10 May 2023
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David Stein
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Via Email: dstein@silverpetrucelli.com

Re: Geotechnical Engineering Study
Old Greenwich School
Old Greenwich, Connecticut
Langan Project No.: 140265801

Dear David:

This report presents our geotechnical engineering study for the proposed addition to Old Greenwich School at 285 Sound Beach Avenue in Old Greenwich, Connecticut. The purposes of this study were to explore subsurface conditions, evaluate feasible foundation options, and develop geotechnical engineering recommendations. Services were performed in accordance with our authorized proposal (revised 11 January 2023).

Our boring exploration approach was developed considering a sketch showing the proposed building footprint and boring locations by Silver Petrucelli + Associates (SP+A) sent via email on 9 March 2023. We note that a revised building footprint is shown in the drawing set entitled "Scheme D.2" (18 April 2023) by SP+A, which was received after our geotechnical field program. Changes to the design scheme must be reviewed by Langan for effects on our recommendations.

Elevations are referenced from a plan titled "Boundary & Topographic Survey" (01 May 2023) prepared by Langan referencing the North American Vertical Datum of 1988 (NAVD88).

SITE DESCRIPTION

The about 7.3-acre site is located at 285 Sound Beach Avenue in Old Greenwich, Connecticut. The site is bordered by commercial and residential properties to the north, Sound Beach Avenue to the east, residential properties to the south, and wetlands/marsh the west. The site is occupied by the existing Old Greenwich School, which is a three-story brick building at the east part of the site. The existing school has a footprint of about 39,600 square feet (SF) and no below-grade levels. The finished floor elevation (FFE) varies between about el +11.3 and el +15.4. Associated site features surround the structure, including an asphalt parking lot to the north, asphalt sports courts and a playground area to the southwest, and grass sports fields to the west. Figure 1 shows the site location and surrounding properties.

Existing site grades gently slope down from east to west, from about el +15 to el +7. Site grades within the proposed building addition footprint vary between about el +13 to el +10.

Underground utilities are present throughout the site including stormwater, electric, gas, and sanitary.

PROPOSED DEVELOPMENT

The proposed project consists of renovations within the existing Old Greenwich School and the construction of an addition to the southwest of the existing structure. Interior renovations consist of one new elevator pits and infilling select portions of the existing building to raise the FFE.

The addition consists of a 1-story, about 7,260 SF footprint structure. The FFEs of the proposed classrooms are el +14 and the FFE of the proposed hallways connecting the addition to the existing structure varies between about el +11.5 to +14. The FFE of two classrooms within the existing building will be raised from about el +10.75 to +12.5 Cuts of up to about 5 feet are anticipated to reach the bottom of the proposed elevator pits and fills up 4 feet are expected to reach the FFE of the proposed addition.

Estimated building column and slab loads are currently unavailable. Based on our experience with similar buildings of this type, we estimate column loads of up to 100 kips and slab loads up to about 200 pounds per square foot (psf).

REVIEW OF AVAILABLE INFORMATION

Regional Geology

The 1992 “Surficial Materials Map of Connecticut” (Figure 2) indicates the overburden is predominantly sand and gravel within the proposed renovation and addition footprints, with thin till located along the east and west edges of the site. The 1985 “Bedrock Geological Map of Connecticut” (Figure 3) indicates that bedrock below the site is predominately Harrison gneiss (typically hard rock) with Golden Hill schist is located along the west edge of the site. Both maps were prepared by the Connecticut Geological and Natural Resource Survey.

Federal Emergency Management Agency Flood Map

We reviewed the Flood Insurance Rate Map (FIRM) for the town of Old Greenwich published by the Federal Emergency Management Agency (FEMA), Map Nos. 09001C0512G effective 8 July 2013 and 09001C0514G effective 8 July 2013 (Figure 4). The proposed renovations and addition footprint are predominately located in Zone AE: shaded, "1% annual chance flood hazard" with a provided base flood elevation of el +13. The southeast corner of the site, and some renovation areas, are located in Zone X: unshaded, "areas of minimal flood hazard" (outside the 500-year floodplain).

SUBSURFACE EXPLORATION

Langan performed a subsurface exploration consisting of 3 borings. The exploration was overseen by a Langan field engineer. An exploration location plan is shown in Figure 5. We note that test pits were also proposed as part of the exploration scope and will be completed at a later date.

Borings

Three borings (LB-01 through LB-03 were drilled by SoilTesting, Inc. on 11 April 2023. The borings were advanced with a CME55 LC track-mounted rig using hollow-stem-auger drilling techniques. Borings were terminated from 25.9 to 27 feet below the existing grades (about el -13.9 to el -17).

Standard Penetration Test (SPT) N-values[1] were documented and soil samples were generally obtained continuously to a depth of about 12 feet and every 5 feet thereafter. Disturbed soil samples were obtained using a standard 2-inch-outer-diameter split-spoon sampler driven by a 140-pound safety hammer in accordance with ASTM D1586, Standard Penetration Test.

Recovered soil samples were visually examined and classified in the field in general accordance with the Unified Soil Classification System (USCS). Soil classifications, N-values, and other field observations were recorded on our field logs provided in Appendix A.

Test Pits

Four test pits (TP-01 through TP-04) were performed by Polster Industries on 30 August 2023, under Langan's full time observation. The test pits were advanced with a CAT 304E Mini Excavator to depths of about 6 to 7.5 feet below the existing grades (el +2.5 to el +4). Test pits

[1] The Standard Penetration Test (SPT) is an in situ testing technique used to infer soil density and consistency. The SPT N-value is defined as the number of blows required to drive a 2-inch-diameter split-barrel sampler 12 inches after an initial penetration of 6-inches using a 140-pound hammer falling freely from 30 inches.

were performed to observe subsurface conditions within the proposed addition footprint and to perform infiltration testing within proposed stormwater management areas. Soil classifications and other field observations were recorded on our field logs provided in Appendix B. Select test pit photographs are provided in Appendix C.

Infiltration Testing

Infiltration rates were measured in test pits TP-01 and TP-02 in the proposed stormwater system footprint. Infiltration tests were performed in general accordance with the Town of Greenwich Drainage Manual - Appendix B. Infiltration testing was performed at 1 to 2 feet above the encountered groundwater level in each test pit. A summary of the average infiltration rates, reduced by a factor of two, is presented in Table 1. It should be noted that the rates shown below do not include a 24-hour presoak due to time constraints. A detailed summary of infiltration testing performed at each location is provided in Appendix D. Final design infiltration rates should be selected by the civil engineer based on the stormwater system design and allowable infiltration rates.

Table 1. Infiltration Test Results Summary

Location	Surface Elev. (NAVD88)	Test Depth (ft)	Test Elev. (NAVD88)	Results (in/hr)	Material Type
TP-01	10	4.5	±5.5	1.6	Brown to grayish brown fine-coarse SAND, some fine gravel, trace silt
TP-02	10	5.5	±4.5	3.5	Gray silty SAND, trace gravel

Lab Testing

Selected samples were sent to a testing laboratory to confirm visual classifications and to determine index properties (physical and mechanical). Five moisture-content determinations, three grain-size analyses, two Atterberg limits tests, and one organic content test were performed; the results are provided in Appendix E.

SUBSURFACE CONDITIONS

The subsurface conditions generally consist of a surficial layer of asphalt or topsoil underlain by layers of fill, estuarine deposits, sand, decomposed rock, and bedrock. Bedrock was inferred from about 26 to 27 feet below existing grades (about el -14 to el -16). Groundwater was observed in all borings and test pits from about 5.5 to 8 feet below existing grades (between about el +4.5 and el +2). A detailed description of subsurface materials encountered is provided below in order of increasing depth.

