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MEMORANDUM

To:	Rob Holmlund (Humboldt Bay Harbor, Recreation, and Conservation District)
From:	Michael Jokerst and Maged El-Mestkawy
Date:	April 25, 2024
Subject:	Wharf Pile Type Selection – *Update to 09/15/22 TA1 Deliverable*
Project:	Redwood Marine Multipurpose Terminal Replacement Project
Location:	Eureka, California
M&N Job No.:	212991-03
Cc:	Shane Phillips Raj Varatharaj & Arul K. Arulmoli (Earth Mechanics, Inc.)

Disclaimer: *This draft technical memorandum is a work-in-progress and is intended to be an internal document for use by the Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project team as a part of the conceptual design process and the ongoing permitting process. This memorandum is meant to be read as a part of a comprehensive packet of technical analyses. It is not written to be a standalone document and it is assumed that the reader has substantial project knowledge and context to understand the memorandum's content. All aspects of this memorandum are subject to change and may become less accurate over time. To better understand the project, please review the more comprehensive and up to date documents posted to the Humboldt Bay Harbor District's website at https://humboldtbay.org/humboldt-bay-offshore-wind-heavy-lift-marine-terminal-project-3.*

The purpose of this memorandum is to document Moffatt & Nichol's (M&N's) evaluation process that led to the selection of open-ended steel pipe piles for the wharf foundation. This memorandum is organized as follows:

1. Introduction
2. Design Criteria
3. Pile Type Evaluation
4. Conclusion
5. Limitations
6. Next Phase Considerations

1. INTRODUCTION

The proposed Redwood Marine Multi-Purpose Terminal includes two wharves and a wet storage tie-up pier to meet the operational needs of a heavy-lift marine terminal facility to support the offshore wind energy industry and other coastal-dependent industries. See Figure 1 for a preliminary layout of the structures.

The first wharf will be a replacement of the existing Redwood Marine Terminal 1 (RMT1). The "North Wharf" will be built in two phases. The first phase wharf will be 800 linear feet (LF) and will be wide enough to accommodate a large crane that will be used for assembly of the Wind Turbine Devices (WTD). The second phase will extend the North Wharf 800 LF and would be used primarily as a delivery berth.

The second wharf will be the "South Wharf," and will similarly be able to accommodate both delivery and assembly operations. The second wharf will have a smaller area dedicated to assembly and larger berth area dedicated to delivery operations, 250 LF and 1,350 LF, respectively.

The wet storage tie-up pier will be a structure used to berth assembled WTD and allow for landside access for component testing, maintenance, etc.

The main function of the delivery berth is to provide berthing, mooring, and offloading capabilities for the delivery vessels and launching of WTD foundations. The assembly berth main functions include staging, and assembly of WTDs.

The selection of the wharf structural foundation pile type is controlled by numerous factors. The main considerations include:

- Bay Shoreline & Habitat Preservation

  Humboldt Bay is an environmentally sensitive area. Gravity-based wharf structures, such as concrete caissons, would disturb and impact a considerable area of the existing sensitive intertidal habitat and vegetation (including eelgrass) along the shoreline of the site and result in a substantial fill and loss of bay substrate. Gravity-based structures were eliminated as an option.

  Pile supported concrete deck structures cause the least environmental impact due to their minimal benthic footprint, though compensatory mitigation will be required for eelgrass impacts. The main environmental impact of pile driving is the noise. This impact can be minimized by implementing noise suppression measures. However, compensatory mitigation may also be required for impacts to aquatic species listed under the state and federal Endangered Species Acts.

- Geotechnical Characteristics of the Site

  Based on SHN's Supplemental Geotechnical Data Report and EMI's Preliminary Geotechnical Memo, the subsurface soil profile at the proposed site is a typical California coast profile consisting of poor near surface soil layers with suitable bearing soil below -80 ft NAVD88.

  For this type of soil profile, a concrete deck supported on piles is the most economical solution. A detailed site exploration program is required to reduce the risk of unplanned costs and claims during the construction phase.

- Economic Considerations

  Economic analysis of alternate structural types will often dictate structural requirements. Design of fixed wharves is usually controlled by live load and lateral load requirements. Given the high live load demand, the pile design is likely to be controlled by the live load with smaller influence from the seismic loads. The wharf structure type selection is limited to concrete deck supported by piles.

Alternative concepts such as concrete caissons and sheet pile bulkheads were not considered because they are not the most economical solution to the topics described above. Specifically, both structure types have poor seismic performance compared to pile supported structures. The constructability of these structure types are more complex than pile supported structures. Cellular sheet pile structures in particular have poor performance for longevity and require more maintenance than pile supported structures. For these reasons they were not considered for this project.

High-capacity piles will be required to transfer the wharves 6,000 psf live load to the deep bearing soil layer. To meet the loading requirements, 24 inch and 30 inch prestressed precast concrete piles were initially considered along with a 36" open ended steel pipe pile. The 30-inch concrete pile was excluded because drivability of a large size displacement pile is expected to be a challenge. The comparison of pile type was limited to 24" concrete piles and 36" steel pile as viable options.

Figure 1 – Structures Layout

2. DESIGN CRITERIA

Table 1 provides a summary of relevant wharf structure design criteria. Detailed design criteria for the wharves are presented in Section 8 of the Preliminary Basis of Design, Sep. 2022.

