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MEMORANDUM

3 January 2013
File No. 39281-000

TO: Scott Simons Architects
Austin K. Smith, AIA, RLA, LEED AP

C: Becker Structural Engineers, Inc.: Nathan Merrill, P.E.
Woodard & Curran: Lauren Swett, P.E., David Senus, P.E.

FROM: Haley & Aldrich, Inc.
Bryan C. Steinert, P.E., Wayne A Chadbourne, P.E.
BCS

SUBJECT: Geotechnical Design Memorandum
Proposed Building Addition
CBITD Ferry Terminal
Portland, Maine

This memorandum presents geotechnical design recommendations and construction considerations for the proposed building addition to the Casco Bay Island Transit District (CBITD) Ferry Terminal in Portland, Maine. A geotechnical data report summarizing the results of our geotechnical site investigation and laboratory testing program was issued on 16 November 2012. The data report also provided a summary of the subsurface conditions at the site as determined from both historic and recent test borings.

We have coordinated our work with the following project team members:

Casco Bay Lines (CBL)	Owner
Scott Simons Architects (SSA)	Architect
Becker Structural Engineers, Inc. (BSE)	Structural Engineer
Woodard & Curran (W&C)	Civil Engineer

ELEVATION DATUM

Elevations referenced herein and shown on the attached figures are in feet and reference Mean Lower Low Water (MLLW). Tidal datum relationships at the site (in feet) are as follows:

El. 0 (MHHW) =	El. 9.91 MLLW
El. 0 (NAVD 88) =	El. 5.26 MLLW
El. 0 (MSL) =	El. 4.94 MLLW

Please note that this tidal information is taken from National Oceanic Atmospheric Administration (NOAA) tidal station No. 8418150 located on the Maine State Pier, Portland, Maine. This is the closest NOAA tidal station to the project site.

GEOTECHNICAL ENGINEERING RECOMMENDATIONS

This section, intended primarily for members of the design team responsible for design of the structures and preparation of contract documents, provides geotechnical design recommendations for foundation design of the proposed building addition. In general, design and construction of the proposed development should be completed in accordance with the requirements of the 2009 International Building Code (IBC Code).

Please note that the recommendations outlined herein are based on a lowest level floor slab equal to El. 16.90 (MLLW datum) unless otherwise noted.

Reuse of Existing Pile Foundation System

The existing terminal building is supported on steel pipe piles that were driven to practicable refusal in/on glacial till or bedrock. Based on the concept plans provided by SSA and BSE, it is our understanding that a portion of the existing building will be demolished to create space for the new building addition (see attached Figure 1). The columns for the new building were laid out so that the existing piles can be reused to support the new addition. Similarly, the floor slab in these areas will be reused to the extent possible. The existing floor slab is a structural slab supported by the existing pipe piles.

Based on our review of historic construction documents, we understand that the piles consist of 150-kip design capacity, 12.75-in. outside diameter pipe piles with a 0.33-in. thick wall. We also understand that the piles were driven open-ended and filled with concrete upon completion of driving. Three piles were dynamically tested during construction of the initial CBITD building in the general vicinity of the proposed addition footprint. These tests were conducted to confirm that the piles had been driven to the minimum required ultimate capacity without damage caused by pile overstress. The piles were installed using a Delmag D22 single-acting diesel hammer with a maximum rated energy equal to approximately 40 kip-ft. A summary of the dynamic test results is provided below.

Pile No.	Pile Penetration[1] (ft)	Ultimate Capacity (kips)			Design Capacity[2] (kips)
		Side Friction	End Bearing	Total	
N-2/113	137	100	209	309	155
M+4/119	135	-	-	320	160
M+4/125	149	129	180	309	155

[1] – Relative to ground surface prior to construction of existing Terminal Building
[2] - Based on a factor of safety equal to 2.0

Preliminary unfactored column reactions for the proposed addition were provided by BSE on 19 November 2012 and are summarized below. It is our understanding that these reactions do not include load contribution from dead and live loads associated with the ground floor slab.

Load	Magnitude (kips)[1]	
	Minimum	Maximum
Axial Compression	8	83
Axial Tension (Uplift)[2]	0	15
Lateral	0	15

[1] – 1 kip = 1,000 lbs.
[2] – Lateral and uplift loads do not occur at each column location.

Based on a comparison between existing pile compressive resistance and the preliminary unfactored compression demand summarized above, it is our opinion that the existing piles are capable of resisting the proposed compressive loads. In addition, we back-calculated the minimum required unit frictional resistance along the embedded pile length needed to resist the 15-kip (maximum) uplift load (33 kips per square foot; ksf). Based on our evaluations and experience, it is our opinion that the soil present along the existing embedded pile length will provide sufficient resistance to support the preliminary uplift loads. Finally, based on discussions with BSE, we understand that lateral loads will be resisted by frictional resistance between substructure elements and the surrounding soil. Therefore, lateral resistance from the existing piles will not be needed.

We recommend that BSE evaluate the structural design of the existing pile caps and grade beams to confirm that they are sufficient for reuse.