Surficial Materials – A 5-inch-thick surficial layer of asphalt pavement was encountered in borings LB-02 and LB-03. A 4-inch to 1-foot-thick layer of topsoil was encountered in boring LB-01 and all test pits. In all test pits, an about 2-inch- to 6-inch-thick layer of wood chips was encountered above the topsoil. The topsoil generally consists of brown silty fine to medium sand with vary proportions of gravel, organics, roots, asphalt fragments, and plastic debris.

Fill – An about 1- to- 4-foot-thick layer of fill was encountered below the surficial material in all borings and test pits TP-01, TP-03, and TP-04. The fill is generally composed of brown fine to coarse sand, with varying proportions of fine to coarse gravel, silt, organics, roots, asphalt, and plastic debris. SPT N-values within the fill layer vary from about 6 blows per foot (bpf) to 11 bpf. Laboratory testing of one sample reported a fines content of about 23% and measured moisture content of about 9%. The fill layer is generally classified as silty sand with gravel (SM) in accordance with the USCS.

Estuarine Deposits – An about 1.4- to- 4.5-foot-thick layer of estuarine (marsh) deposits (top of layer corresponding to about el +7 to el +8.5) was encountered below the fill in all borings and in test pits TP-02 and TP-04. The estuarine layer is generally composed of dark brown dark to orangish gray silt or clayey sand with varying proportions of organics, fine to medium sand, silt, clay, gravel, roots, and mottling. SPT N-values within the estuarine layer vary from about 4 to 12 bpf. Laboratory testing of samples reported a liquid limit between about 24 to 34, a plastic limit between about 17 and 23, and a measured moisture content between about 24% to 34%. The measured organic content was about 3.6%. The estuarine layer is generally classified as clayey sand, clay, and clayey silt (SC, CL, and CL-ML) in accordance with the USCS.

Sand – An about 4- to- 21-foot-thick layer of sand (top of layer corresponding to about el +3 to el +9) was encountered below the estuarine layer in all borings and test pits TP-02 and TP-04, and below the fill or surficial materials in TP-01 and TP-03 . The sand layer is generally composed of light brown, orangish brown, or gray fine to coarse sand with varying proportions of gravel, and silt. SPT N-values within the sand layer vary from about 7 bpf to 52 bpf. Laboratory testing of samples reported a fines content of about 8% to 13% and a measured moisture content between about 5% to 19%. The sand layer is generally classified as well graded sand with silt and gravel (SW-SM) in accordance with the USCS.

Decomposed Rock – An about 0.7- to 16-foot-thick layer of decomposed rock (top of layer corresponding to about el -16 to el +2) was encountered below the sand layer in all borings. Lb-03 was terminated in the decomposed rock layer, and therefore thicknesses may be greater than reported herein. The decomposed rock layer is generally composed of brown to gray silty fine to coarse sand with varying amounts of gravel, weathered rock fragments, mica fragments and visible stratification. SPT N-values within the sand layer vary from about 17 bpf to split-spoon refusal (greater than 100 bpf). The decomposed rock displayed the structure of the parent rock but broke apart under the action of the split spoon.

Bedrock – Bedrock was inferred below the decomposed rock layer as evidenced by refusal of the drilling equipment (augers and split spoons) from about 26 to 27 feet below existing grades (top of rock between about el -14 to el -16) in borings LB-01 and LB-02.

Groundwater - Groundwater was encountered in all borings and test pits from about 5.5 to 8 feet below existing grades (about el +2 to el +4.5). Groundwater was measured upon completion of each of the borings from about 9 to 18 feet below existing grades (about el +1 to el -6). We note that the drop in the groundwater measurements at the completion of the boring may be due to the groundwater having insufficient time to recharge through the denser decomposed rock layer. Due to the proximity of the nearby Greenwich Cove, we believe that groundwater levels may be tidally influenced. Groundwater, if encountered, should be expected to fluctuate with seasons, precipitation, construction activities, utility breaks, etc.

GEOTECHNICAL DESIGN RECOMMENDATIONS

The following key geotechnical issues have been identified:

- Loose uncontrolled fills and estuarine (marsh) deposits below the proposed building footprint,
- Fills up to 3 feet within the proposed building footprint over soft estuarine soils,
- Shallow groundwater,
- Proposed structure within FEMA zone AE, and
- The presence of loose sands below the groundwater table.

Additional Exploration

We recommend additional test pits be performed adjacent to the existing building footprint to further understand fill and estuarine deposit thicknesses within the addition footprint, and to understand fill thicknesses adjacent to the existing building. Further exploration may also be required at the proposed elevator pit locations to understand existing building foundations and pit bearing materials.

Seismic Design

This section presents seismic design recommendation, in accordance with the 2022 Connecticut State Building Code (International Building Code 2021). We have considered the soil conditions encountered in the borings to be consistent and representative of the soil conditions in the top 100 feet of soil at this site.

Based on the spectral accelerations and the anticipated risk category in Table 2, we have estimated the Seismic Design Category (SDC). The structural engineer is responsible for confirming the appropriate use group, occupancy category, and final SDC for the proposed structure.

Table 2. Seismic Design Values

Description	Parameter	Recommended Value
Mapped Spectral Acceleration for short periods:	S_s	0.274
Mapped Spectral Acceleration for 1-sec period:	S_1	0.059
Site Class:	--	**D – Stiff soil profile**
Site Coefficient:	F_a	1.58
Site Coefficient:	F_v	2.4
5% damped design spectral response acceleration at short periods:	$\mathbf{S_{DS}}$	**0.281**
5% damped design spectral response acceleration at 1-sec period:	$\mathbf{S_{D1}}$	**0.094**
Anticipated Risk Category	--	**III**
Seismic Design Category	**--**	**B**

Based on the above spectral accelerations and the anticipated risk category, we have estimated the Seismic Design Category (SDC). The structural engineer is responsible for confirming the appropriate use group, occupancy category, and final SDC for the proposed structure.

Liquefaction

Due to the presence of loose sands (low N-values) below the groundwater table in LB-03, we evaluated the liquefaction potential of non-cohesive soil below the groundwater table up to 100 feet below the ground surface (as required by the Connecticut Building Code) using the procedure outlined by Youd et al. (2001). Our analysis included all Langan borings within the building footprint that were potentially susceptible to liquefaction. The Youd et al. method is considered to be the state-of-practice recommended by the National Earthquake Hazard Reduction Program. The method presents an empirical relationship between the earthquake demand, represented by the Cyclic Stress Ratio (CSR), and the soil's resistance to dynamic loading, represented by the Cyclic Resistance Ratio (CRR). Field N-values are converted to $N_{1,60,cs}$ by applying corrections for hammer energy efficiency, soil overburden pressure, borehole diameter, rod length, sampler lining, and fines content.

Our analysis parameters included a peak ground acceleration of 0.161g and mean earthquake magnitude of 5.49 (from the Unified Hazard Tool[2]). Our analysis indicates that all SPT N-values evaluated have a factor of safety against liquefaction greater than one. It is our judgment that liquefaction need not be considered in the design. A plot showing factors of safety versus depth is provided as Figure 6.