Table 1 – Summary of Berths Preliminary Design Criteria

Wharf	North Wharf		South Wharf	
	Assembly Berth	Delivery Berth	Assembly Berth	Delivery Berth
Length [ft]	800	800	250	1350
Width [ft]	250	150	250	150
Water Depth [NAVD 88 FT]	-40	-40	-40	-40
Berth Live Load [psf]	6,000	6,000	6,000	6,000

The seismic design criteria is not considered at this stage because the large number of piles required to transfer the live loads to the bearing layer are expected to result in minimal structural damage under Operation Level Earthquake.

3. PILE TYPE EVALUATION

The pile type is generally selected based on local practice, structural requirements, and subsurface conditions; size and length are contingent on soil properties and bearing layers. Pile drivability and other construction considerations are affected by the overall site characterization, including relative density, layering, and soil response to pile driving. The bearing soil layers are located below -80 ft NAVD88. The top layers have different composition and strength. Soft clayey and loose sand layers were encountered under dense sandy silt and silty sand layers.

Concrete piles, being displacement piles, need more driving effort to penetrate dense sandy silt and silty sand layers to reach the bearing soil layer. Driving open ended steel pipe piles through dense layer is less risky if obstructions or remnant timber piles are encountered and will require much less driving effort. While concrete piles would need to be installed exclusively with impact hammers, steel piles can utilize vibratory hammers for the majority of the installation and only use impact hammers at the end of drive to seat the pile.

Based on local practices, preliminary calculations, and M&N/EMI experience with heavy lift wharves, an open-ended, 30-in or 36-in are the most suitable piles for the site. Pile diameter and wall thickness will be defined in the detailed engineering phase. An approximate pile ultimate axial load of 1,900 kips is required to meet the 6,000 psf berth live loading. To achieve this capacity, per EMI's Preliminary Geotechnical Memo, the pile tip elevation will be below -140ft, NAVD 88, with a total length of 150 ft.

For comparison, a 24-in octagonal, prestressed, precast concrete pile design was examined. Concrete pile would need to be driven at smaller spacing and would require approximate ultimate axial load capacity of 850 kips. To achieve this capacity, per EMI's Preliminary Geotechnical Memo, the pile tip elevation will be below -105 ft, NAVD 88, with a total length of 115 ft. Table 2 includes the approximate number of required pile for each wharf.

Another consideration is that the allowable in water work window on this project is expected to be as short as three months. Any reduction to the quantity of piles driven within the work window will reduce the project duration significantly.

Table 2 – Pile Type Evaluation Summary*

Wharf	North Wharf		South Wharf	
	Assembly Berth	Delivery Berth	Assembly Berth	Delivery Berth
Area [ft^2]	200,000	120,000	62,500	202,500
Required No. of 36" Steel Piles [EA]	1,260	780	399	1,313
Required No. of 24" Prestressed Precast Concrete Piles [EA]	2,489	1,495	778	2,523

* Dimensions, layout, and required number of piles are preliminary and will be revised based on future site investigation data.

4. CONCLUSIONS

Based on M&N and EMI's assessment, open-ended steel pipe piles were determined to be the preferred foundation type for both wharves. In general, driving a concrete pile, takes much more effort and time than driving an open-ended steel pile. In addition, the number of concrete piles required to provide adequate load resistance is approximately double the number of steel piles required for each wharf.

Further, drivability risk of concrete piles is higher than open-ended steel piles if obstructions or remnant timber piles are encountered. Therefore, using open-ended steel piles would reduce the construction window and construction risk.

Pile spacings, dimensions, and tip elevation will be further evaluated in view of the future marine subsurface investigation and as the project progresses.

5. LIMITATIONS

The purpose for the work conducted in this phase was to help advance a conceptual design for project planning, initiation of environmental permitting and regulatory processes, and to aid in development of an overall project narrative and budget estimate. Additional geotechnical investigation and analysis will be required in subsequent phases of work to refine and update the results and recommendations outlined in this memorandum.

6. NEXT PHASE CONSIDERATIONS

At the start of the next phase of work, the following are critical steps in the continuation of the planning, analysis, and design work.

- Perform a marine subsurface exploration soil boring and in-situ testing program along with laboratory testing to prepare a subsurface profile at the proposed North Wharf and South Wharf locations. Current phase work is based on a preliminary nearshore geotechnical data collection program. Update of the wharf and pile design will need to be conducted at that time.

- Evaluate the timber wharf demolition strategy relative to risks of remnant timber piles in the substrate for pile driving work. Assessment will include a review of work sequencing of dredging and wharf demolition; methods for pile removal will need to be considered to reduce risks for construction and to outline the construction requirements and procedures for narratives to be captured in the environmental permitting process.

- Determine which types of corrosion protection, as listed in Section 8 of the Basis of Design, are most suitable for the project.

7. REFERENCE DOCUMENTS

- Preliminary Geotechnical Memorandum, EMI 2024
- Supplemental Geotechnical Data Report, SHN 2024
- Wharf Pile Type Selection Memorandum, Moffatt & Nichol, 9/15/2022
- Preliminary Basis of Design, Moffatt & Nichol, Sep. 2022.