Settlement in Areas of Raises in Grade

Based on our review of existing and proposed grading plans prepared by W&C, it is our understanding that fill placement will be required to raise site grades within and around the proposed building footprint. The thickness of fill ranges from approximately 1 ft in the northwest corner of the proposed building footprint to approximately 2.5 ft in the northeast corner. Placement of normal-weight earthfill will cause elastic compression of man-placed fill soils and consolidation settlement of the harbor bottom and marine clay soils underlying the site. As a result, evaluations were conducted to estimate the magnitude of total settlement (i.e., elastic plus consolidation) within and adjacent to the building footprint. This evaluation helped us to determine the impacts of the raise in site grades on existing and proposed site utilities as well as the feasibility of supporting a portion of the new addition (i.e., the portion of the addition outside the limits of the existing terminal building) on shallow foundations. Based on information provided by BSE, we understand that the proposed building addition can accommodate up to ½ in. of total settlement at each column location and up to ¼ in. of differential settlement between column locations spaced 20 ft apart (i.e., angular distortion of no greater than 1/960).

Detailed settlement evaluations were conducted using the computer program Settle 3D modeling the proposed building addition geometry provided by BSE assuming shallow foundation support, proposed site grading information provided by W&C and the subsurface conditions encountered in historic and recent test borings drilled at the site. Structural column loads provided by BSE for the footings and the load from a 6 in. thick, concrete slab on grade were included in our settlement model (the live load on the floor slab was not included due to the transient nature of the load). Estimates of settlement were computed at each proposed column location as summarized below.

	Estimated Settlement from Proposed Raise in Grade (in.)		Estimated Settlement from Proposed Foundations (in.)		Total Estimated Settlement (in.)	
	Min.	Max.	Min.	Max.	Min.	Max.
Elastic	0.25	0.50	0.00	0.25	0.25	0.75
Consolidation	0.50	0.50	0.25	0.50	0.75	1.0
Total	0.75	1.0	0.25	0.50	1.0	1.5

As summarized above, the estimated magnitude of total settlement as a result of fill placement and shallow foundations is in excess of the ½-in. settlement tolerance. In addition, calculated values of differential settlement between column lines 122 and 122.1 and M1 and M2 exceed the ¼-in. differential settlement tolerance (see attached Figure 1 for column locations). Since the estimates of combined total settlement (fill placement and proposed foundations) exceed the total and differential settlement tolerances, multiple alternatives were evaluated to reduce the settlement to within acceptable limits. These alternatives are discussed separately in the following sections of this memorandum.

Foundation Systems

Several different foundation system alternatives were evaluated considering the settlement tolerance criteria provided by BSE, overall feasibility, constructability, impact on utilities and existing structures, risk, cost and impacts on the project schedule. A summary of each alternative, including advantages and disadvantages and cost estimates is provided in the attached Table I. Please note that this information was previously provided to the project team in our email sent on 4 December 2012 at 12:25.

A. Alternatives Evaluation

Alternative No. 1 - Temporary Earthfill Surcharge

This alternative consists of supporting each proposed column location outside the limits of the existing building with spread footings bearing on a "reinforced fill pad" as described in the next section of this memorandum. The floor slab would consist of a soil-supported, cast-in-place concrete slab-on-grade. Normal weight earthfill would be used to raise site grades within the interior and exterior of the proposed building footprint.

As discussed previously, placement of up to 2.5 ft of normal weight earthfill will cause between ¾-in. and 1-in. of settlement. As a result, a temporary normal weight earthfill surcharge would be used to mitigate the settlement and would require placing fill up to the proposed finish floor elevation (El. 16.90) and then adding an additional 3 to 4-ft of earthfill above the proposed FFE and allowing the settlement to occur over a period of 3 to 4 months. The fill would be placed within the proposed building footprint and would extend 15 to 20 ft beyond the outside edge of the building. Settlement would be monitored throughout the approximate 3 to 4 month duration and the 3 to 4 ft of earthfill surcharge would be removed once the predicted settlement had occurred at which time construction of the spread footing foundation elements and soil-supported slab-on-grade could occur.

This alternative would minimize post-construction total and differential settlement of the proposed structure and ground floor slab, and has the lowest overall cost as compared to the other alternatives. Disadvantages include negative impacts on the overall project schedule due to surcharge placement and time required for settlement to occur, settlement of existing site utilities, potential movement/damage to the existing seawall, and disruption to facility operation during fill placement and settlement duration.

Alternative No. 2 - Geofoam Lightweight Fill

Similar to Alternative No. 1, this alternative consists of supporting each proposed column location outside the limits of the existing building with spread footings bearing on a "reinforced fill pad". The floor slab would also consist of a soil-supported, cast-in-place concrete slab-on-grade.

As discussed previously, placement of up to 2.5 ft of normal weight earthfill will cause between ¾-in. and 1-in. of settlement. Total and differential settlement within the building footprint would be mitigated by placement of an approximate 3 to 4-ft thick "cell" of geofoam lightweight fill within and immediately outside of the proposed building footprint. Normal weight earthfill would be used to raise site grades in all other areas.

