Report No. 04.10120193-3 – Revision No. 3,
May 14, 2015

Lockwood, Andrews & Newnam, Inc. 2925
Briarpark Drive, Suite 400
Houston, Texas 77042-3720

Attention: Mr. Jon Jelinek, P.E.
Associate, Facilities Team Leader

Additional Geotechnical Consultation Services
Berth 6 Expansion
Port of Port Arthur
Port Arthur, Texas

Introduction

Fugro Consultants, Inc. (Fugro) is pleased to present this supplement report regarding additional geotechnical consultation services for the proposed Port of Port Arthur Berth 6 Expansion in Port Arthur, Texas. Mr. Percy R. James, P.E. with Lockwood, Andrews & Newman, Inc. (LAN) requested our additional services in an e-mail to Mr. Nathan S. Daniels, P.E. of Fugro on November 21, 2014. Mr. Dennis J. Turner, P.E. and Ms. Julia P. Clarke, P.E. met with LAN representatives on December 2, 2014 to discuss the additional services. An additional meeting between Mr. Turner and Mr. James was held on March 4, 2015 to discuss revisions to our previous supplement reports. Our additional services were authorized under Work Authorization No. 120-10849-016-000, Additional Services Authorization No. 3, dated December 4, 2014. Our additional services were performed in general accordance with Fugro Proposal No. 04.10120193-4p-Rev 2 dated December 3, 2014.

This revised supplement report supersedes our previous supplement reports, should be used along with the recommendations presented in Fugro Report No. 04.10120193 dated April 11, 2013 and Fugro Report No. 04.10120193-2 dated November 5, 2013, and not as a stand-alone document.

Project Description. We understand that the Port of Port Arthur is planning to expand an existing wharf located along the Sabine-Neches Ship Channel in Port Arthur, Texas. The expansion will include construction of Berth 6, a 61.5-foot wide, 600-foot long extension of the existing wharf and additional bulkhead wall with an accompanying anchor wall. The project also includes modifications to approximately 200 feet of existing bulkhead and anchor wall system that falls within the footprint of the Berth 6 expansion. We understand that the existing bulkhead retrofit will include a new combination wall 18-inch H-Piles and steel sheet piles. The proposed new bulkhead will include a combination wall with 48-inch diameter steel pipe piles and infilled steel sheet piles.
In addition, LAN has requested that we include the existing relieving platform piles and proposed wharf piles in our global stability analysis. We recommend LAN consider the potential effects on these piles from any loads applied by the bulkhead and retained soil. The various pile types and material properties are presented in Table 1 below:

<table>
<thead>
<tr>
<th>Piles</th>
<th>Transverse Spacing (ft)</th>
<th>Pile Shear Strength (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-inch Square Concrete Piles</td>
<td>9.5</td>
<td>35,000</td>
</tr>
<tr>
<td>24-inch Square Prestressed Concrete Piles</td>
<td>14</td>
<td>82,000</td>
</tr>
<tr>
<td>54-inch Diameter Prestressed Concrete Piles</td>
<td>14</td>
<td>78,000</td>
</tr>
<tr>
<td>18-inch H-Piles</td>
<td>8.25</td>
<td>249,000</td>
</tr>
<tr>
<td>48-inch Diameter Steel Pipe Piles</td>
<td>8.8</td>
<td>1,447,000</td>
</tr>
</tbody>
</table>

We further understand that a future pavement section will be constructed for the laydown area behind the bulkhead structure. The pavement will likely be composed of a 12-inch thick reinforced concrete section overlying 30-inch thick light weight aggregate (LWA) or a conventional granular backfill (e.g. sand).

The requested additional global stability analysis cases are grouped as follows:

- **Case A** – Proposed Retrofit of Existing Bulkhead with Relieving Platform
  - LWA Pavement Subgrade
- **Case B** – Proposed Retrofit of Existing Bulkhead with Relieving Platform
  - Conventional Pavement Subgrade
- **Case C** – Proposed Retrofit of Existing Bulkhead without Relieving Platform
  - LWA Pavement Subgrade
- **Case D** – Proposed Retrofit of Existing Bulkhead without Relieving Platform
  - Conventional Pavement Subgrade
- **Case E** – Proposed New Bulkhead
  - LWA Pavement Subgrade
- **Case F** – Proposed New Bulkhead
  - Conventional Pavement Subgrade
Global Stability Analysis

Our additional global stability analyses were performed using the SLIDE software program with the soil parameters presented in Fugro Report Nos. 04.10120193 and 04.10120193-2, and information provided to us by LAN regarding the pile and sheet pile configurations and material properties. Please note that assessments of the condition and structural design of the existing bulkhead structure or the structural design of the proposed bulkhead structure are beyond the scope of our services.

