of the offshore wind farm:
    - **Crew Transfer Vessel (CTV):** transfers small crews to offshore wind turbine installations for day-trip O&M visits and inspections.
    - **Service Operating Vessel (SOV):** vessels that loiter and operate as in-field accommodations for workers and platform assist for wind turbine servicing and repair work.
    - **Service Accommodation Transfer Vessel (SATV):** intermediate between SOVs and CTVs, with ability to sleep onboard for multiday trips.

The following port infrastructure requirements were developed as part of the previous BOEM study (Moffatt & Nichol 2023) and are used to identify the anticipated port improvements for this report. As stated in the previous report, turbine sizes of up to 25 MW were considered to derive these requirements. Loading capacities provided in **Table 1** are in units of pounds per square foot (psf).

Table 1. Port infrastructure requirements (Moffatt & Nichol 2023)

Floating Offshore Wind Turbine	Approximate Criteria for S&I Sites	Approximate Criteria for MF Sites	Approximate Criteria for O&M Sites
Acreage, preferred range	30 – 100 acres	30 – 100 acres	2 – 10 acres
Wharf Length, minimum	1,500 ft	800 ft	300 ft
Minimum Draft at Berth	38 ft	38 ft	20 – 30 ft
Draft at Sinking Basin*	40 – 100 ft	N/A	N/A
Wharf Loading	6,000 psf	6,000 psf	100 – 500 psf
Uplands / Yard Loading (for WTG components)	2,000 – 3,000 psf	2,000 – 3,000 psf	100 – 500 psf

*Options for transfer of floating foundation from land to water include use of semi-submersible barge and sinking basin, ramp system, or direct transfer methods (lifting portions or complete foundation units from land into water)

2.1 Staging and Integration (S&I) Sites

Based on previous developer outreach, 80 acres is a sufficient amount of upland space for an offshore wind developer to receive, stage, and store components for final turbine assembly at the wharf (Moffatt & Nichol 2022). A sample layout for an 80-acre S&I site with the necessary infrastructure is shown in **Figure 2**. Components such as blades, nacelles, and tower sections are delivered to the site and stored within the uplands area that is rated for 2,000 to 3,000 psf.

A major challenge the industry identified is the transfer of the completed semi-submersible or TLP foundation from the assembly wharf into the water (i.e., launching). Several options are available to overcome this challenge and each developer may prefer a different option; however, a few common approaches were identified: semi-submersible barge (which requires a sinking basin), ramp system, and direct transfer. A sinking basin is shown near the site that can be used to transfer a floating foundation substructure into the water. The heavy lift wharf is rated for 6,000 psf to withstand the heavy loads from components and equipment that load and unload cargo and assemble the wind turbine onto the floating foundation substructure. Cost estimates for the S&I sites are provided in **Table 2**.