This alternative would also minimize post-construction total and differential settlement of the proposed structure and ground floor slab, and has a "moderate" overall cost compared to the other alternatives. Disadvantages include settlement of existing site utilities outside the limits of the geofoam lightweight fill and potential movement/damage to the existing seawall caused by earthfill placement outside the limits of the proposed building.

Alternative No. 3 - Pile Support with Structural Floor Slab

This alternative consists of supporting each proposed column location outside the limits of the existing building with piles. Piles beneath each column would be connected into a cast-in-place concrete pile cap and the pile caps would be tied together with cast-in-place concrete grade beams. For this alternative, the floor slab would consist of a cast-in-place concrete structural slab. This alternative essentially replicates the design used to support the existing building.

For this alternative, fill would still be required to meet proposed finish grades. Since the proposed building addition and floor slab would be structurally supported, post-construction settlement of the structure and floor slab would be negligible. However, fill placement outside the limits of the existing and proposed building footprints would still cause post-construction ground surface settlement and settlement of existing and proposed utilities.

Advantages of this alternative include eliminating concern of post-construction total and differential settlement of the proposed structure and ground floor slab, and minimizing the impact on project schedule. Disadvantages include but may not be limited to the following: high cost compared to other alternatives, risk associated with the potential impact of pile driving on the existing seawall, and potential for encountering obstructions in the man-placed fill soils which could necessitate pre-augering prior to pile installation.

B. Recommended Alternative

Each alternative described above and the advantages/disadvantages of each were presented to the design team during our 27 November 2012 meeting. It is our understanding that SSA has presented and discussed the information shown in the attached Table I to CBL, and that CBL has advised SSA to advance the design for Alternative No. 2 as it provides the best combination of cost, risk and impact on project schedule as compared to the other two alternatives. Detailed design recommendations for Alternative No. 2 are provided below.

We recommend that the proposed building addition, outside the limits of the existing building, be supported on interior spread footings and exterior continuous wall footings bearing on a minimum 3-ft thick "reinforced fill pad" consisting of a non-woven geotextile strength/separation fabric (e.g., Mirafi HP570 or approved equal) and lifts of compacted ¾-in. crushed stone. The fill pad is needed to reduce the contact pressures from the footings such that the increase in stress at the top of the compressible harbor bottom deposit is reduced to the degree necessary to limit compression of these soils and to maintain the settlement tolerances specified by BSE.

All fill materials should be removed from within the zone of influence (ZOI) beneath the proposed footings to a depth of at least 3 ft below footing bearing levels. For the purposes of this report, the ZOI is defined as the area below the footings and below imaginary lines that extend 1 ft laterally beyond the footing outer bottom edges and down on a one horizontal to one vertical (1H:1V) slope for a minimum vertical distance of 3 ft. We have provided a sketch showing the details of the reinforced fill pad beneath new footings on the attached Figure 2.

Footings bearing on a "reinforced fill pad" as described and recommended herein should be designed for a maximum allowable bearing pressure expressed in kips per square foot (ksf) equal to 0.67 multiplied by the least lateral dimension of the footing expressed in feet, up to a maximum value of 2.0 ksf. Continuous wall and interior footings should be designed to be at least 2-ft wide. Please keep in mind that the allowable bearing capacity of the footings is not controlled by the geotechnical capacity of the soil, but rather by the settlement requirements as defined by BSE. That is the lower allowable bearing capacity reduces the stress increase at the top of the harbor bottom deposit, thereby limiting the settlement of this highly compressible, organic soil.

At the recommended allowable bearing pressure, we anticipate that the settlement of individual footings under static loading conditions, constructed as recommended herein, will not exceed approximately ½ in. with differential settlements over a 20-ft length not exceeding approximately ¼ in. We anticipate that most of the settlement will occur during construction shortly after structure dead loads are placed on the foundations and during the initial snow loading of the roof.

We recommend that a geofoam lightweight fill cell be constructed within (outside the limits of the existing building) and immediately outside of the proposed building footprint (i.e., a minimum of 10 ft beyond the edge of the proposed building addition) as roughly shown on Figure 1. All topsoil, organic matter and debris present at subgrade level should be removed from within the building footprint prior to geofoam placement. Extending the geofoam lightweight fill beyond the building edges will help minimize post-construction differential settlement between the adjacent sidewalks and entrances to the proposed building.

The bottom of the geofoam lightweight fill cell should be roughly coincident with the bearing level of the footings (which we estimate to be approximately El. 12) and should extend up to 1 ft below the bottom of the floor slab (approximately El. 15.5, assuming a 4 to 5-in. thick slab on grade). Geofoam fill should not be placed below or within the ZOI of footings. We recommend that accommodations be made to prevent any underslab utilities from penetrating through the geofoam lightweight fill cell.

Based on the design floor slab live load of 250 psf (provided by BSE) and the minimum 12-in. thick layer of compacted granular fill to be placed over the geofoam cell (see next section), we recommend that the geofoam used for this project be manufactured to meet the minimum strength requirements of type EPS19 geofoam. A lower strength geofoam product will not adequately support the soil, slab and live load above the geofoam cell.