The selection of geotechnical parameters and our method of analyses are in general accordance with the guidelines outlined in the United States Army Corps of Engineers (USACE) EM 1110-2-2504\(^1\), Naval Facilities Engineering Command (NAVFAC) DM 7.2\(^2\), and our experience with similar structures and subsurface conditions. The proposed bulkhead wall should be evaluated for short-term, long-term, and rapid drawdown conditions. Our experience has shown that long-term conditions are often the most critical. For satisfactory performance, the proposed dredge slope underneath the deck and shoreline slope should have an acceptable factor of safety during their entire projected time of service. Factors of safety for all potential loading conditions and modes of failure should be considered. The following paragraphs discuss each stability condition that should be analyzed.

**Short-Term (Undrained).** Short-term (undrained) loading conditions models the soil condition during and immediately following construction. EM 1110-2-2504 indicates that the end of construction usually represents the critical short-term (undrained) loading condition for bulkhead walls. For this loading condition, any excess pore pressures developed during construction activities have not had the opportunity to dissipate. A factor of safety of at least 2 should be applied to the passive soil pressures for this loading condition according to EM 1110-2-2504. In general accordance with USACE EM 1110-2-1913\(^3\), we recommend a minimum factor of safety of 1.3 for global stability in short-term conditions. We performed our analysis with an assumed water surface elevation at El. +0.83 feet at the bulkhead wall sloping to the ground surface at El. +15 feet behind the face of the wall.

**Long-Term (Drained).** The long-term (drained) loading condition models the soils after excess pore water pressures have dissipated to post-construction equilibrium and post-construction consolidation of the cohesive soils has taken place. EM 1110-2-2504 indicates that a factor of safety of 1.5 should be applied to the passive soils pressures for long-term conditions. In general

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\(^1\) Design of Sheet Pile Walls, EM 1110-2-2504, 31 March 1994, United States Army Corps of Engineers.


\(^3\) Design and Construction of Levees, EM 1110-2-1902, 30 April 2000, United States Army Corps of Engineers, Washington, D.C.
accordance with USACE EM 1110-2-1913, we recommend a minimum factor of safety of 1.5 for global stability in long-term conditions. Our long-term analysis modeled the depth-of-water using the same assumptions as used in our short-term analyses. It should be noted that relatively minor differences in the selected soil parameters for long-term analysis can have a significant impact on the results of our analyses.

**Rapid Drawdown.** Under certain circumstances, many slopes along rivers, creeks, bayous, channels, and basins are subject to rapid drops in the water level. This condition is known as rapid drawdown and causes seepage stresses in the slope that require special attention. Long-term (drained) soil parameters are used in evaluating this loading condition. In general accordance with USACE EM 1110-2-1913, we recommend a minimum factor of safety of 1.0 for global stability in rapid drawdown conditions. In our rapid drawdown analysis, it is assumed that the water surface elevation is at El. +15 feet behind the face of the bulkhead wall and suddenly drops down to El. +0.83 feet at the bulkhead wall.

**Combination Wall – Infill Steel Sheet Piles.** LAN also requested Fugro recommend minimum tip elevations for the infilled steel sheet pile sections based on global stability for the existing and proposed bulkhead walls as provided in Fugro Report No. 04.10120193 for previously considered design cases. As indicated in Fugro Report 04.10120193, we recommend that the steel sheet pile section extend to a depth to provide a minimum factor of safety for global stability (without King Piles) of 1.0 for short-term conditions and 1.1 for long term conditions. We also recommend that steel sheet piles extend at least 10 feet below the planned future dredge depth of the channel in front of the bulkhead wall, which we understand to be El. +50 feet.