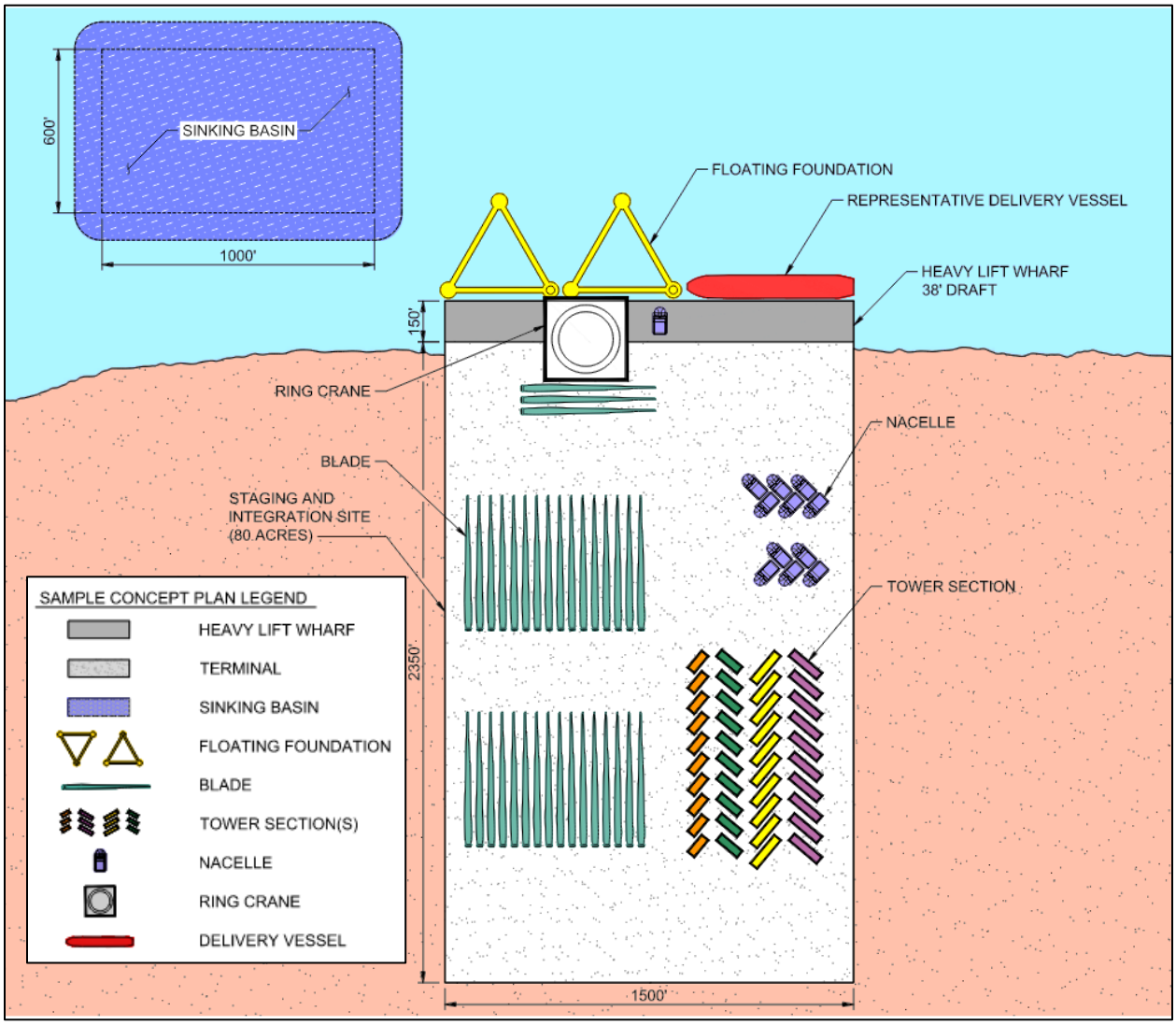

Figure 2. Sample 80-acre S&I site layout

2.2 Manufacturing/Fabrication (MF) Site

A sample layout for a 40-acre nacelle assembly site and 800-ft heavy lift wharf, with specifications as described above, is shown in **Figure 3**. In the figure, nacelles are assembled within the manufacturing building, stored on site, and then transferred via waterborne transport to an S&I site for turbine assembly. Cost estimates for the MF sites are provided in **Table 3**.

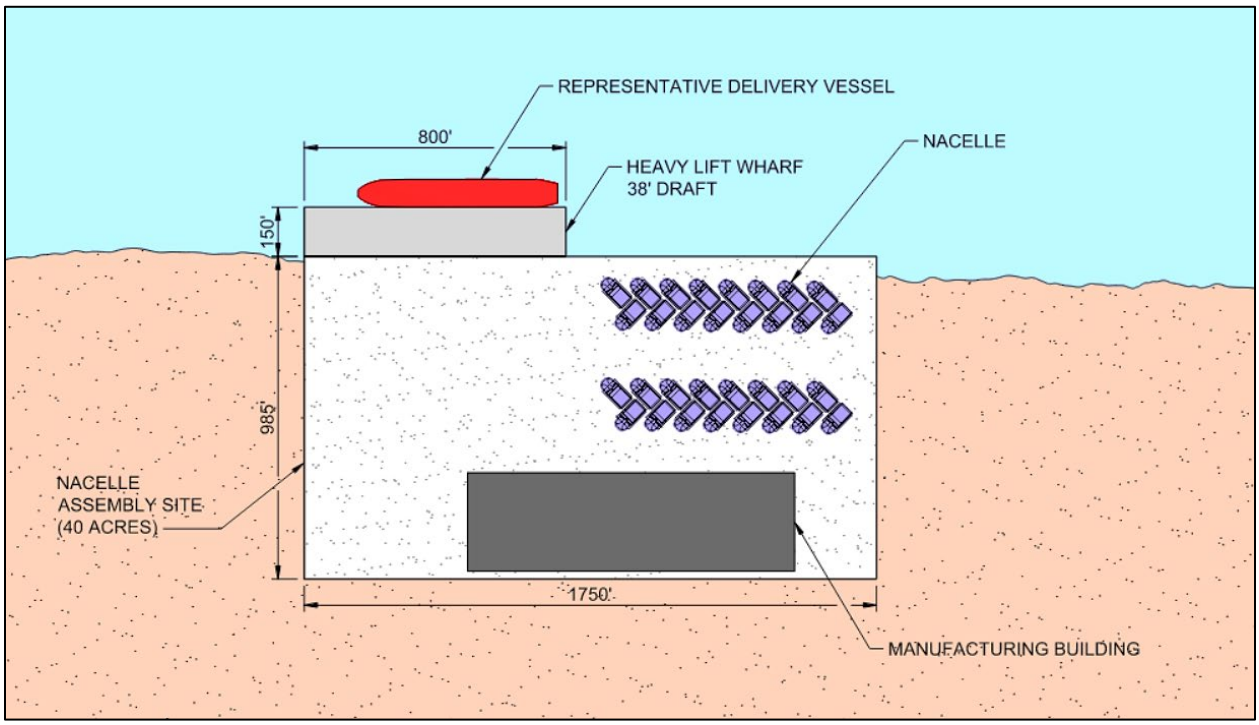

Figure 3. Sample 40-acre nacelle assembly site layout

2.3 Operations & Maintenance (O&M) Sites

Ideally, O&M sites, which transfer crew to and from the offshore wind farm, shall be close to the wind farm location to minimize travel time. Other maintenance activities, where the turbine system needs to be towed back to port from the offshore wind farm, are assumed to be performed at the S&I sites where the large assembly cranes are – Port of Humboldt, Port of Los Angeles, and Port of Long Beach.

A sample layout for an O&M site with a 300 ft wharf and 10-acre nearshore area is shown in **Figure 4**. In the figure, an SOV and CTV are using the wharf for activities such as loading and unloading supplies and transferring crew to the offshore wind area. Cost estimates for the O&M sites are provided in **Table 4**.