As discussed with you during our 27 November 2012 meeting, it is our opinion that, based on the site usage and the relatively low probability that the geofoam will be exposed to significant hydrocarbon spills in the future, a HDPE geomembrane liner, which is typically placed around the geofoam cell for protection, is not needed for this project. This recommendation should be reviewed with CBL to ensure that they are comfortable with this level of risk tolerance.

C. Ground Floor Slab

We recommend that the floor slab for the proposed building addition, outside the limits of the existing building, be designed as a soil-supported, reinforced, concrete slab-on-grade. The ground floor slab should bear directly on a minimum 12-in. thick layer of compacted granular fill (CGF), as defined herein, placed on top of the geofoam lightweight fill cell (which we estimate to be approximately El. 15.5).

Impacts on Utilities and Existing Seawall

Based on proximity of the proposed normal weight earthfill outside the limits of the proposed building footprint to the existing seawall, the bearing level of the new footings, the limits of the proposed "reinforced fill pad", and the design building loads, we do not anticipate a significant increase in load on the existing seawall. However, we recommend that BSE review the current condition of the seawall along with available design information, so that they can make an independent assessment of the ability of the existing seawall to support additional lateral load from the new building foundations and new site fills.

In addition, up to 1 in. of settlement is anticipated outside the limits of the proposed building addition (and geofoam lightweight fill cell) that could impact the integrity and performance of existing/proposed utilities and manhole/catch basin structures located in these areas. We recommend that W&C evaluate the potential impacts that the anticipated settlement may have on these utilities.

As outlined in our proposal, please note that we did not evaluate the condition of the existing seawall, potential impacts to the stability of the seawall due to site filling or other construction activities, or impacts on existing/proposed utilities as a result of settlement caused by placement of normal weight earthfill outside the limits of the geofoam lightweight fill cell.

Frost Protection

Bottoms of exterior footings should be constructed a minimum of 4.5 ft below the lowest surface exposed to freezing (i.e., exterior site grades). Because the geofoam fill cannot be placed below/within the ZOI of footings, bottoms of interior footings should be constructed coincident with the bottom of the geofoam cell, which we estimate will be at approximately El. 12 based on the current proposed slab FFE of El. 16.9.

Foundation Drainage

Due to the proximity of the water table to the proposed elevation of the ground floor slab (at approximate existing ground surface elevation), a foundation drainage system (perimeter and underslab drain) is not considered necessary for the proposed building.

Surface runoff should be directed away from the buildings. In general, the finished ground surface immediately around the building should be sloped downward away from the structure. To limit surface water infiltration adjacent to the building, it is recommended that the upper 8 in. of backfill within 10 ft of the building, in unpaved areas, consist of topsoil or other soil having low permeability.

Dampproofing/Waterproofing/Vapor Barriers

In is our opinion that dampproofing and waterproofing the outside face of foundation walls is not necessary. The use of vapor barriers beneath the floor slab is recommended. If vapor barriers are used in this area, the floor slab design should be coordinated with the vapor barrier installation, as it may impact concrete curing and curling.

Resistance of Lateral Design Building Loads

We recommend that lateral building loads be resisted by frictional resistance along the base of footings. Due to the presence of the geofoam adjacent to footings, we do not recommend that passive earth pressure on the vertical faces of footings and below grade foundation walls be used to resist lateral building loads. Frictional resistance should be computed using an ultimate base friction coefficient (tan δ) equal to 0.50 between the footing concrete and the crushed stone placed within the limits of the "reinforced fill pads".

A minimum factor of safety for sliding equal to 2.0 should be achieved for resistance of permanent lateral loads.

Seismic Design Considerations

We recommend that the building addition be designed in accordance with the seismic requirements of the latest edition of the IBC Code as outlined below.

Due to the nature and thickness of the harbor bottom soils encountered in the recent test boring, we recommend the site be considered “Site Class E”. In addition, we recommend the following values be used by BSE to determine the design spectral response acceleration parameters (S_{DS} and S_{D1}) and to calculate the base shear for purposes of seismic design.

- Mapped Spectral Response Accelerations for Short Periods: $S_S = 0.313$ g
- Mapped Spectral Response Accelerations for 1-second Periods: $S_1 = 0.077$ g
- Site Coefficient for Short Periods: $F_a = 2.297$
- Site Coefficient for 1-second Periods: $F_V = 3.50$

Please note that “g” refers to acceleration due to gravity. We do not consider the soils encountered at this site to be liquefaction susceptible.

CONSTRUCTION CONSIDERATIONS

General

The purpose of this section of the report is to provide comments and recommendations on items related to excavation, earthwork, and other geotechnical aspects of the proposed construction. It is written primarily for the engineer having responsibility for the preparation of contract drawings and specifications. Since it identifies potential construction problems related to foundations and earthwork, it will also aid personnel who monitor the construction activity. Prospective Contractors for this project should evaluate construction problems on the basis of their own knowledge and experience in the area, taking into consideration their proposed construction methods and procedures.