Foundations

Removal and Replacement Program

The materials encountered at the anticipated footing elevation (estimated to be between about el +9 to el +11) consist of fill and estuarine deposits. The surficial materials, fill, and estuarine deposits are not suitable for foundation or slab support. A removal and replacement program should be performed to remove the fill and estuarine deposits to the native sands, and be replaced with structural fill to the bottom of proposed foundation elevation. Replacement fill materials should be placed in accordance with the Excavation, Fill Placement, and Compaction Criteria section of this report to support shallow foundation construction. We estimate over-excavations up to about 6 feet will be necessary to reach the native sandy soils. The proposed structure can be supported on shallow foundations bearing on structural fill or natural sands using an allowable bearing pressure of 4,000 psf. Footing subgrades should be prepared in accordance with the Subgrade Preparation section of this report.

Flood Conditions

Foundations should be designed to account for anticipated flooding associated with the design flood elevation (see the Ground Floor Slab and Permanent Groundwater Controls sections below) and ASCE 24 requirements. Foundations should also be designed to account for erosion or local scour where necessary.

General

All exterior footings should be constructed 42 inches or deeper below the lowest adjacent grade for frost protection. Interior footings in heated spaces may be constructed at a convenient depth below the slab; however, all bottoms of footings should be at least 1.5 feet below the finished-floor elevation. Isolated column footings should have a minimum dimension of 3 feet, and strip footings should have a minimum width of 2 feet even if smaller dimensions can be justified using the recommended allowable bearing pressure.

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[2] Unified Hazard Tool via U.S. Geological Survey – Earthquake Hazards Program

Foundations should not be located so that one foundation is within the zone of influence of an adjacent foundation. The zone of influence is taken as a 1H:1V projection extending outward and downward from the edge of the foundation. New foundation elements should match the bottom of footing elevation of the existing foundations for adjacent elements. Excavations to remove unsuitable materials should be sloped from the existing foundations or existing foundations should be underpinned to avoid undermining existing foundations. Additional information is included in the underpinning section below.

Foundation Settlement

Total settlement of the new structure is estimated to be on the order of 3/4 inch or less, provided the bearing pressure recommended here is used and the subgrade preparation work described here is performed. Differential settlements between the existing structure and new foundations are expected to be reach settlement limits of about 3/4 inch. A majority of the settlement is expected to take place during construction.

Ground Floor Slabs

Design Flood Elevation

The FEMA base flood elevation (BFE) is el +13, and the design flood elevation should be taken as BFE +1 feet for a design flood elevation (DFE) of el +14. The ground finished floor level varies throughout the proposed addition, and the lowest level slab should consider hydrostatic pressures from flood events. The building slab should be designed to account for anticipated flooding associated with the design groundwater elevation from the adjacent water bodies and ASCE 24 requirements.

Uplift Resistance

The lowest level slab should be designed to resist uplift pressures by increasing the dead load, through smaller structural spans, or uplift anchors. If anchors are necessary, we can provide a preliminary design. The anchors should be double corrosion protected to account for the marine environment and use below water.

Scheme 1 – Slab-on-Grade

Slab-on-grade construction should consider the DFE and be designed in accordance with ASCE 24 requirements. A slab-on-grade can be constructed bearing on natural soils, structural fill, or compacted existing fill prepared in accordance with the recommendations here. Removal and replacement of estuarine soils should be performed below slab-on-grade areas prior to placement of any raise-in-grade fills to limit settlement of the slabs over time. Subgrades within the building footprint should be prepared in accordance with recommendations in the Subgrade Preparation section of this report prior to placing any additional fill materials. We anticipate that the existing fill materials can be reused as structural fill provided the fill is placed in compacted lift as outlined herein. We recommend designing slab-on-grade for a modulus of subgrade reaction of 125 pounds per cubic inch.

We recommend a minimum 12-inch-thick layer of ¾-inch clean crushed stone be included beneath the slab to protect the prepared subgrade and to serve as a capillary break. We recommend any slab below the DFE have a waterproofing membrane below the ground-floor slab. The barrier should be coordinated with any environmental requirements for the development. Omission of a barrier can lead to floor-covering problems including delamination and mold.

Scheme 2 – Structural Slab

Slabs that cannot be designed to meet ASCE 24 requirements or resist uplift loads from the DGE should be designed as a structural slab. The structural slab can be designed to withstand hydrostatic pressures from flood conditions. The slab should be designed to account for anticipated flooding associated with the design flood elevation from the adjacent water bodies and ASCE 24 requirements.

Permanent Groundwater Controls

Waterproofing

The design groundwater elevation is el +14, and we recommend that all foundations, slabs, and pits below the DGE will be fully waterproofed to protect mechanical equipment and finishes against moisture. We recommend that a membrane-type waterproofing be used such as Preprufe and Bithuthene products by GCP. Bentonite is not recommended. The vertical waterproofing should be protected with a rigid barrier to prevent damage during backfilling. A drainage board can serve as protection as well. After installation of the waterproofing, care must be taken so as to not damage the waterproofing. Waterproofing damaged during construction should be repaired as determined by the manufacturer.

Additional Flood-proofing Measures

We understand existing and proposed portions of the structure lie below the design flood elevation. Additional measures may be necessary at existing building areas, structure entrances, utility penetrations, etc. to maintain dry conditions during high water events.

Below-Grade Pits

Permanent below-grade walls that are considered to be fixed against rotation should be designed to resist soil, groundwater, and surcharge pressures. Backfill should not be placed against below-grade walls until the wall concrete has reached its 28-day compressive design strength and has been approved by the structural engineer.

We recommend that the below-grade foundation walls (i.e., fixed walls) be designed using a triangular earth-pressure distribution having an equivalent fluid weight 90 lb/ft^2 per foot of depth below the design flood elevation. Above the design flood elevation, below grade foundation walls can be designed using 60 lb/ft^2 per foot of depth presuming that free-draining clean stone as backfill or a manufactured drain is used.

Surcharge loading on the below-grade foundation walls should be included by adding a uniform stress equal to one-half the surcharge load in addition to the soil loading.

For the design of pit slabs and foundations, the allowable bearing pressures in the Foundations section and the modulus of subgrade reaction on the Ground Floor Slabs section can be used.

Underpinning

We understand that one elevator pit will be added within the existing building footprint and will likely extend below the existing slabs and foundations. Additionally, if removal and replacement is necessary next to the existing building foundations to construct the proposed addition, localized underpinning may be necessary to perform the removal and replacement program. Additional exploration (see additional exploration section above) or historic information will be necessary to understand the bottom of footing elevations of the existing adjacent foundation elements. Underpinning can be used to support the adjacent foundations and avoid undermining the adjacent foundation elements.

In locations where localized underpinning is necessary, conventional underpinning concrete piers can likely be constructed to transfer the loads to the same elevation of the proposed pit level or over-excavation limit and prevent undermining. Concrete underpinning piers are typically a maximum of 4 feet wide and constructed in sequence below the adjacent building foundations. Piers are typically constructed at a spacing of 12 feet on-center and allowed to set before the next sequence is constructed.

Concrete underpinning piers are permanent design features and should be designed by the site geotechnical engineer as part of the design phase. We can design the underpinning piers and sequencing after further exploration or understanding of existing building foundations. The contractor should submit shop drawings for review to the design engineer prior to construction.

GEOTECHNICAL CONSTRUCTION RECOMMENDATIONS

Site Preparation

All existing foundations, floor slabs, and utilities should be completely removed within 10 feet of the proposed footprint. Below-grade structures outside of the building footprint can be abandoned in place provided they are removed to at least 3 feet below finished subgrade levels, 2 feet below proposed utilities, and to eliminate conflicts with new utilities or structures. Slabs left in place should be sufficiently broken up to allow water to drain, and so that a geotechnical engineer can observe if voids exist beneath the slab. Existing asphalt pavement and concrete walkways should be completely removed.