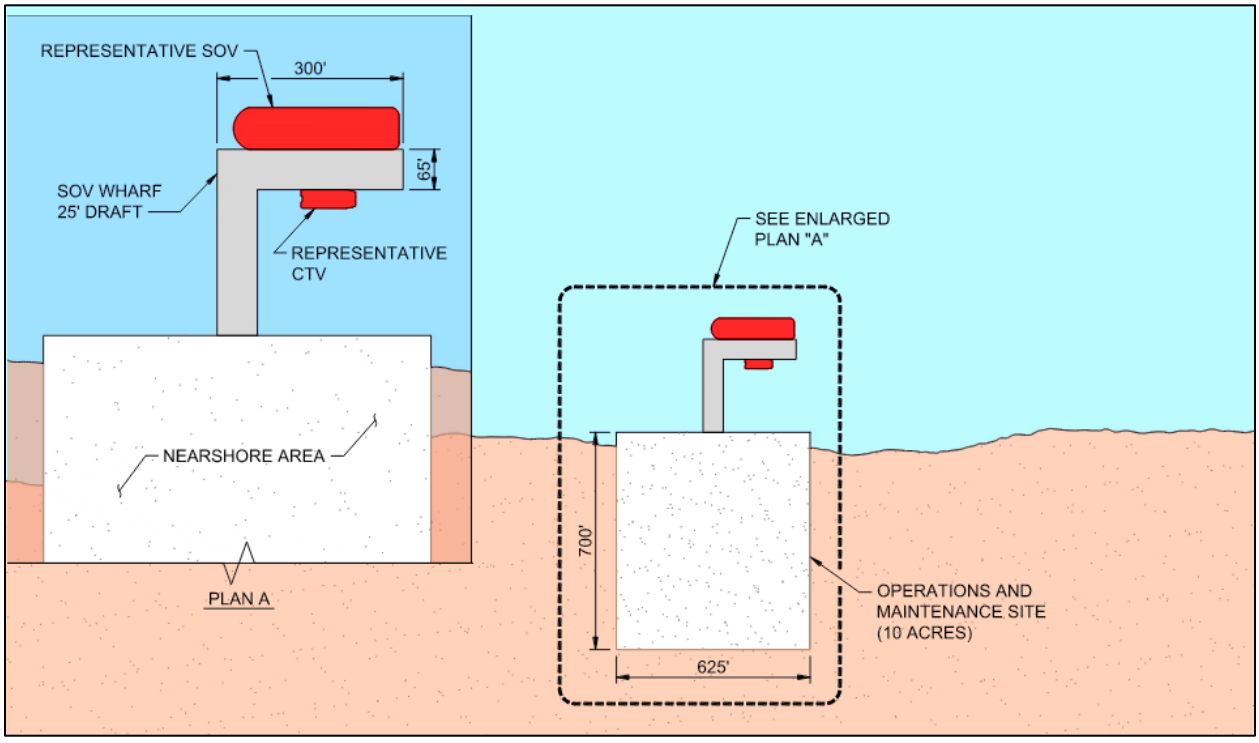

Figure 4. Sample O&M site layout

3 Evaluated Ports and Facilities

This section lists which port sites were evaluated within this study.

3.1 Staging and Integration (S&I) Sites

The following three ports that were identified as candidates for S&I sites in the previous BOEM study (Moffatt & Nichol 2023) were evaluated to assess the feasibility of implementing the required infrastructure improvements for an S&I site.

- Port of Humboldt
- Port of Los Angeles
- Port of Long Beach

3.2 Manufacturing/Fabrication (MF) Site

The following ports and facilities that were identified as candidates for MF sites in the previous BOEM study (Moffatt & Nichol 2023) were evaluated to assess the feasibility of implementing the required infrastructure improvements for an MF site.

During this study, it was noted that the San Francisco Bay Area has a number of private terminals along the channel that could serve as potential MF port sites. Outreach was performed to several private terminals to assess their interest and site suitability for offshore wind development. As a result, two private terminals were identified within Antioch and Pittsburg as potential MF sites and were added to this study.

- Port of Humboldt
- Port of Stockton
- Port of Benicia
- Port of Richmond
- Port of San Francisco
- Port of Oakland
- Port of Redwood City
- Port of Los Angeles
- Port of Long Beach
- Port of San Diego
- Antioch
- Pittsburg

3.3 Operations & Maintenance (O&M) Sites

The following six ports and facilities that were identified as candidates for O&M sites in the previous BOEM study (Moffatt & Nichol 2023) were evaluated within this study to assess the feasibility of implementing the required infrastructure improvements for an O&M site.

- Crescent City Harbor District
- Port of Humboldt
- City of Morro Bay
- Diablo Canyon Power Plant
- Port San Luis
- Port of Hueneme

4 Cost Estimates and Construction Durations

To evaluate the feasibility and cost of recommended port upgrades, this study assessed each port site to determine the infrastructure improvements required to meet the criteria in **Table 1** and developed cost estimates and general construction durations.