Excavation

Excavation will be required to install the reinforced fill pad and geofoam lightweight fill in preparation for construction of the footings and ground floor slab. We recommend that the Contractor be responsible for the design, stability and safety of all temporary excavations.

We recommend that all fill materials within the ZOI below the proposed footing foundations to a depth of at least 3 ft below footing bearing levels be excavated and replaced with ¾-in. crushed stone as shown in Figure 2. All foundations, underground utilities and tanks, and slabs from the existing structure (to be demolished) should be completely removed from within the footprint of the new building and within the ZOI beneath new building addition footings.

We expect that excavation of the fill soils can be accomplished using normal earth-moving equipment. Temporary cut earth slopes should, typically, be stable if constructed no steeper than about 2H:1V. Some sloughing and raveling should be anticipated in temporary earth slopes.

All excavation support systems and temporary earth slopes shall comply with OSHA and all other applicable local, state and/or federal safety regulations.

Construction Dewatering

Based on the historic tide levels for the site, it is possible that groundwater will be encountered in some areas during the excavation for the “reinforced fill pad”. The Mean High Water (MHW) level for the site is at approximately El. 10. We anticipate that excavations as deep as 5 to 7 ft BGS will be required to construct the “reinforced fill pad” beneath the spread and wall footings. These depths correspond to a subgrade level between El. 9 and El. 9.5, or approximately 0.5 to 1 ft below the MHW level. If needed, we anticipate that excavation dewatering can be controlled and can be accomplished by pumping from open sumps and temporary ditches located within and around the excavations. Sumps should be provided with filters suitable to prevent pumping of fine grained soil particles. The Contractor should be responsible for the design, installation, and removal of an appropriate excavation dewatering system.

The man-placed fill soils at subgrade level may be sensitive to disturbance and softening due to construction activities and when exposed to water and adverse weather conditions. Dewatering should be performed as required to maintain the undisturbed nature of the soil bearing surfaces and enable all final excavation, foundation construction and backfilling to be conducted in the dry.

Water entering any temporary excavation should be controlled and promptly removed to avoid subgrade disturbance. Rainwater or snowmelt should be directed away from exposed soil bearing surfaces. Dewatering should be performed in accordance with all applicable regulations. Dewatering discharge should be directed into on-site excavations and remain on-site if possible. Dewatering should be conducted in a manner that avoids disturbance or undermining of existing foundations, backfill, prepared foundation subgrades, and that limits pumping of fines.

Subgrade Preparation and Reinforcing Fabric Placement

The following guidelines are recommended to prepare the subgrade level and construct the reinforced fill pad beneath the footings and slab:

- Make final excavations to the bearing subgrade either by hand or by using smooth-bladed equipment to minimize disturbance. Excavation within 12 in. of the final subgrade level <u>must be performed with care</u>.

- Prevent water from accumulating on subgrade surfaces to reduce the possibility of soil softening. Subgrades that become disturbed due to water infiltration should be <u>carefully</u> re-excavated and stabilized.

- Exposed subgrade should be examined in the field by a qualified geotechnical engineer working on behalf of the owner to verify strength and bearing capacity. Excavation may be necessary to remove localized areas of weak, disturbed or otherwise unacceptable soils. Based on the condition of the exposed soil surface, the Contractor will likely be required to compact/ proofroll the subgrade prior to fill placement.

- The Contractor should not be allowed to excavate within 12 in. of the final bearing level until they are ready to compact/proofroll subgrade and construct the reinforced fill pad. Subgrade should be compacted/proofrolled on the same day that the final bearing level is exposed.

- If needed, install a 2 to 4-in. thick lean concrete mudmat or a 6-in. thick layer of crushed stone over the approved subgrade to provide a stable working surface for workers and light equipment. The method of stabilization should be submitted by the Contractor in advance of excavation and should be approved by a qualified geotechnical engineer.

- Equipment and worker traffic should not be allowed on the exposed soil bearing surfaces until the subgrade surface has been approved. Care should be taken to prevent surface water from collecting on exposed bearing surfaces.

- A non-woven geotextile strength/separation fabric (e.g., Mirafi HP570 or approved equal) should be placed directly over the approved soil subgrade as shown on Figure 2. Adjacent pieces of fabric should be overlapped by a minimum of 3 ft, or the joints should be sewn per manufacturer's recommendations.

Soil bearing surfaces below completed foundations and slabs must be protected against freezing, before and after foundation construction. If construction is performed during freezing weather, footings should be backfilled to a sufficient depth (up to 4.5 ft) as soon as possible after they are constructed. Alternatively, insulating blankets or other means may be used for protection against freezing. The "reinforced fill pad" and footings should not be constructed on frozen soil.

3/4-in. Crushed Stone

Crushed stone should be uniformly blended according to the gradation for Aggregate for Crushed Stone Surface, Section 703.12 of the Maine DOT Standard Specification, Highways and Bridges. The crushed stone should be free from clay, loam or other deleterious material and not more than 1.0 percent passing the No. 200 sieve.