Existing utilities within the building footprint should be completely removed. Existing utilities outside of the proposed building footprint should be removed or abandoned in place by completely filling with grout.

Excavations made to remove below-grade elements should be backfilled with approved, compacted fill in accordance with the Excavation, Fill, Placement, and Compaction Criteria section of this report and any environmental requirements.

Clearing and grubbing of trees and vegetation designated for removal (including root systems) should be performed. Buried debris should be completely removed beneath proposed building slab and footing locations. Topsoil should be stripped from the proposed building and pavement areas and should be stockpiled and protected from erosion. Topsoil should be evaluated by a landscape architect for reuse in landscape areas (if permitted by the environmental engineer). All clearing and stripping activities should be performed in strict accordance with the approved soil-erosion and sediment-control plan and the environmental reports prepared for the project.

All demolition and site-clearing work should be performed in accordance with any environmental requirements established for the site, and all local, state, and federal regulations. All debris and trees and other vegetation should be properly disposed of offsite in accordance with applicable regulations. All construction work should be performed so as not to adversely impact the existing school, neighboring buildings, off-site structures or utilities, including the existing utilities and trees that are to remain. Protection of these elements should be provided as necessary. Before beginning grading or placing fill, any miscellaneous trash, debris, or other unsuitable materials should be removed from the site.

Subgrade Preparation

All footing and utility-trench subgrades, except rock subgrades, should be proofrolled with six overlapping coverages of a double-drum 1-ton walk-behind vibratory roller (such as a Bomag BW75 or equivalent). All slab subgrade areas should be proofrolled with six overlapping coverages of a vibratory drum roller having a minimum static drum weight of 5 tons.

Soft areas identified during proofrolling should be excavated and replaced with approved structural fill. The actual extent of necessary excavation and replacement should be determined by a qualified Langan geotechnical engineer. Care should be taken when proofrolling near any existing underground utilities of structures that are to remain.

Soil footing subgrades should be excavated level. If any cobbles or boulders are encountered at the footing subgrade such that a relatively level subgrade is not achieved, they should be removed and replaced with compacted structural fill, compacted ¾-inch crushed stone, or lean concrete. All soil subgrades for footings or slabs should be compacted to the project specified compaction criteria.

If foundations are not poured in a timely manner, the subgrade should be protected with a lean concrete mud mat to protect the footing subgrades.

Steps should be taken by the contractor to control and remove surface-water runoff and precipitation. When soil is wet and subjected to construction traffic, previously acceptable subgrades can soften and become unacceptable. A smooth drum roller should be used to seal the surface and provide for better drainage. We also recommend crowning or sloping the subgrade to provide positive drainage off the subgrades.

Excavation, Fill, Placement, and Compaction Criteria

Excavation through the fill, estuarine deposits and the underlying natural sands can likely be performed using conventional earthmoving equipment (e.g., backhoes, excavators, dozers, etc.). Excavations made for footings and utilities should be conducted to minimize disturbance to the subgrade (i.e., backhoe with a smooth-edge bucket).

All excavations should be properly sloped or braced and conform with applicable OSHA regulations including, but not limited to, temporary shoring, trench boxes, or proper benching.

All excavation and backfilling must be performed in accordance with the project environmental engineer's recommendations.

The following types of fill can be used.

> Structural Fill – Structural fill should be well-graded sand and gravel having a maximum particle size of 3 inches and no more than 10% passing the No. 200 sieve. Additionally, the structural fill should be free of organics, clay, roots, concrete, other non-soil constituents, and other deleterious or compressible materials. Any approved imported structural fill should be "certified clean fill" free of hazardous substances and meeting all local, state, federal and the Connecticut Department of Energy and Environmental Protection Soil Waste regulations.

Material Reuse – The contractor may reuse the on-site fill or natural sand as structural fill provided the soil meet the requirements for structural fill outlined above and is approved by the environmental engineer. Note that samples obtained within the fill and natural sand layers have a fines content (material passing the No. 200 sieve) of about 13 to 23%; therefore, the soil may be sensitive to moisture. The overall amount of soil that can be reused will be dependent on the amount of fines present within the soil, the time of year the earthwork is carried out (e.g., potentially inclement weather), and the earthwork contractor's ability to stage, aerate and process the material to facilitate placement and compaction. We do not anticipate the estuarine deposits can be reused on-site.

General Fill – On-site soils not meeting the requirements for structural fill can be used as general fill for site landscape and other nonstructural areas if environmentally suitable for reuse.

Compaction Criteria – All fill should be placed in uniform 12-inch-thick loose lifts and compacted. Fill in landscaped areas should be compacted to 90% of its maximum dry unit weight as determined by ASTM D1557; all other fill should be compacted to at least 95%. In restricted areas where only hand-operated compactors can be used, the maximum lift thickness should be limited to 8 inches. The appropriate water content at the time of compaction should be plus or minus 2% of optimum as determined by the laboratory compaction tests of proposed fill. No backfill should be placed on areas where free water is standing or on frozen subsoil areas.

Temporary Groundwater Control

We anticipate that dewatering will be required during construction. Water infiltration to the foundation excavation and during the removal and replacement program can likely be controlled using gravity-fed sump pumps via gravel trenches or sumps assisted with collector trenches. The final dewatering measures required should be evaluated and designed by the contractor. The dewatering measures implemented should adequately dewater all foundation-related excavations such that compaction of footing subgrades is feasible.

Collection of rainwater runoff will also be needed during the excavation for the removal and replacement program and during the subgrade preparation work. Water runoff is expected to be controlled with the use of gravel-lined collection trenches, pits and submersible pumps. Care should be taken to ensure that drainage is provided during all phases of excavation work. Environmental pretreatment of groundwater, if necessary, is beyond the scope of this study. Collected water should be discharged in accordance with applicable regulations.

Monitoring

We understand that the existing school is to remain, will receive renovations, and is to be tied into the new addition, therefor damage to the existing school is to be avoided as much as possible. As such, we recommend that a monitoring program be developed and incorporated into the Contract Documents during construction. Monitoring should include means to measure vibrations from construction operations and ground movement. The type and locations of specific monitoring equipment, threshold values, and durations should be developed based on review of the anticipated construction means and methods in conjunction with proximity and type of existing structures and utilities. The purpose of performing monitoring is to provide reasonable feedback to the contractor with respect to protecting existing structures and utilities, and to assess any necessary changes to means and methods of construction.

We recommend developing a monitoring plan and project specifications prior to construction. These would detail the methods and equipment required for monitoring vibration and movement, and would provide limits along with requirements for frequency of readings and reporting. The monitoring program would likely include optical surveying, seismographs (vibration monitoring), and crack gauges. We recommend that all monitoring be performed by a third-party consultant independent of the contractor; however, the contractor should reserve the right to perform additional monitoring. Threshold criteria should be developed during deign and coordinated with the structural engineer.

SERVICES DURING DESIGN, CONSTRUCTION DOCUMENTS AND CONSTRUCTION QUALITY ASSURANCE

During final design, Langan should be retained to consult with the design team as geotechnical questions arise. Technical specifications and design drawings should incorporate our recommendations. When authorized, we will assist the design team in preparing specification sections related to geotechnical issues such as earthwork, shallow foundations, backfill, and excavation support. Langan should also, when authorized, review the project plans and contractor submittals relating to materials and construction procedures for geotechnical work to confirm the designs incorporate the intent of our recommendations.