Please note that in our analysis for the retrofit of the existing bulkhead structure, the steel sheet piling was required to extend to the same tip elevation as the H-Piles, which coincides with embedding the sheet piles and H-Piles approximately 5 feet into the sand layer anticipated at El. -83 feet.

**Global Stability Analysis Results Summary.** A summary of our global stability analyses are presented below in Table 2. Please note that internal design requirements, other structural loading conditions, and minimum embedment depths may control the design of the bulkhead walls and minimum pile tip elevations.
### Table 2. Global Stability Analysis Summary

<table>
<thead>
<tr>
<th>Analysis Case</th>
<th>Controlling Load Condition</th>
<th>Minimum Sheet Pile Tip Elevation (feet)</th>
<th>Minimum King Pile Tip Elevation (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case A – Existing Bulkhead</td>
<td>Long-Term</td>
<td>El. -88</td>
<td>El. -88</td>
</tr>
<tr>
<td>Case B – Existing Bulkhead</td>
<td>Long-Term</td>
<td>El. -88</td>
<td>El. -88</td>
</tr>
<tr>
<td>Case C – Existing Bulkhead</td>
<td>Long-Term</td>
<td>El. -88</td>
<td>El. -88</td>
</tr>
<tr>
<td>Case D – Existing Bulkhead</td>
<td>Long-Term</td>
<td>El. -88</td>
<td>El. -88</td>
</tr>
<tr>
<td>Case E – Proposed Bulkhead</td>
<td>Long-Term</td>
<td>El. -62</td>
<td>El. -89</td>
</tr>
<tr>
<td>Case F – Proposed Bulkhead</td>
<td>Long-Term</td>
<td>El. -62</td>
<td>El. -90</td>
</tr>
</tbody>
</table>

**Use of Lightweight Aggregate (LWA)**

Our sensitivity analysis of various combinations of lightweight aggregate (LWA) and conventional backfill indicates that there is minimal impact to global stability with the use of lightweight aggregate in the active wedge behind the bulkhead wall and as a pavement subgrade. However, based on our experience, the use of lightweight aggregate will have a greater impact to the required steel sheet pile section, anchor loads, long-term settlements, and project costs.

Fugro previously performed a settlement analysis for the proposed laydown area or storage yard behind the proposed Berth 6 to evaluate the impact of the site grade raise and a design live load of 1,000 psf on the laydown area and anchor rods. Based on our review of our previous analysis and current understanding of replacing approximately 3.5 feet of material with a pavement structure, we do not anticipate a significant increase in settlements beyond those presented in Fugro Report No. 04.10120193-2 dated November 5, 2013.
The following appendices of our global stability analyses are attached and complete this report:

Appendix A
Existing Bulkhead Retrofit, Relieving Platform, LWA Pavement Subgrade ..........A-1 thru A-3

Appendix B
Existing Bulkhead Retrofit, Relieving Platform, Sand Pavement Subgrade ..........B-1 thru B-3

Appendix C
Existing Bulkhead Retrofit, No Relieving Platform, LWA Pavement Subgrade ....... C-1 thru C-3

Appendix D
Existing Bulkhead Retrofit, No Relieving Platform, Sand Pavement Subgrade ....... D-1 thru D-3

Appendix E
Proposed Bulkhead, LWA Pavement Subgrade .......................................................E-1 thru E-5

Appendix F
Proposed Bulkhead, Sand Pavement Subgrade .......................................................F-1 thru F-5
Closing

We appreciate the opportunity to be of continued service to Lockwood, Andrews & Newnam, Inc. Please call us at 713-369-5400 if you have any questions concerning this supplement letter report.

Sincerely,

FUGRO CONSULTANTS, INC.
TBPE Firm Registration No. F-299

Luis Perez-Milicua, E.I.T.
Senior Project Professional

Dennis J. Turner, P.E.
Engineering Manager

Copies Submitted: Electronic PDF Document (1)
APPENDIX A

EXISTING BULKHEAD RETROFIT, RELIEVING PLATFORM, LWA PAVEMENT SUBGRADE
APPENDIX B

EXISTING BULKHEAD RETROFIT, RELIEVING PLATFORM, SAND PAVEMENT SUBGRADE
APPENDIX C

EXISTING BULKHEAD RETROFIT, NO RELIEVING PLATFORM, LWA PAVEMENT
SUBGRADE
1.39

1.39

W (Initial)