Crushed stone should be placed in lift thicknesses not exceeding 12 in. loose measure. Compaction equipment in open areas should consist of self-propelled static rollers. In confined areas, hand-guided equipment such as a large vibratory plate compactor should be used and the loose lift thickness should not exceed 6 in.

Compacted Granular Fill

Compacted granular fill placed beneath the addition slab should consist of bank-run sand and gravel, free of organic material, snow, ice, or other unsuitable materials and should be well-graded within the following limits:

Sieve Size	Percent Finer by Weight
6 in. (1)	100
No. 4	30 - 80
No. 40	10 - 50
No. 200	0 – 8

(1) Cobbles or boulders having a size exceeding 2/3 of the loose lift thickness should be removed prior to compaction.

Other materials could be acceptable for compacted granular fill, and should be evaluated by the geotechnical engineer on a case-by-case basis if proposed by the Contractor.

Compacted granular fill placed over the geofoam cell should be placed in lift thicknesses not exceeding 9 in. loose measure. Compaction equipment in open areas should consist of self-propelled vibratory rollers. In confined areas, hand-guided equipment such as a large vibratory plate compactor should be used and the loose lift thickness should not exceed 6 in.

Cobbles or boulders having a size exceeding 2/3 of the loose lift thickness should be removed prior to compaction.

Compaction

A summary of recommended compaction requirements is as follows:

Location	Minimum Compaction Requirements
Beneath footings and building slabs	95 percent
Parking, roadways and sidewalks	92 percent up to 3 ft below finished grade 95 percent in the upper 3 ft
Landscaped areas	90 percent nominal compaction

Minimum compaction requirements refer to percentages of the maximum dry density determined in accordance with ASTM D1557.

Contract Document Preparation/Review and Construction Monitoring

Based on our experience on previous building projects that have utilized geofoam lightweight fill, it is our opinion that drawings and specifications should be included in the Contract Documents that clearly illustrate the horizontal and vertical limits of the geofoam and describe material requirements. These drawings should include multiple plan view sheets that show the limits of the geofoam and various elevations, typical cross sections depicting where the geofoam is placed relative to the spread/continuous wall footings and ground floor slab, and other special details (i.e., in areas where there are conflicts between geofoam and underslab utilities, and at the interface between the existing slab to remain and the edge of the geofoam cell). We recommend that Haley & Aldrich provide these services.

In addition, the proposed foundation/"reinforced fill pad" system will require the selected Contractor to perform excavation and backfilling activities in and above potentially sensitive man-placed fill materials. The earthwork specifications should be written so that the Contractor is aware of the sensitive nature of this work. The specifications should include restrictions on disturbing the subgrade soils (with worker and equipment traffic).

The foundation recommendations contained herein are based on the predictable behavior of a properly engineered and constructed foundation. Monitoring of the foundation installation is required to enable the geotechnical engineer to verify that the procedures and techniques used during construction are in accordance with the recommendations contained herein and the contract documents. Therefore, it is recommended that a geotechnical engineer or experienced technician be present during construction to:

- Observe excavation of the in-situ fill soils down to bearing level.
- Observe the condition of the soil subgrade and assess the need for subgrade compaction/ proofrolling.
- If needed, observe installation of the subgrade stabilization system (mudmat or crushed stone).
- Observe construction of the reinforced fill pad beneath the new building footings.
- Observe placement/compaction of compacted granular fill between the top of the geofoam cell and the bottom of the ground floor slab. Provide in-situ density testing of the compacted lifts of material to assure that they conform to the requirements of the project specifications.
- Observe placement of geofoam lightweight fill cell.
- Confirm that soils used as fill and backfill are in accordance with the project plans and specifications.

CLOSURE

This report has been prepared for specific application to the proposed site development as described herein. In the event that changes in the nature, design, or location of the proposed site development are made, the interpretations, conclusions, and recommendations presented herein should not be considered valid unless the changes are reviewed and the conclusions of this report are modified or verified in writing by Haley & Aldrich.

Our recommendations are based in part on the data obtained from the referenced explorations, the existing site information and the proposed design that is available to us at this time. The nature and extent of variations between explorations may not become evident until or during construction. If variations then appear, it may be necessary to re-evaluate the recommendations included in this report.

We strongly recommend that Haley & Aldrich be provided the opportunity to prepare and/or review the final design drawings, specifications and applicable Contractor submittals to confirm that the geotechnical recommendations outlined herein have been interpreted and implemented as they were intended, especially related to geofoam materials and placement.

We appreciate the opportunity to serve your project team during the design phase of the project, and look forward to our continued association with you through final design and construction. Please do not hesitate to contact us if you have any questions or comments on the information provided herein.