Langan has explored and interpreted the site subsurface conditions and developed the foundation design recommendations contained here and is, therefore, best suited to perform quality-assurance observation and testing of geotechnical-related work during construction. The work requiring quality-assurance confirmation or special inspections per the Building Code includes, but is not limited to, earthwork, shallow foundations, backfill, and excavation support.

Recognizing that construction observation is the final stage of geotechnical design, quality-assurance observation during construction by Langan is necessary to confirm the design assumptions and design elements, to maintain our continuity of responsibility on this project, and allow us to make changes to our recommendations, as necessary. The foundation system and general geotechnical construction methods recommended herein are predicated upon Langan's assisting with the final design and providing construction observation services for the owner. If Langan is not retained for these services, we cannot assume the role of geotechnical engineer of record, and the entity providing the final design and construction observation services must serve as the engineer of record.

LIMITATIONS

The conclusions and recommendations provided in this report result from our interpretation of the geotechnical conditions existing at the site inferred from a limited number of borings and information provided by the design team. Actual subsurface conditions may vary. Recommendations provided are dependent upon one another and no recommendation should be followed independent of the others.

Any proposed changes in structures or their locations should be brought to Langan's attention as soon as possible so we can determine whether such changes affect our recommendations. Information on subsurface strata and groundwater levels shown on the logs represent conditions encountered only at the locations indicated and at the time of our exploration. If different conditions are encountered during construction, they should immediately be brought to Langan's attention for evaluation because they might affect our recommendations.

This report has been prepared to assist the owner, architect, and structural engineer in the design process and is only applicable to the design of the specific project identified. The information in this report cannot be used or depended on by engineers or contractors involved in evaluations or designs of facilities (including underpinning, grouting, stabilization, etc.) on adjacent properties beyond the limits of that which is the specific subject of this report.

Environmental issues (such as permitting or potentially contaminated soil and groundwater) are outside the scope of this study and should be addressed in a separate evaluation.

CLOSING

We have appreciated being of service on this project, and look forward to working with you to successfully complete this project.

Sincerely,
Langan CT, Inc.

Taylor Dalling, P.E
Project Engineer

Clayton Patterson, P.E.
Associate

TSD:cp/jd/cpc

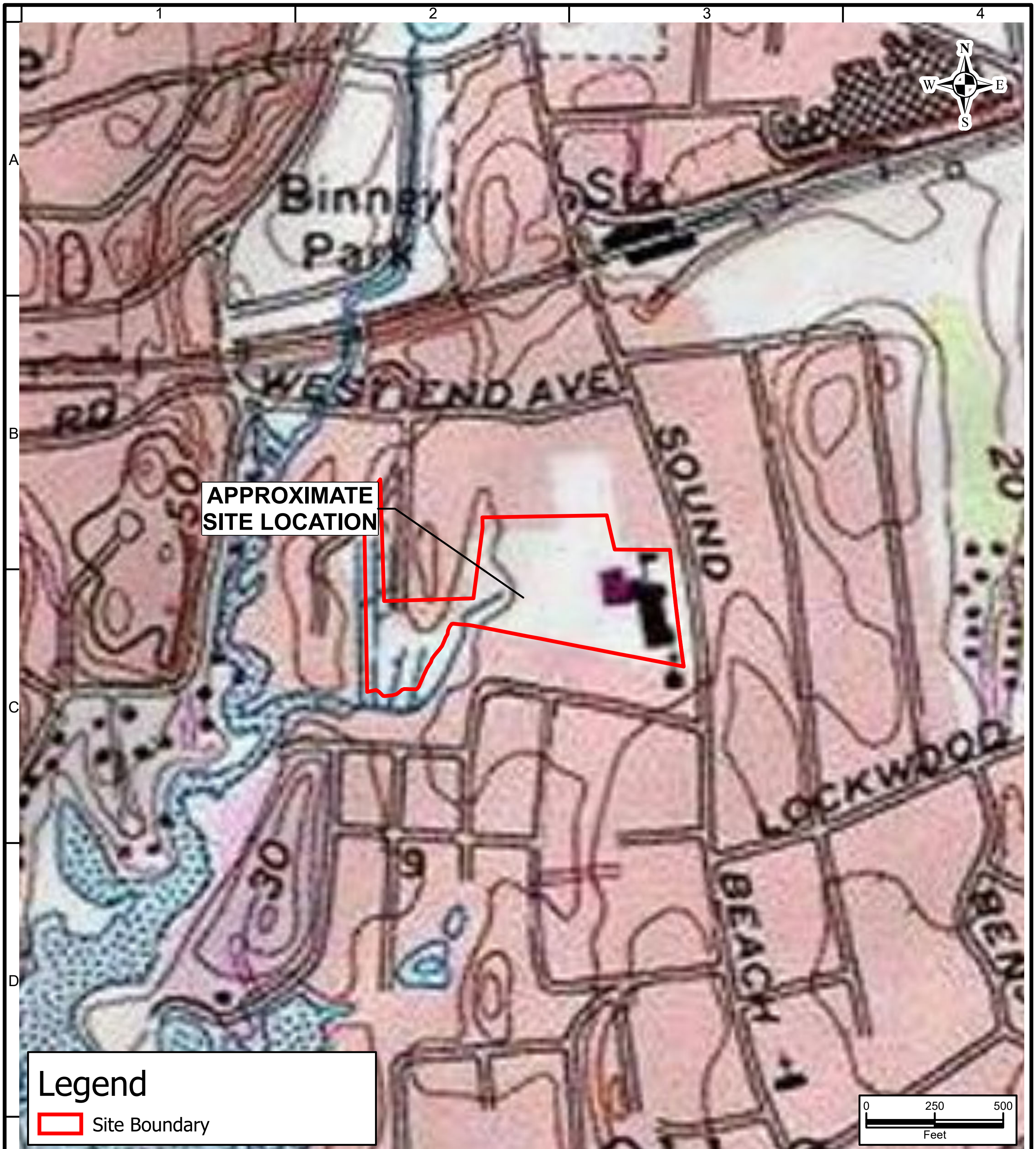
\\langan.com\data\NHV\data8\140265801\Project Data_Discipline\Geotechnical\Reports\2023-09 Revised Geotech Report\2023-09-28 - 140265801 - OGS_Revised Geo Report.docx

Attachments:

Figure 1: Site Location
Figure 2: CT Surficial Materials Map
Figure 3: CT Bedrock Geology
Figure 4: Effective FEMA FIRM
Figure 5: Exploration Location Plan
Figure 6: Soil Liquefaction Evaluation

Appendix A: Boring Logs
Appendix B: Test Pit Logs
Appendix C: Test Pit Photographs
Appendix D: Infiltration Testing Results
Appendix E: Laboratory Testing Results