4.1 Basis of Cost Estimate

Cost estimates were developed to an Association for the Advancement of Cost Estimating (AACE) Class 5 level of accuracy. The typical expected cost variation for a Class 5 estimate is -20% to -50% on the low range and +30% to 100% on the high range. Cost estimates were developed with the following approach:

1. Determine the infrastructure improvements required based on the intended site type: S&I, MF, and O&M.
2. Calculate quantity take-offs for the various types of infrastructure improvements required (i.e., dredging, wharf construction, upland improvements, etc.)
3. Once quantifiable values are established for required infrastructure improvements, unit costs for each item based on the location of the site and information from previous studies/projects were applied.

Additional assumptions for the construction cost estimates include:

- The costs have been developed based on historical and current data using information from previous studies as well as budget price quotations solicited from local suppliers and contractors. All costs are in 2023 US Dollars. Estimates do not include escalation to account for increases in the cost of labor, equipment, or materials due to continuing price changes over time.
- Cost estimates include all material, labor, and equipment to complete the work and indirect costs including Contractor Supervision (General Conditions), Corporate Overhead and Profit, and Bonds and Insurance costs.
- A project contingency of 50% is applied to cover undefined items due to the level of engineering carried out at this time. The contingency is not a reflection of the accuracy of the estimate. It covers items of work that will have to be performed and elements of costs that will be incurred but are not explicitly detailed or described due to the level of investigation, engineering, and estimating completed. A contingency of 50% is a common assumption for this level of design for port structures.

Note, these construction cost estimates exclude any above-grade construction (i.e., warehouses and buildings) to facilitate fair cost comparisons as each developer will determine the necessary above-grade construction for each site. In addition, the cost estimates do not include any costs for navigation channel improvements such as widening or deepening, wet storage, or equipment such as SPMTs or cranes. For all assumptions included in the cost estimates, please see the **Appendix**.

4.2 Staging and Integration (S&I) Sites

For sites listed in **Section 3.1**, an evaluation was completed to determine the required improvements and estimated cost to develop the site for offshore wind industry use. See **Table 2** and the descriptions below for a detailed breakdown of the improvements and costs at the S&I sites.

- **All Sites**
    - Wharf: A new wharf that can withstand 6,000 psf loading is required. The width is assumed to be 150 ft and the length is assumed to be 1,500 ft per 80 acres.

- **Port of Humboldt**
    - Demolition: Demolition is included for any existing structures or features such as a wharf, buildings on site, or any pavement.
    - Site Acreage: Based on previous outreach to the Port of Humboldt, up to 320 acres of existing uplands space may be available for S&I and MF sites. The uplands area shall support at least 2,000 to 3,000 psf.
    - Berth Pocket Dredging: The berth pocket at the wharf shall be dredged to a minimum water depth of 38 ft.
    - Sinking Basin: Depending on the floating foundation technology, a sinking basin may be required to off-float the floating foundations. The cost for dredging a sinking basin to various depths (water depth = 60 ft, 80 ft, and 100 ft) is included separately. The base of the sinking basin is assumed to be 600 ft by 1,000 ft to accommodate semi-submersible barges.
- **Port of Los Angeles**
    - Site Acreage: Based on previous outreach to the Port of Los Angeles, potentially 160 acres of new land could be created within the port for S&I and MF sites. This is assumed to be achieved by dredging portions of the port to provide the necessary sediment to create 160 acres. The uplands area shall support at least 2,000 to 3,000 psf. Demolition is not required since the site is not on existing land.
    - Berth Pocket Dredging: Portions of the port will be significantly dredged to produce enough material to create 160 acres of new land; therefore, the berth pocket could be approximately -60 ft.
    - Sinking Basin: Depending on the floating foundation technology, a sinking basin may be required to off-float the floating foundations. Since there are already deep waters to approximately -80 ft available within the port, only a sinking basin dredging cost to 100 ft is provided. The base of the sinking basin is assumed to be 600 ft by 1,000 ft to accommodate semi-submersible barges.
- **Port of Long Beach**
    - Site Acreage: Based on previous outreach to the Port of Long Beach, potentially 400 acres of new land could be created within the port for S&I and MF sites. This would be achieved by dredging portions of the port to provide the necessary sediment to create 400 acres. The uplands area shall support at least 2,000 to 3,000 psf. Demolition is not required since the site is not on existing land.
    - Berth Pocket Dredging: Portions of the port will be significantly dredged to produce enough material to create 400 acres of new land; therefore, the berth pocket is anticipated to be approximately -60 ft.
    - Sinking Basin: Depending on the floating foundation technology, a sinking basin may be required to off-float the floating foundations. Since there are already deep waters to approximately -80 ft available within the port, only a sinking basin dredging cost to 100 ft is provided. The base of the sinking basin is assumed to be 600 ft by 1,000 ft to accommodate semi-submersible barges.

The cost of an 80-acre S&I site at the Port of Humboldt ($700M) is less than an 80-acre S&I site at the Port of Los Angeles ($1,000M) or Port of Long Beach ($1,110M) because it can utilize existing land within the port. The cost of a sinking basin is included as a separate cost and provided for various depths. Constructing a sinking basin within the Port of Los Angeles or Port of Long Beach costs less than that for the Port of Humboldt due to the deep waters available within these Southern California ports.

Note, the estimated costs and schedules provided are based on the assumed infrastructure improvements listed above, actual project costs and schedule may vary. The Port of Long Beach recently published a Concept Report that provides a more detailed evaluation of cost and schedule for their 400-acre facility (POLB 2023). Based on their concept design, the cost estimate for the Port of Long Beach 400-acre facility is $4,700M, and thus an 80-acre S&I site is approximately $940M.