Attachments:
Table I – Foundation Alternative Evaluation Matrix
Figure 1 – Preliminary Foundation Plan
Figure 2 – Schematic Foundation Cross Section

STATE OF MAINE
WAYNE A.
CHADBOURNE
No. 10820
LICENSED
PROFESSIONAL ENGINEER

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TABLE I - FOUNDATION ALTERNATIVE EVALUATION MATRIX
PROPOSED CBITD FERRY TERMINAL ADDITION
PORTLAND, MAINE

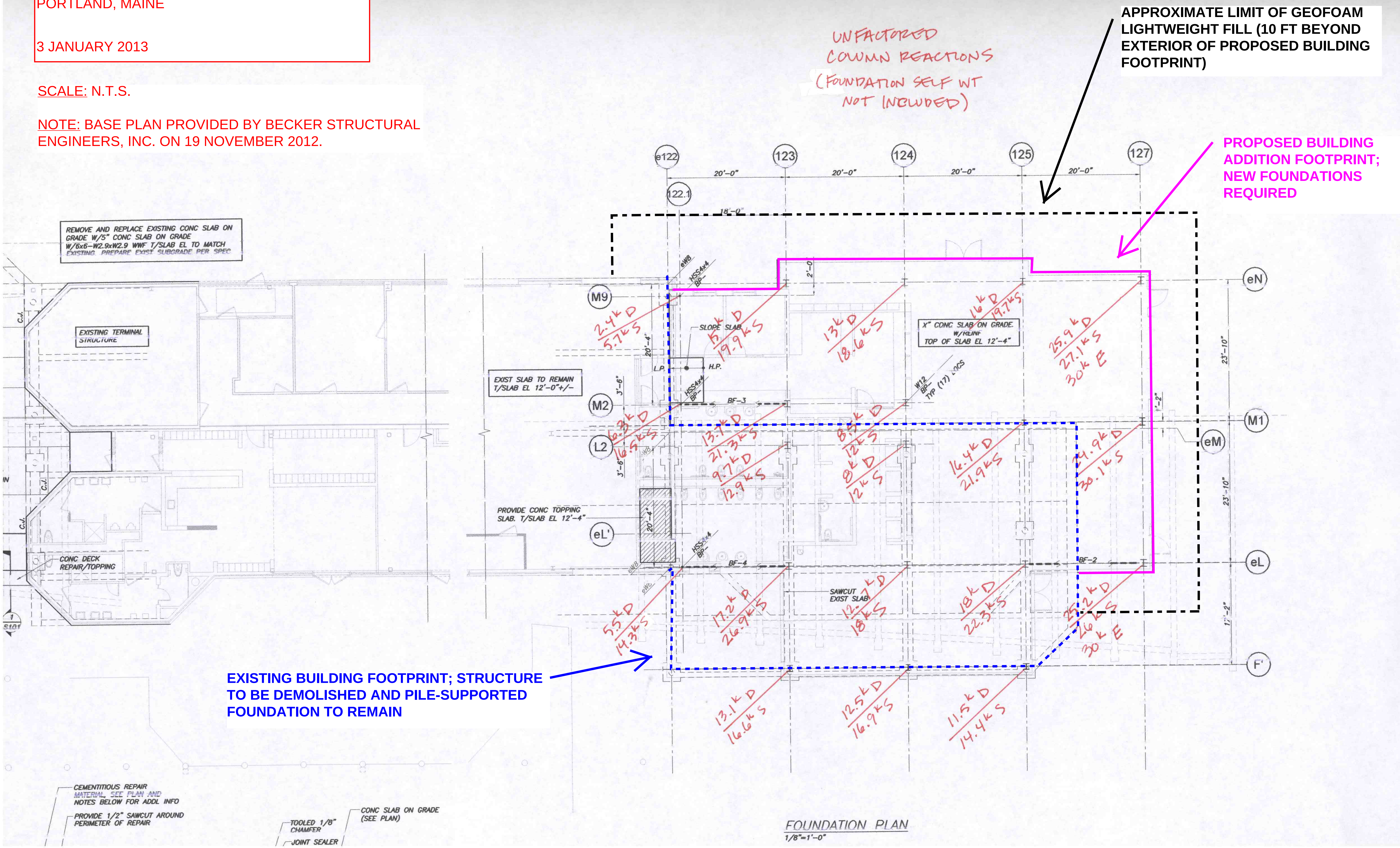
		Alternative No. 1		Alternative No. 2		Alternative No. 3	
Description		preload/surcharge, support building on spread footings, floor slab consists of slab-on-grade		geofoam lightweight fill, support building on spread footings, floor slab consists of slab-on-grade		support building on piles, tied together with pile caps and grade beams, floor slab consists of structural slab	
Impacts	Project Schedule	High; need total 3 to 5 months to complete preload/surcharge		Low		Low	
	Facility Operations	High		Medium		Medium to High	
	Existing/Proposed Utilities	High		Low		Medium	
	Existing Seawall	Medium		Low to Medium		Medium to High	
Engineer's Cost Estimate	Earthwork Cost (Within/Adjacent to Bldg. Footprint)	Fill Below Slab =		Fill Below Slab =		Fill Below Slab =	
		Preload/Surcharge Fill =					
	Foundation System	Spread Footings =	$ 35,000	Spread Footings =	$ 35,000	Piles =	$ 95,000
						Pile Caps =	$ 10,000
						Grade Beams =	$ 30,000
	Floor Slab	Slab-on-Grade =	$ 15,000	Slab-on-Grade =	$ 15,000	Structural Slab =	$ 40,000
	Over-Excavation and Replacement w/Reinforced Fill	Cost =	$ 5,000	Cost =	$ 5,000	NA	$ -
	Geofoam Lightweight Fill	NA	$ -	Geofoam =	$ 50,000	NA	$ -
	Total Cost Estimate	$ 55,000		$ 105,000		$ 175,000	

FIGURE 1 - PRELIMINARY FOUNDATION PLAN
PROPOSED CBITD FERRY TERMINAL ADDITION
PORTLAND, MAINE

3 JANUARY 2013

SCALE: N.T.S.