FIGURES



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Langan International
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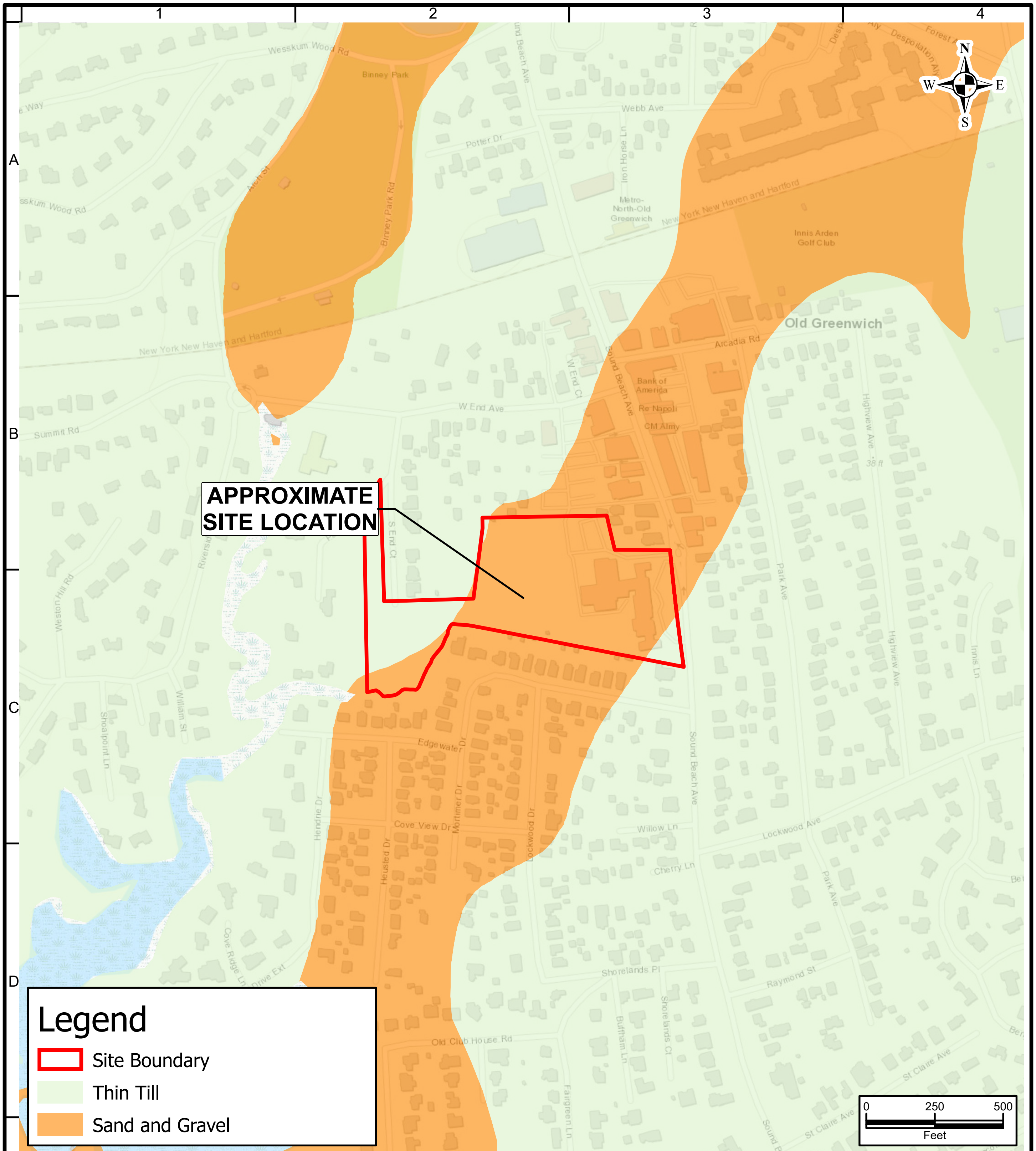
Project	Drawing Title	Project No.	Figure
Old Greenwich School OLD GREENWICH CONNECTICUT WESTERN CONNECTICUT	**SITE LOCATION**	140265801 Date: 4/27/2023 Scale: 1:500 Drawn By: Site Analyzer Submission Date: 04/27/2023	1 Sheet 1 of 4

Spatial Reference: NAD 1983 StatePlane Connecticut FIPS 0600 Feet



County of Westchester, UConn/CTDEEP, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA; USGS, CT DEEP

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Project	Drawing Title	Project No.	Figure
Old Greenwich School OLD GREENWICH CONNECTICUT WESTERN CONNECTICUT	**CT SURFICIAL MATERIALS MAP**	140265801 Date: 4/27/2023 Scale: 1:500 Drawn By: Site Analyzer Submission Date: 04/27/2023	2 Sheet 2 of 4

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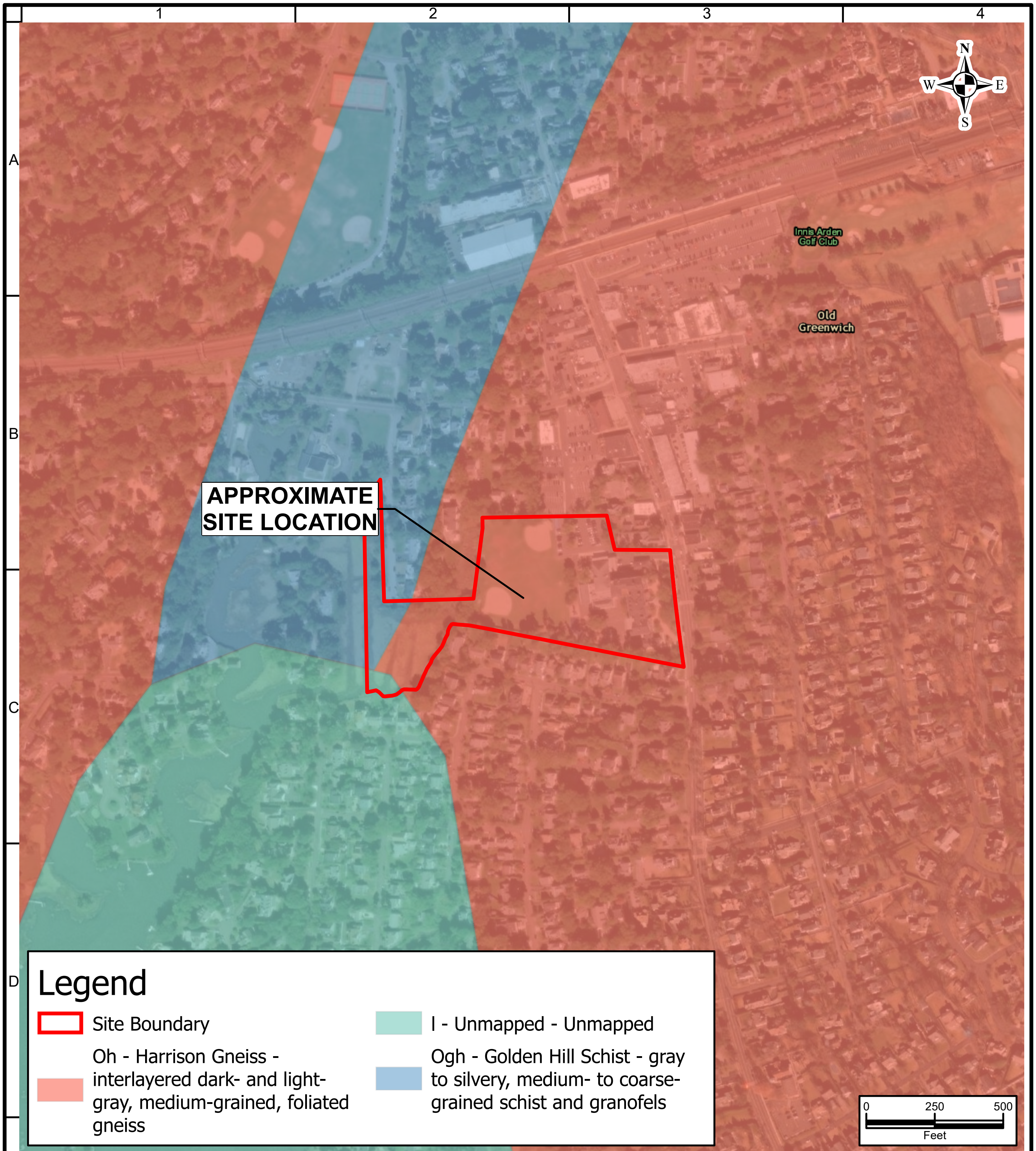
Spatial Reference: NAD 1983 StatePlane Connecticut FIPS 0600 Feet