W (Final)

1000.00 lbs/ft²

El. -165

El. -153

El. -138

El. -33

El. -43

El. -83

Sand

Silty Sand

Stiff Clay 1

Sandy Silt

Stiff Clay 2

Very Stiff Clay

Support Name | Color | Type | Force Application | Out-Of-Plane Spacing | Pile Shear Strength
---|---|---|---|---|---
54" Diameter Prestressed Concrete Piles | Micro Pile | Passive (Method B) | 14 | 78000
18-inch H-Piles | Micro Pile | Passive (Method B) | 9 | 249000
24" Square Prestressed Concrete Piles | Micro Pile | Passive (Method B) | 14 | 82000

Material Name | Color | Unit Weight (lbs/ft³) | Strength Type | Cohesion (lb/ft²) | RD | Water Surface
---|---|---|---|---|---|---
Sand | 120 | Mohr-Coulomb | 0 | 30 | Yes | Water Surface
Firm Clay | 120 | Mohr-Coulomb | 90 | 18 | Yes | Water Surface
Stiff Clay 1 | 120 | Mohr-Coulomb | 150 | 20 | Yes | Water Surface
Stiff Clay 2 | 120 | Mohr-Coulomb | 200 | 22 | Yes | Water Surface
Sheet Pile Wall | 120 | Infinite strength | No | None
Structural Sand Backfill | 115 | Mohr-Coulomb | 0 | 28 | Yes | Water Surface
Silty Sand | 115 | Mohr-Coulomb | 0 | 28 | Yes | Water Surface
Very Stiff Clay | 120 | Mohr-Coulomb | 250 | 22 | Yes | Water Surface
Sandy Silt | 120 | Mohr-Coulomb | 0 | 30 | Yes | Water Surface
Lightweight Aggregate | 70 | Mohr-Coulomb | 0 | 35 | No | Water Surface
Concrete Pavement | 150 | Mohr-Coulomb | 5000 | 0 | No | Water Surface

Safety Factor

0.00

0.25

0.50

0.75

1.00

1.25

1.50

1.75

2.00

2.25

2.50

2.75

3.00

3.25

3.50

3.75

4.00

4.25

4.50

4.75

5.00

5.25

5.50

5.75

6.00+

Company

Fugro Consultants, Inc.

Scale

1:600

Date

March 12, 2015

Project

BERTH 6 EXPANSION

Analysis Description

Global Stability - Existing Retrofit - Rapid Draw Down - Combination Wall - Lightweight Aggregate

Drawn By

Dennis Turner, P.E.
APPENDIX D

EXISTING BULKHEAD RETROFIT, NO RELIEVING PLATFORM, SAND PAVEMENT SUBGRADE
1.52
1.52
1000.00 lbs/ft²

El. -165
El. -153
El. -138
El. -33
El. -83
El. -108
El. -138
El. -153
El. -165

[Diagram of soil layers and support structures]

**Material Name** | **Color** | **Unit Weight (lbs/ft³)** | **Strength Type** | **Cohesion (lb/ft²)** | **Pile** | **Water Surface**
--- | --- | --- | --- | --- | --- | ---
Sand | | 120 | Mohr-Coulomb | 0 | 30 | Water Surface
Firm Clay | | 120 | Mohr-Coulomb | 90 | 18 | Water Surface
Stiff Clay 1 | | 120 | Mohr-Coulomb | 150 | 20 | Water Surface
Stiff Clay 2 | | 120 | Mohr-Coulomb | 200 | 22 | Water Surface
Sheet Pile Wall | | | Infinite strength | None | | None
Structural Sand Backfill | | 115 | Mohr-Coulomb | 0 | 28 | Water Surface
Silty Sand | | 115 | Mohr-Coulomb | 0 | 28 | Water Surface
Very Stiff Clay | | 120 | Mohr-Coulomb | 250 | 22 | Water Surface
Sandy Silt | | 120 | Mohr-Coulomb | 0 | 30 | Water Surface

