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DRAFT MEMORANDUM

To:	Rob Holmlund (Humboldt Bay Harbor, Recreation, and Conservation District)
From:	Michael Jokerst (M&N) and Gary Simpson (SHN)
Date:	March 27, 2024
Subject:	Dense Grade Aggregate Sourcing Memo
Project:	Redwood Marine Multipurpose Terminal Replacement Project
Location:	Eureka, California
M&N Job No.:	212991-03
Cc:	Shane Phillips

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) findings regarding delivery of the backlands aggregate on site. This memorandum is organized as follows:

1. Introduction
2. Methodology
3. Volume Estimate
4. Results
5. Next Phase Considerations
6. Reference Documents

1. INTRODUCTION

The proposed Redwood Marine Multi-Purpose Terminal (RMMT) is being designed as a heavy-lift marine terminal facility to support the offshore wind energy industry and other coastal-dependent industries. The components and equipment that are anticipated to be used at this site will necessitate that the wharf can handle a 6,000 pound per square foot (PSF) loading and the backlands can handle a 3,000 PSF loading.

Because of the transient nature of how the components will be stored and the large scale of the components, the entire backlands area is required to have no fixed structures in the core of the site.

Similar sites that have been designed to meet these demands have used a layer of "dense grade aggregate" (DGA) over compacted soil to achieve 3,000 PSF loading, and used on top of a wharf deck to achieve the 6,000 PSF loading.

This is a cost-effective solution rather than the alternative which would likely be some form of roller compacted concrete or reinforced-steel concrete.

2. METHODOLOGY

Delivering material via barge and offloading with a conveyor system is a more efficient way of getting material on site compared to trucking. Especially if the material can be loaded onto the barge directly from a waterfront quarry. This reduces emissions and has a less expensive unit cost than delivering material via trucks.

A supply of DGA will be needed during Phase 0 of the project to build access roads to the site. It will not be needed on site again until after site preparation of the backlands for Phase 1 which will be multiple years after Phase 0 concludes (reference Constructability Memo). Due to the gap in time, it is most likely that the Phase 0 DGA will be brought to the site via trucking from a local source. The larger quantity of DGA used for the wharf and backlands would likely be supplied via a waterfront quarry and barges.

Additionally, as seen in other wind terminals where DGA is used as a base, there will be some amount of localized settling in areas of long-term storage and along the routes where components are moved. These localized areas will require to be filled with additional DGA as a maintenance action. This volume would most likely be supplied via truck from a local source.

Moffatt & Nichol (M&N) requested the local consultant firm SHN Engineers & Geologists, Inc. to contact local quarries on their ability to supply the dense grade aggregate via trucking.

M&N took charge of contacting regional quarries with water access regarding their ability to supply the project using barges.

Each supplier was provided with the following gradation which is a specification from a similar heavy loading backlands terminal.

M2.01.7: Dense Graded Crushed Stone for Sub-base

This Specification covers the quality and gradation requirements for a sub-base material combining crusher-run coarse aggregates of crushed stone (trap only, meeting M2.01.0,1), and fine aggregates uniformly premixed with a predetermined quantity of water.

Coarse aggregate shall consist of hard, durable particles of fragments of stone. Materials that break up when alternately frozen and thawed or wetted and dried shall not be used.

Coarse aggregate shall have a percentage of wear, by the Los Angeles test, of not more than 45.

Fine aggregate shall consist of natural or crushed sand.

The composite material shall be free from clay, loam or other plastic material, and shall conform to the following grading requirements:

Table M2.01.7-1, Gradation Requirements for Dense Graded Crushed Stone for Sub-base

Sieve Designation	Percentage by Weight Passing Square Mesh Sieves
2 in.	100
1 ½ in.	70-100
¾ in.	50-85
No. 4	30-55
No. 50	8-24
No. 200	3-10

Figure 1: Dense Grade Aggregate Sample Specification

3. VOLUME ESTIMATE

Typically, a 3' section of DGA is required in order for the soil to accept a 3,000 PSF loading. To reduce the amount of required DGA, Moffatt & Nichol had conversations with a geo-grid supplier, Tensar Corp, who is confident they can achieve a 3,000 PSF section with only 18" of DGA if two layers of their geo-grid product are used in the section. This concept needs to be vetted in the next phase of work once more site-specific geotechnical data is collected. However, it is likely the section can be reduced from 3' which will reduce the amount of DGA material that needs to be brought on site, as well as improve the wharf design seismically by reducing the weight of the structure. The reduced amount of DGA in the backlands would be replaced with surcharge material as an additional cost savings. Without detailed analysis it can be inferred this is an option that will be utilized in the design but must be confirmed.

For the purposes of permitting, a 3' section of DGA is assumed and further refinement of the section will occur in subsequent phases of the design based on more comprehensive geotechnical data collection and more detailed analysis.