New York State, State of Connecticut, Maxar, Westchester County GIS, Esri, HERE, Garmin, iPC; CT DEEP, USGS

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Project	Drawing Title	Project No.	Figure
Old Greenwich School	**CT BEDROCK GEOLOGY**	140265801	3
OLD GREENWICH CONNECTICUT		Date: 4/27/2023	
WESTERN CONNECTICUT		Scale: 1:500	
		Drawn By: Site Analyzer	
		Submission Date: 04/27/2023	Sheet 3 of 4

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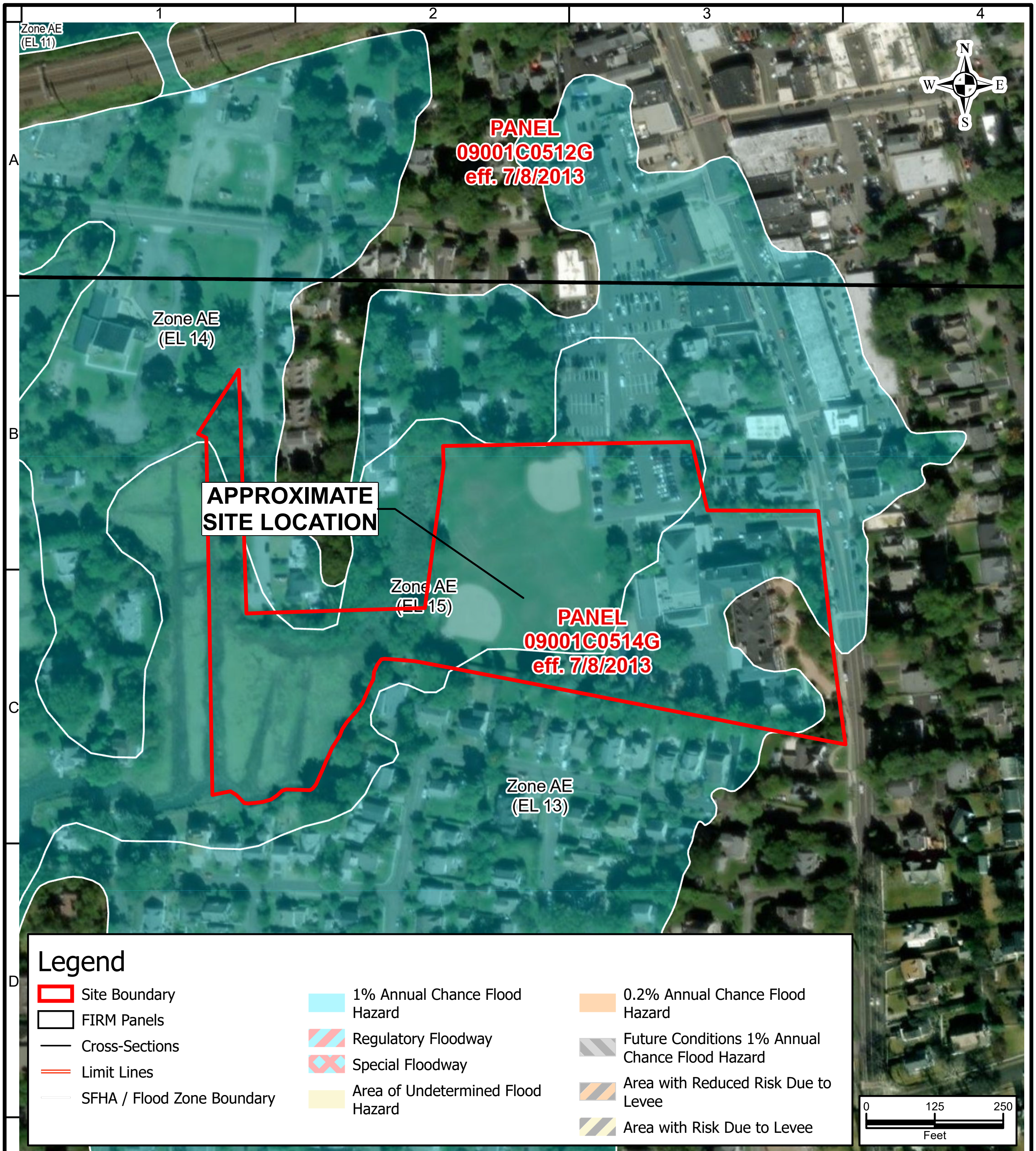
Spatial Reference: NAD 1983 StatePlane Connecticut FIPS 0600 Feet



New York State, State of Connecticut, Maxar; FEMA, FEMA RiskMap CDS

LANGAN	Project	Drawing Title	Project No.	Figure
Long Wharf Maritime Center, 555 Long Wharf Drive New Haven, CT 06511 T: 203.562.5771 F: 203.789.6142 www.langan.com	**Old Greenwich School**	**EFFECTIVE FEMA FIRM**	140265801	4
Langan Engineering & Environmental Services, Inc. Langan Engineering, Environmental, Surveying, Landscape Architecture and Geology, D.P.C. Langan International Collectively known as Langan	OLD GREENWICH CONNECTICUT WESTERN CONNECTICUT		Date 4/27/2023 Scale 1:250 Drawn By Site Analyzer Submission Date 04/27/2023	Sheet 4 of 4

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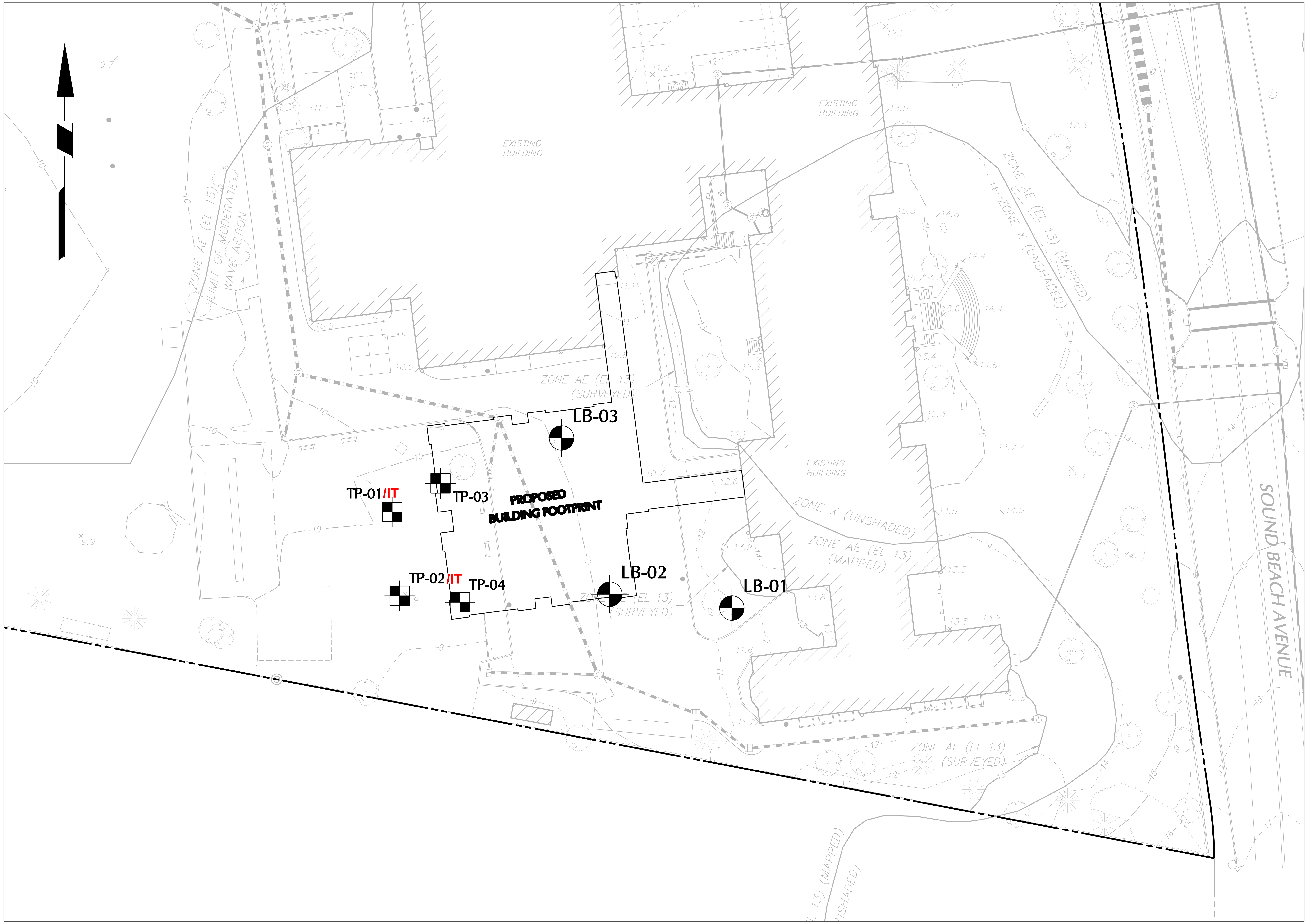
Spatial Reference: NAD 1983 StatePlane Connecticut FIPS 0600 Feet