**Support Name** | **Color** | **Type** | **Force Application** | **Out-Of-Plane Spacing** | **Pile Shear Strength**
--- | --- | --- | --- | --- | ---
54" Diameter Prestressed Concrete Piles | | Micro Pile | Passive (Method B) | 14 | 78000
18-inch H-Piles | | Micro Pile | Passive (Method B) | 8.25 | 249000
24" Square Prestressed Concrete Piles | | Micro Pile | Passive (Method B) | 14 | 82000
16" Square Concrete Piles | | Micro Pile | Passive (Method B) | 9.5 | 35000

**Analysis Description**
Global Stability - Existing Retrofit - Long Term - Combination Wall - Structural Sand Backfill

**Drawn By**
Dennis Turner, P.E.

**Date**
March 12, 2015

**Company**
Fugro Consultants, Inc.
APPENDIX E
PROPOSED BULKHEAD, LWA PAVEMENT SUBGRADE
<table>
<thead>
<tr>
<th>Support Name</th>
<th>Color</th>
<th>Type</th>
<th>Force Application</th>
<th>Out-Of-Plane Spacing</th>
<th>Pile Shear Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>54&quot; Diameter Prestressed Concrete Piles</td>
<td>Micro Pile</td>
<td>Passive (Method B)</td>
<td>14</td>
<td>78000</td>
<td></td>
</tr>
<tr>
<td>24&quot; Square Prestressed Concrete Piles</td>
<td>Micro Pile</td>
<td>Passive (Method B)</td>
<td>14</td>
<td>82000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Color</th>
<th>Unit Weight (lbs/ft³)</th>
<th>Strength Type</th>
<th>Cohesion (lb/ft²)</th>
<th>Phi</th>
<th>Water Surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Clay 1</td>
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<td>120</td>
<td>Mohr-Coulomb</td>
<td>800</td>
<td>0</td>
<td>Water Surface</td>
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<tr>
<td>Stiff Clay 1</td>
<td></td>
<td>120</td>
<td>Mohr-Coulomb</td>
<td>1000</td>
<td>0</td>
<td>Water Surface</td>
</tr>
<tr>
<td>Sand</td>
<td></td>
<td>115</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>25</td>
<td>Water Surface</td>
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<tr>
<td>Firm Clay 2</td>
<td></td>
<td>120</td>
<td>Mohr-Coulomb</td>
<td>800</td>
<td>0</td>
<td>Water Surface</td>
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<tr>
<td>Sheet Pile Wall</td>
<td></td>
<td>120</td>
<td>Infinite strength</td>
<td>None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Rip-rap</td>
<td></td>
<td>120</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>35</td>
<td>Water Surface</td>
</tr>
<tr>
<td>Structural Sand Backfill</td>
<td></td>
<td>115</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>28</td>
<td>Water Surface</td>
</tr>
<tr>
<td>Stiff Clay 2</td>
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<td>120</td>
<td>Mohr-Coulomb</td>
<td>1700</td>
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<td>Water Surface</td>
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<td>Lightweight Aggregate</td>
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<td>Water Surface</td>
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<td>Concrete Pavement</td>
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<td>150</td>
<td>Mohr-Coulomb</td>
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<td>0</td>
<td>Water Surface</td>
</tr>
</tbody>
</table>

**Analysis Description**

Global Stability - Proposed Structure - Short Term - Sheet Pile Wall - Lightweight Aggregate

**Drawn By**

Dennis Turner, P.E.

**Scale**

1:600

**Company**

Fugro Consultants, Inc.