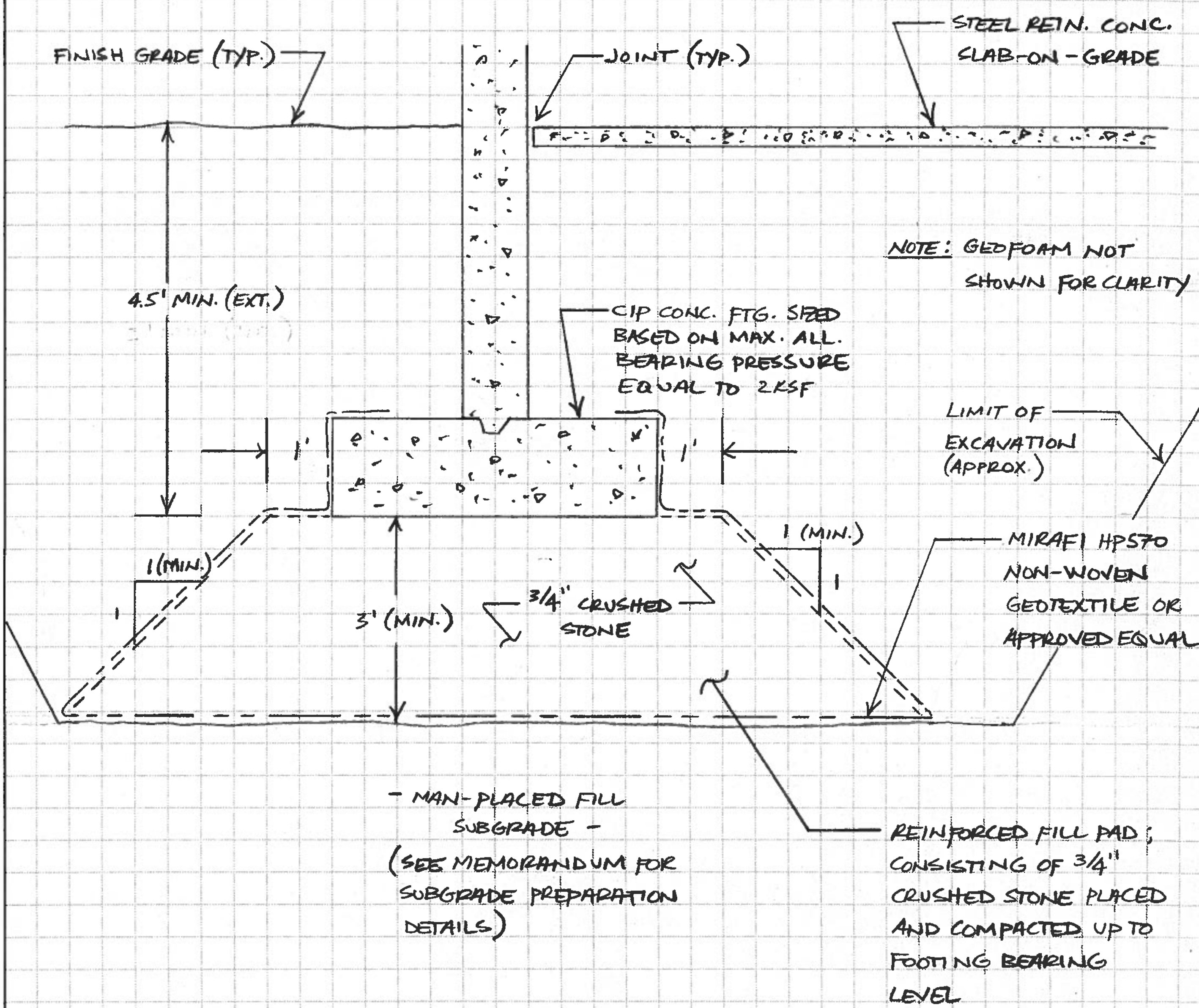
NOTE: BASE PLAN PROVIDED BY BECKER STRUCTURAL ENGINEERS, INC. ON 19 NOVEMBER 2012.



HALEY & ALDRICH

Calculations

Client	SCOTT SIMONS ARCHITECTS	File No.	39281-000
Project	CBITD FERRY TERMINAL ADDITION	Sheet	1 of 1
Subject	FIGURE 2 – SCHEMATIC FOUNDATION CROSS SECTION	Date	12/2/2012
		Computed By	BCS
		Checked By	MAC 12/3/12



SCALE: N.T.S.

FIGURE 2 – SCHEMATIC FND. CROSS-SECTION