The construction duration to provide or upgrade an 80-acre S&I site with a 1,500 feet heavy lift wharf at the Port of Humboldt, Los Angeles, and Long Beach could be between **4 to 6 years.**

Table 2. S&I site infrastructure improvements and cost estimates

Item	Port of Humboldt	Port of Los Angeles	Port of Long Beach [1]
Site Type(s)	Staging & Integration	Staging & Integration	Staging & Integration
Site Acreage	320 acres (existing land) 2,000 – 3,000 psf capacity	160 acres (new land) 2,000 – 3,000 psf capacity	400 acres (new land) 2,000 – 3,000 psf capacity
Wharf Improvement	6,000 ft long wharf 6,000 psf capacity	3,200 ft long wharf 6,000 psf capacity	7,500 ft long wharf 6,000 psf capacity
Berth Pocket Dredging	-38 ft	-60 ft	-60 ft
Total Cost Estimate	**$2,700M**	**$2,100M**	**$5,400M [1]**
Cost Accuracy Range	$1,900M to $4,100M (-30% / +50%)	$1,500M to $3,200M (-30% / +50%)	$3,800M to $8,100M (-30% / +50%)
Cost / 80 acres	**$700M**	**$1,000M**	**$1,110M [1]**
Sinking Basin to EL. -60	$85M	Deep water to El. -80 is available within the harbor	Deep water to El. -80 is available within the harbor
Sinking Basin to EL. -80	$215M	Deep water to El. -80 is available within the harbor	Deep water to El. -80 is available within the harbor
Sinking Basin to EL. -100	$420M	$35M	$35M

[1] The Port of Long Beach recently published a Concept Report with a more detailed cost estimate and schedule for their 400-acre facility. The total cost estimate is $4,700M and for 80 acres it is $940M (POLB 2023).

4.3 Manufacturing/Fabrication (MF) Site

For sites listed in **Section 3.2**, an evaluation was completed to determine the required improvements and estimated cost to develop the site for offshore wind industry use. See **Table 3** and the descriptions below for a detailed breakdown of the improvements and costs at the MF sites.

- **All Sites**
  - Demolition: Demolition is included for any existing structures or features such as a wharf, buildings on site, or any pavement.
  - Wharf: A new wharf that can withstand 6,000 psf loading is required. The width is assumed to be 150 ft and the length is assumed to be 800 ft for a delivery vessel.
- **Port of Stockton, Port of Benicia, Port of Richmond, and Port of Redwood City**
  - Site Acreage: Based on previous outreach to the Port of Benicia and Port of Redwood City, potentially 20 acres of existing uplands space may be available for an MF site. For the Port of Stockton and Port of Richmond, potentially 40 acres of existing uplands space

may be available for an MF site. The uplands area shall support at least 2,000 to 3,000 psf.
    - Berth Pocket Dredging: The berth pocket at the wharf shall be dredged to a minimum water depth of 38 ft.
- **Port of San Francisco**
    - Site Acreage: Based on previous outreach to the Port of San Francisco, potentially 95 acres of existing uplands space may be available for an MF site at each port. The uplands area shall support at least 2,000 to 3,000 psf.
    - Berth Pocket: The berth pocket at the wharf is greater than 38 ft and meets the minimum requirement, therefore dredging is not required.
- **Port of Oakland**
    - Site Acreage: Based on previous outreach to the Port of Oakland, potentially 40 acres of existing uplands space may be available for an MF site at each port. The uplands area shall support at least 2,000 to 3,000 pounds per square feet (psf).
    - Berth Pocket: The berth pocket at the wharf is greater than 38 ft and meets the minimum requirement, therefore dredging is not required.
- **Antioch & Pittsburg**
    - Site Acreage: Based on previous outreach to private terminals in Antioch and Pittsburg in the San Francisco Bay Area, potentially 100 acres of existing uplands space may be available for an MF site at each location. The uplands area shall support at least 2,000 to 3,000 psf.
    - Berth Pocket Dredging: The berth pocket at the wharf shall be dredged to a minimum water depth of 38 ft.
- **Port of San Diego**
    - Site Acreage: Based on previous outreach to the Port of San Diego, potentially 40 acres of existing uplands space may be available for an MF site. The uplands area shall support at least 2,000 to 3,000 pounds per square feet (psf).
    - Berth Pocket Dredging: The berth pocket at the wharf shall be dredged to a minimum water depth of 38 ft.

The cost for a 20-acre or 40-acre MF site within the San Francisco Bay Area generally costs the same between the various ports/facilities.

The construction duration to provide a 40-acre MF site and 800 feet heavy lift wharf could be between **4 to 5 years**.

- **Port of Humboldt, Port of Los Angeles, and Port of Long Beach**
    - These three ports have identified a significant amount of acreage for both S&I and MF sites. The distribution of acreage for S&I sites versus MF sites is currently unknown and will be driven by the offshore wind industry needs. Because the infrastructure improvements are relatively similar for both site types (i.e., same capacity for the heavy lift wharf, upland acreage, and draft at berth) the cost for an 80-acre S&I site in **Table 2** can be used for an 80-acre MF site for these ports.