There will also be a need for an additional volume of DGA that will be used for maintenance, repairing any localized settling from long term storage of Wind Turbine Generator (WTG) components.

Per the Preliminary Geotechnical Memo (EMI, 2024), the site is expected to settle up to 36" from the site fill and the 3,000 PSF component loads. There are two ways the site will settle. The first is by pre-loading the area with a surcharge to induce settlement. Surcharge material will be used as fill to replace the settled volume. The second way the site will settle will be from site operations (long-term storage of WTG components for 12-to-18-month periods), DGA will be used to replace this settled volume as a maintenance task. How much of the 36 inches of settlement should occur in which phase is dependent on cost and time impacts of building the surcharge, cost of using surcharge as fill versus importing DGA, as well as operational settlement requirements from the tenant Operator.

Based on prior Moffatt & Nichol experience, components cannot settle more than 2-3" while they are stored. It is expected more than 2-3" of settlement would occur during the 12-18 month storage period, so it is recommended to eliminate all but that amount during the pre-load surcharge phase. If after confirming with operators that the allowable settlement requirements are not as strict, or if storage periods are for a shorter duration than anticipated, there is potential to reduce the amount of initial pre-loading and instead allow for more settlement to occur during the operation phase. In this scenario multiple settlement events (i.e. storing then removing a component) could occur during the operations phase and DGA material would be placed back to restore the site grade after each event.

For purposes of estimating a maintenance repair volume, it is assumed that every 2 years 20% of the site will experience localized settling of 2" from storage of components. There will be a one-time repair of these locations. As operations turn over on the site it can be assumed a different 20% of the site will experience localized settling and another one-time repair of the new locations will be required. The upper limit of repairs for the lifetime of the site will be determined by the amount of settlement remaining after the pre-load operation. Two potential scenarios are provided in Table 3 below, one for 3" which is the likely scenario, and the second is for 6" which is an estimate for a reasonable allowable settlement if more than 3" might be acceptable. This value would need to be confirmed by an operator but is provided here to help gain perspective on potential volumes of DGA that may be required for maintenance.

Finally, it is assumed that an additional 15% of the delivered material will be required to satisfy the "neat line take off" or in-place volume once the material is compacted.

Table 2: Approximate Quantity Delivered from Local Sources

	Approx. Footprint (SY)	DGA Required if 18" Section (CY)	DGA Required if 3' Section (CY)
Phase 0	42,000	24,150	48,300
Total	42,000	24,150	48,300

Table 2: Approximate Quantity Delivered from Regional Waterfront Quarries

	Approx. Footprint (SY)	DGA Required if 18" Section (CY)	DGA Required if 3' Section (CY)
Phase 1	193,600	111,300	222,600
Phase 2	474,320	272,700	545,400
Total	667,920	384,000	768,000

Table 3: Approximate Quantity Delivered from Local Sources for Maintenance

	Approx. Footprint (SY)	DGA Required per Repair Event(1) (CY)	Total DGA Required for Site Maintenance if 3" Remaining Settlement(2) (CY)	Total DGA Required for Site Maintenance if 6" Remaining Settlement(2) (CY)
Phase 1	193,600	2,470	18,550	37,100
Phase 2	474,320	6,060	45,450	90,900
Total	667,920	8,530	64,000	128,000

1) Repair event defined as 20% of the footprint and a 2" thick layer of replacement
2) Upper limit based on entire footprint eventually being used, and 6" of settlement (15 events)

4. RESULTS

Local Sources:

There are two local quarries which would be able to supply the specified DGA.

- Liscom Hill Quarry in Blue Lake, CA approximately 18 miles east of the project site
- R. Brown & Sons Quarry in Willow Creek, CA approximately 45 miles east of the project site

R. Brown Construction Co. Inc operates both quarries. They have indicated producing the DGA is feasible but stockpiling of material would be the limiting factor to supply the project. Stockpiling of material on the project site should be considered as part of the construction.