**Date**

March 12, 2015

**Project**

BERTH 6 EXPANSION
### Material Properties

<table>
<thead>
<tr>
<th>Material Name</th>
<th>Color</th>
<th>Unit Weight (lbs/ft³)</th>
<th>Strength Type</th>
<th>Cohesion (lb/ft²)</th>
<th>Phi</th>
<th>Water Surface</th>
<th>Hu Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Clay 1</td>
<td>⬤</td>
<td>120</td>
<td>Mohr-Coulomb</td>
<td>90</td>
<td>18</td>
<td>Water Surface</td>
<td>Constant</td>
</tr>
<tr>
<td>Stiff Clay 1</td>
<td>⬤</td>
<td>120</td>
<td>Mohr-Coulomb</td>
<td>100</td>
<td>22</td>
<td>Water Surface</td>
<td>Constant</td>
</tr>
<tr>
<td>Sand</td>
<td>⬤</td>
<td>115</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>25</td>
<td>Water Surface</td>
<td>Constant</td>
</tr>
<tr>
<td>Stiff Clay 2</td>
<td>⬤</td>
<td>120</td>
<td>Mohr-Coulomb</td>
<td>90</td>
<td>18</td>
<td>Water Surface</td>
<td>Constant</td>
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<tr>
<td>Sheet Pile Wall</td>
<td>⬤</td>
<td>120</td>
<td>(infinite strength)</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete Rip-rap</td>
<td>L</td>
<td>120</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>35</td>
<td>Water Surface</td>
<td>Constant</td>
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<tr>
<td>Structural Sand Backfill</td>
<td>L</td>
<td>115</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>28</td>
<td>Water Surface</td>
<td>Constant</td>
</tr>
<tr>
<td>Stiff Clay 2</td>
<td>G</td>
<td>120</td>
<td>Mohr-Coulomb</td>
<td>200</td>
<td>22</td>
<td>Water Surface</td>
<td>Constant</td>
</tr>
<tr>
<td>Lightweight Aggregate</td>
<td>N</td>
<td>70</td>
<td>Mohr-Coulomb</td>
<td>0</td>
<td>35</td>
<td>Water Surface</td>
<td>Constant</td>
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<tr>
<td>Concrete Pavement</td>
<td>N</td>
<td>150</td>
<td>Mohr-Coulomb</td>
<td>5000</td>
<td>0</td>
<td>Water Surface</td>
<td>Constant</td>
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</table>

### Support Conditions

<table>
<thead>
<tr>
<th>Support Name</th>
<th>Color</th>
<th>Type</th>
<th>Force Application</th>
<th>Out-Of-Plane Spacing</th>
<th>Pile Shear Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>54” Diameter Prestressed Concrete Piles</td>
<td>⬤</td>
<td>Micro Pile</td>
<td>Passive (Method B)</td>
<td>14</td>
<td>78000</td>
</tr>
<tr>
<td>24” Square Prestressed Concrete Piles</td>
<td>⬤</td>
<td>Micro Pile</td>
<td>Passive (Method B)</td>
<td>14</td>
<td>82000</td>
</tr>
<tr>
<td>48” Diameter Steel Pipe Pile</td>
<td>G</td>
<td>Micro Pile</td>
<td>Passive (Method B)</td>
<td>8.8</td>
<td>1.447e+006</td>
</tr>
</tbody>
</table>

- **Safety Factor**
  - 0.00
  - 0.25
  - 0.50
  - 0.75
  - 1.00
  - 1.25
  - 1.50
  - 1.75
  - 2.00
  - 2.25
  - 2.50
  - 2.75
  - 3.00
  - 3.25
  - 3.50
  - 3.75
  - 4.00
  - 4.25
  - 4.50
  - 4.75
  - 5.00
  - 5.25
  - 5.50
  - 5.75
  - 6.00
  - 6.00+

- **Analysis Description**
  - Global Stability - Proposed Structure - Long Term - Combination Wall - Lightweight Aggregate

- **Drawn By**
  - Dennis Turner, P.E.

- **Date**
  - March 12, 2015

- **Company**
  - Fugro Consultants, Inc.
APPENDIX F

PROPOSED BULKHEAD, SAND PAVEMENT SUBGRADE
Material Name                  Color  Unit Weight (lbs/ft^3)  Strength Type  Cohesion (lb/ft^2)  Phi  Water Surface
Firm Clay 1                      120  Mohr-Coulomb         90            18   Water Surface
Stiff Clay 1                    120  Mohr-Coulomb        100           22   Water Surface
Sand                             115  Mohr-Coulomb          0            25   Water Surface
Firm Clay 2                      120  Mohr-Coulomb         90            18   Water Surface
Sheet Pile Wall                  120  Infinite strength      None                      None
Concrete Rip-rap                 120  Mohr-Coulomb          0            35   Water Surface
Structural Sand Backfill        115  Mohr-Coulomb          0            28   Water Surface
Stiff Clay 2                      120  Mohr-Coulomb        200           22   Water Surface
Concrete Pavement             150  Mohr-Coulomb       5000            0   Water Surface