Table 3. MF site infrastructure improvements and cost estimates

Item	Port of Redwood City	Port of Benicia	Port of Stockton	Port of Richmond	Port of Oakland	Port of San Francisco	Port of San Diego	Antioch	Pittsburg
Site Type	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Manufacturing	Manufacturing
Site Acreage	20 acres 2,000 – 3,000 psf	20 acres 2,000 – 3,000 psf	40 acres 2,000 – 3,000 psf	40 acres 2,000 – 3,000 psf	40 acres 2,000 – 3,000 psf	95 acres 2,000 – 3,000 psf	40 acres 2,000 – 3,000 psf	100 acres 2,000 – 3,000 psf	100 acres 2,000 – 3,000 psf
Wharf Improvement	800 ft long wharf 6,000 psf capacity	800 ft long wharf 6,000 psf capacity	800 ft long wharf 6,000 psf capacity	800 ft long wharf 6,000 psf capacity	800 ft long wharf 6,000 psf capacity	800 ft long wharf 6,000 psf capacity	800 ft long wharf 6,000 psf capacity	800 ft long wharf 6,000 psf capacity	800 ft long wharf 6,000 psf capacity
Berth Pocket Dredging	-38 ft	-38 ft	-38 ft	-38 ft	-50 ft [1]	-40 ft [1]	-38 ft	-38 ft	-38 ft
Total Cost Estimate	$300M	$325M	$350M	$375M	$350M	$480M	$275M	$520M	$520M
Cost Accuracy Range	$200M to $450M (-30% / +50%)	$225M to $500M (-30% / +50%)	$250M to $525M (-30% / +50%)	$275M to $575M (-30% / +50%)	$250M to $525M (-30% / +50%)	$350M to $720M (-30% / +50%)	$200M to $425M (-30% / +50%)	$375M to $800M (-30% / +50%)	$375M to $800M (-30% / +50%)
Cost / 20 Acres	$300M	$325M	$300M	$320M	$300M	$290M	$225M	$300M	$300M
Cost / 40 acres	Not Available [2]	Not Available [2]	$350M	$375M	$350M	$345M	$275M	$350M	$350M

[1] The existing berth pocket along the wharf is greater than 38 ft, therefore dredging is not required.

[2] For the Port of Benicia and Port of Redwood City, 40-acres for an MF site is not available.

4.4 Operations & Maintenance (O&M) Sites

For sites listed in **Section 3.3**, an evaluation was completed to determine the required improvements and estimated cost to develop the site for offshore wind industry use. See **Table 4** and the descriptions below for a detailed breakdown of the improvements and costs at the O&M sites.

- **Crescent City Harbor District, Port of Humboldt, and City of Morro Bay**
  - Demolition: Demolition is included for any existing structures or features such as a wharf or buildings on site.
  - Site Acreage: Based on previous outreach to Crescent City Harbor District, Port of Humboldt, and City of Morro Bay, 2 to 10 acres of existing nearshore space may be available for an O&M site.
  - Wharf: A new wharf that can withstand 500 psf loading is required. The width is assumed to be 65 ft and the length is assumed to be 300 ft for a SOV and CTV.
  - Berth Pocket Dredging: The berth pocket at the wharf for Crescent City and Morro Bay shall be dredged to a minimum water depth of 25 ft to accommodate an SOV. At the Port of Humboldt there are potential locations where dredging at an O&M berth pocket is not required.
- **Port San Luis**
  - Demolition: Demolition is included for any existing structures or features such as buildings on the nearshore area.
  - Site Acreage: Based on previous outreach to Port San Luis, some onshore area is available, but may not be directly adjacent to the pier.
  - Wharf: An extension of the existing pier to accommodate an SOV is required. The extension of the pier is assumed to be 300 ft to accommodate an SOV and/or CTV.
  - Berth Pocket: The water depth at the end of the existing pier where the vessels will berth is approximately 35 ft and can accommodate an SOV and/or CTV, therefore dredging is not required.
- **Diablo Canyon Power Plant**
  - Demolition: Demolition is included for any existing structures or features such as a wharf or buildings on site.
  - Site Acreage: Based on previous outreach to Diablo Canyon Power Plant, 2 to 10 acres of onshore area is available, but may not be directly adjacent to the pier.
  - Wharf: Due to existing site constraints, Diablo Canyon Power Plant may only be able to accommodate a CTV. Based on this the berthing structure could be docks that are 150 ft long.
  - Berth Pocket Dredging: The existing water depth at this site is greater than 12 ft and can accommodate a CTV, therefore dredging is not required.
- **Port of Hueneme**
  - Infrastructure improvements to best support O&M activities include paving improvements and upgrades to fendering systems.

The construction duration to provide a 2 to 10-acre O&M site and 300 feet wharf for SOV or CTV operations could be approximately **3 years**. Note, if the site is located within an existing facility with adequate infrastructure, it is possible that the timeline could be accelerated.