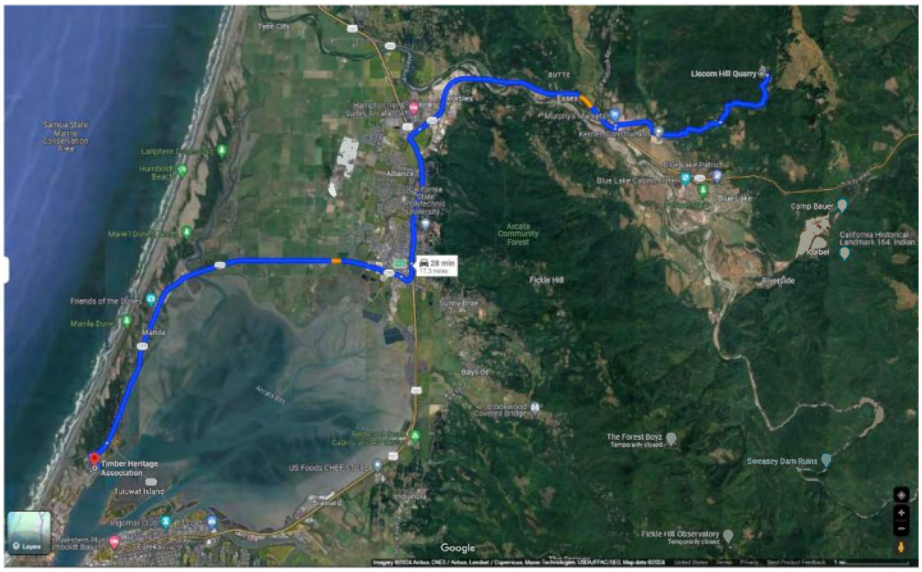

Figure 2: Location of Liscom Hill Quarry Relative to Project Site

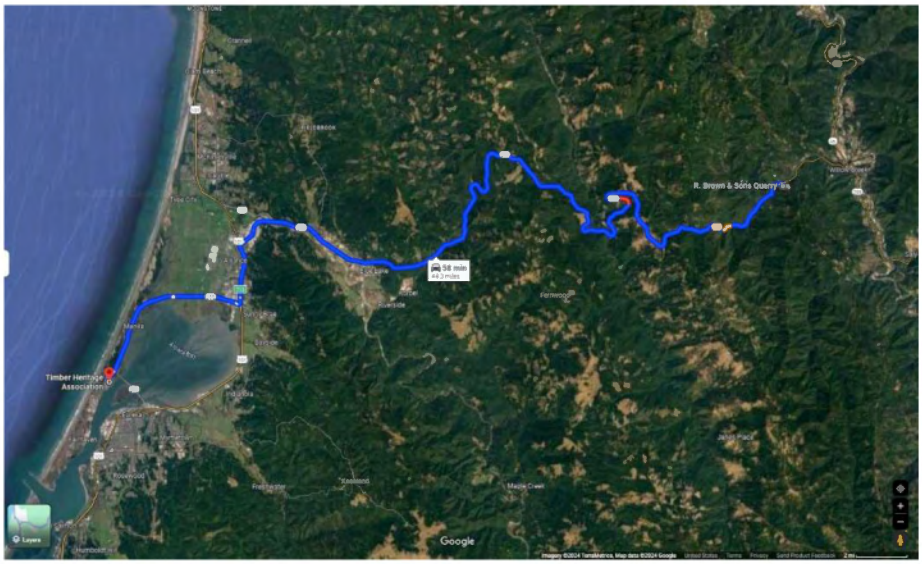

Figure 3: Location of R. Brown & Sons Quarry Relative to Project Site

Regional Sources:

Unfortunately, many quarries have shut down in recent years. Moffatt & Nichol reached out to multiple quarries and received varying responses to their ability to supply the project. There were two suppliers who replied and can supply the project but declined to provide much more insight because the project was too far in the future.

These suppliers should be followed up with in the next phase to gain more insight on their capabilities and identify potential efficiencies for the project.

- Polaris Materials (a subsidiary of Vulcan Material Company)
    - Multiple locations in the Northern California Area and British Columbia, Canada
- Coast Mountain Resources (Granite Construction)
    - Located in British Columbia, Canada

For purposes of project permitting, it is recommended to consider a combination of land and marine barge transportation to construct the project.

Based on the estimates above the volume of DGA delivered via truck will vary between 88,150 and 176,300 cubic yards depending on the design thickness of the DGA and the amount of maintenance required. The time frame will be the beginning of Phase 0 through as many as 30 years after the site become operational.

Based on the estimates above the volume of DGA delivered via barge with vary between 384,000 and 768,000 cubic yards depending on the design thickness of the DGA. The time frame will be towards the end of construction of the Phase 1 and Phase 2 projects, respectively, once pre-loading is complete and the site is graded.

5. 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.

- Gather additional soil data and provide information to Tensar so they can develop a cross section that will reduce the required DGA from 3’ to 18”.
- Continue outreach to suppliers to determine more definitive production rates and constraints.
- Refine remaining soil settlement after pre-loading and refine quantity of remaining DGA required for maintenance as well as need for stockpile or local sourcing
- Develop cost comparisons between supply method (truck versus barge) and confirm most cost efficient method
- Develop and confirm cost savings using two geogrid layers versus additional DGA depth
- Confirm federal funding limitations on Buy America relative to sourcing of aggregates for barge delivery.
- Refine “two-step” settlement mitigation process (preload and post component storage maintenance DGA) based on industry provided settlement component criteria for safe storage.

6. REFERENCE DOCUMENTS

- Constructability Memo (M&N, 2024)
- Preliminary Geotechnical Memo (EMI, 2024)

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