Table 4. O&M site infrastructure improvements and cost estimates

Item	Crescent City Harbor District	Port of Humboldt	City of Morro Bay	Port of San Luis	Diablo Canyon Power Plant	Port of Hueneme
Site Type	Operations & Maintenance	Operations & Maintenance	Operations & Maintenance	Operations & Maintenance	Operations & Maintenance	Operations & Maintenance
Site Acreage	2 acres	2 acres	2 acres	2 acres [2]	2 acres	2 acres
Wharf Improvement	300 ft long wharf 500 psf capacity	300 ft long wharf 500 psf capacity	300 ft long wharf 500 psf capacity	300 ft long pier ext.[3] 500 psf capacity	150 ft long dock [5] 500 psf capacity	Existing Wharf is adequate
Berth Pocket Dredging	-25 ft	-25 ft [1]	-25 ft	-35 ft [4]	-12 ft [6]	-33 ft [7]
Cost Estimate	$35M	$15M	$50M	$20M	$10M	$15M
Cost Accuracy Range	$20M to $45M (-30% / +50%)	$10M to $25M (-30% / +50%)	$35M to $75M (-30% / +50%)	$15M to $30M (-30% / +50%)	$7M to $15M (-30% / +50%)	$10M to $20M (-30% / +50%)
Cost / 10 acres	$37M	$17M	$52M	Not Available	$12M	$20M

[1] At the Port of Humboldt, dredging at the berth pocket may not be required for an O&M site.

[2] For Port San Luis, the upland acreage may not be directly adjacent to the pier.

[3] For Port San Luis, the berthing structure will be an extension of the existing pier.

[4] For Port San Luis, the existing berth water depth is -35 ft, therefore dredging is not required.

[5] For Diablo Canyon Power Plant, the dock would only be able to accommodate CTVs and not SOVs due to site constraints.

[6] For Diablo Canyon Power Plant, the existing berth water depth is -12 ft, therefore dredging is not required.

[7] For Port of Hueneme, the existing berth water depth is approximately -33 ft, therefore dredging is not required.

5 Project Development Process and Timing

To meet the California offshore wind deployment goals of 2 to 5 GW by 2030 and 25 GW by 2045, the timing of when these offshore wind port sites are available for offshore wind industry use is critical. S&I sites are the most critical since there are only a few sites that have the capability to perform final turbine assembly activities. Offshore wind port sites need to follow the below schedule to meet offshore wind deployment goals:

- S&I Sites
    - Based on outreach to the Port of Humboldt and Port of Long Beach, who have started the project planning and design process for S&I and MF sites, they are targeting to have portions or phases of their sites ready by **late 2020s to early 2030s** to meet the offshore wind industry needs.
- MF Sites
    - If a domestic supply chain is to be established within California, MF sites would need to be available by **late 2020s to mid-2030s** to supply components to the initial and future offshore wind projects.
- O&M Sites
    - To service the offshore wind turbines that are installed, O&M sites would need to be available for offshore wind industry use around the same time S&I sites are available – **late 2020s to early 2030s**.

To plan, design, and construct these offshore wind port sites, the following general stages are involved:

1. Secure funding for project implementation
2. Project planning, conceptual design, and vetting of project alternatives
3. Consultation with Native American Tribes
4. Federal and/or State environmental review and compliance
5. Coordination with permitting agencies and affected stakeholders; detailed engineering
6. Obtaining project permits
7. Construction

After project funding has been secured, and the conceptual design has progressed to allow for the development of a project description, the environmental review process can be initiated by the applicable Federal, State, and/or local lead agencies. In addition to compliance with the National Environmental Policy Act (NEPA) for offshore wind deployment, port improvements in California will require compliance with the California Environmental Quality Act (CEQA). Depending on the location of the project and the resources affected, agencies with permitting authority for the proposed California port improvement projects may include one or more of the following:

- United States Army Corps of Engineers (USACE)
- United States Environmental Protection Agency (USEPA)
- United States Fish and Wildlife Service (USFWS)
- National Marine Fisheries Service (NMFS)
- California Air Resources Board (CARB)
- California Coastal Commission (CCC)
- California Department of Fish and Wildlife (CDFW)
- Department of Toxic Substances Control (DTSC)
- California State Lands Commission (SLC)
- San Francisco Bay Conservation and Development Commission (BCDC)

- State Historic Preservation Office (SHPO)
- State Water Resources Control Board (SWRCB)
- Applicable Air Quality Management District (AQMD) or Air Pollution Control District (APCD)
- Applicable Port or Harbor Authority
- Local County or City (for Coastal Development Permit and all applicable ministerial permits)

Federal and/or State environmental review processes are similar, both in intent and in their requirements (i.e., public engagement and preparation of environmental analyses documents to help support permit issuance by multiple agencies). When a project requires multiple Federal, State, regional, and/or local approvals, joint NEPA/CEQA environmental review processes are encouraged to help streamline the review process by helping avoid redundancy, improving efficiency and interagency cooperation, and making it easier for applicants and citizens to navigate the project review and approval process. The environmental review process may also involve negotiations to address compensatory mitigation required due to significant impacts identified through the consultation process or the NEPA and/or CEQA analyses. The resulting environmental documentation from the NEPA and/or CEQA compliance documents process will be used by multiple agencies with jurisdiction over the project to support make decisions on their respective permits.

After the permit application package has been submitted to each applicable Federal, State, regional, and local agency, agency coordination can be initiated. Agencies typically respond to permit submittals with multiple rounds of data requests to the applicant before project permit applications are deemed complete. After the permitting agency deems each application to be complete, the agency can begin the environmental review process to support processing its permit, and subsequent permit approval. Once applications are considered complete, an agency can then formally process and execute their permit. This process also involves negotiations to address compensatory mitigation related to the significant impacts identified as per each agency's regulations.

The typical timeline associated with securing all required permits and approvals for large in-water projects in California could be considerably longer than the timeline that has been identified for meeting California's goal of producing 2 to 5 GW by 2030 and 25 GW by 2045. Projects developed on the coast of California of similar size and scale to the proposed sites considered in this study have taken from 3 to over 10 years from project planning to securing all permits and environmental approvals for construction. Considering the regulatory environment in California, the window for securing all required approvals could range from **4 to 10 years for S&I sites, 4 to 8 years for MF sites, and 4 to 7 years for O&M sites**. Development of facilities within existing ports and in areas with existing industrial land uses may be permitted more quickly, but controversial projects that result in legal challenges to the agency approvals and the adequacy of the environmental documents relied upon may require longer timeframes.

Strategies for expediting the processes for environmental review and permitting can be developed through legislative action, through multi-agency agreements of Memoranda of Understanding (MOUs), or through direct agreements with agencies or the applicants. While each strategy would need to be based on site-specific conditions for each project or group of projects, the following approaches could help streamline the environmental review and permitting process, and may limit the timeframe for legal challenges to projects after approval:

- Early development of mitigation programs and strategies through coordination with resource agencies.
- Early initiation of community engagement and outreach to identify project effects, alternatives, and mitigation and develop community support. An effective outreach and involvement program that considers community concerns may lead to more effective mitigation presented in the environmental documents and may reduce the risk of legal challenges after project approval. This

type of community engagement also provides opportunities to define and address environmental justice issues and leverage investments that could provide local jobs and expand community resources.

- Development of a legislative program similar to that defined in the Judicial Streamlining provisions of California's Environmental Leadership Development Program, as defined in Senate Bill 7 (Atkins, 2021) that would apply to seaport developments supporting offshore wind could reduce the timeframe for legal challenges to agency decisions and environmental documents.

6 Conclusion and Next Steps

The purpose of this study was to perform a feasibility analysis to prepare cost estimates and project development timelines for port infrastructure upgrades required for offshore wind industry use. Cost estimates and project development timelines have been prepared and presented within this report.

A summary of the unit costs and timelines per site type is provided in **Table 5.**

Table 5. Summary of unit cost and timelines per site type

Site Type	S&I Site	MF Site	O&M Site
Unit Acreage	80-acres	40-acres	2 to 10-acres
Unit Cost Range [1]	$700M to $1,100M	$275M to $375M	$0M to $52M
Planning to Permit Timeline	4 to 10 years	4 to 8 years	4 to 7 years
Construction Timeline [2]	4 to 6 years	4 to 5 years	3 years
Sites Needed By [3]	Late 2020s to Early 2030s	Early to Mid-2030s	Late 2020s to Early 2030s

[1] Cost estimate can vary from -20% to -50% on the low range and +30% to 100% on the high range.
[2] Construction timeline starts after all permits are acquired.
[3] Year when sites are needed to meet AB 525 offshore wind planning goals.

Funding these projects and coordinating project delivery schedules need to be further assessed to ensure they are available for industry use in time to meet the AB 525 offshore wind planning goals (2 to 5 GW by 2030 and 25 GW by 2045).

7 References

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Appendix

Cost Estimate Assumptions

The cost estimates provided in this study were based on the following assumptions:

- This cost estimate is an 'Opinion of Probable Construction Cost' made by a consultant. In providing opinions of construction cost, it is recognized that neither the client nor the consultant has control over the cost of labor, equipment, materials, or the contractor's means and methods of determining constructability, pricing or schedule. This opinion of construction cost is based on the consultant's reasonable professional judgement and experience and does not constitute a warranty, expressed or implied, that contractor's bids or negotiated prices for the work will not vary from the estimate.
- The costs have been developed based on historical and current data using in-house sources, information from previous studies as well as budget price quotations solicited from local suppliers and contractors. All costs are in 2023 US Dollars. Estimate does not include escalation.
- Total Construction Cost includes all material, labor, and equipment to complete the work and indirect costs including Contractor Supervision (General Conditions), Corporate Overhead and Profit, and Bonds and Insurance cost.
- Total Construction Cost (with Contingency) includes a project contingency of 50%. The contingency amount has been included to cover undefined items, due to the level of engineering carried out at this time. The contingency is not a reflection of the accuracy of the estimate but covers items of work which will have to be performed, and elements of costs which will be incurred, but which are not explicitly detailed or described due to the level of investigation, engineering and estimating completed today.
- This cost estimate represents an AACE 18R-97 Class 5 Estimate.
- Volumes for uplands site preparation and required berth improvements are based on currently available bathymetric and topographic information. Additional surveys and exploration will be required. Results of this additional exploration program may require quantity and price updates.
- Estimate does not include any improvements or facilities required by the developer or operator.
- Estimate assumes piles are driven to grade with no obstructions and does not include any associated costs due to pile driving/drilling into rock.
- Pricing assumes all resources are readily available locally.
- Estimate is based on unencumbered contractor access to the site.
- Estimate does not include any costs for construction site property lease or acquisition expenses.
- No extreme weather risk included (force majeure).
- Price does not include environmental restrictions.
- Price does not include any associated costs due to hazardous waste.
- Price does not include any costs for post construction site remediation or reconstruction.
- Estimate does not include any required Federal navigation channel dredging.
- Estimate assumes construction of a sinking basin with 100-foot depth is feasible and permittable.

- Estimate includes utilities designed to site limit of work and assumes adequate municipal water and electrical service is available and can be tapped for project needs. Additional offsite utility infrastructure costs are not included.
- Estimate assumes ring crane footprint extends past heavy lift wharf platform onto uplands.

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