NOTES

1. ALL BORING AND TEST PIT LOCATIONS ARE APPROXIMATE.
2. ELEVATIONS REFERENCE NAVD88.
3. SURVEY INFORMATION REFERENCES THE SURVEY ENTITLED "BOUNDARY & TOPOGRAPHIC SURVEY" PREPARED BY LANGAN DATED 28 APRIL 2023.
4. BUILDING INFORMATION REFERENCES THE DRAWING ENTITLED "PROPOSED GROUND FLOOR SCHEME D.2" PREPARED BY SILVER PETRUCELLI + ASSOCIATES DATED 18 APRIL 2023.
5. BORINGS LB-01 THROUGH LB-03 WERE DRILLED BY SOILTESTING, INC. USING A CME55 LC TRACK-MOUNTED RIG UNDER THE FULL-TIME OBSERVATION OF A LANGAN FIELD ENGINEER ON 11 APRIL 2023.
6. TEST PITS TP-01 THROUGH TP-04 WERE EXCAVATED BY POLSTER INDUSTRIES USING A CAT 304E MINI EXCAVATOR UNDER THE FULL-TIME OBSERVATION OF A LANGAN FIELD ENGINEERING ON 30 AUGUST 2023.

LEGEND

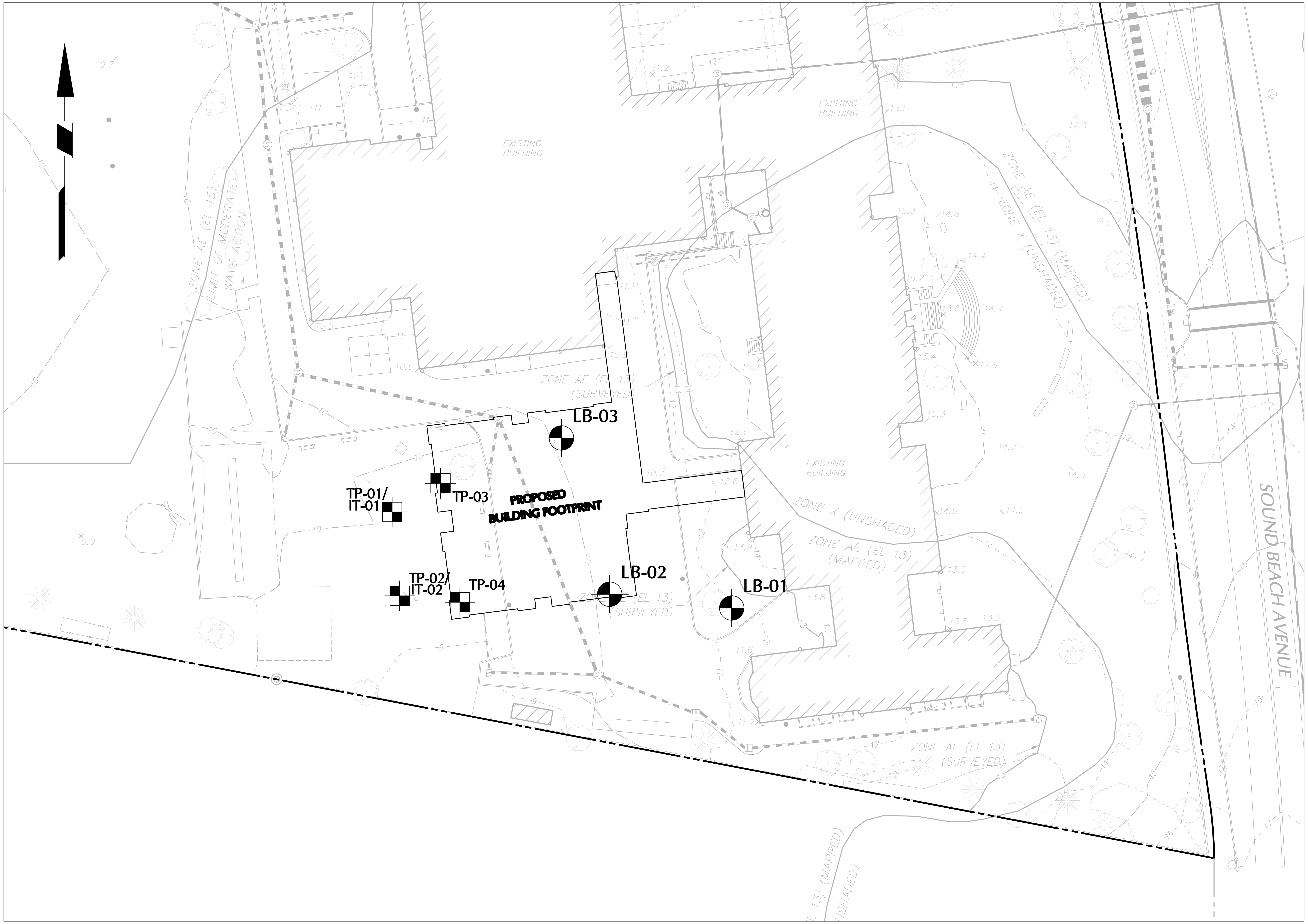
PROPOSED SUBDIVISION LINE	
PROPOSED BUILDING LINE	
2023 LANGAN BORING LOCATION	LB-01
2023 LANGAN TEST PIT LOCATION	TP-01
2023 Infiltration Test Location	IT-01

20 0 5 10 20
SCALE: 1 INCH = 20 FEET

LANGAN Langan CT, Inc. 555 Long Wharf Drive New Haven, CT 06511 T: 203.562.5711 F: 203.789.6142 www.langan.com	Project OLD GREENWICH SCHOOL RENO & ADDITION/SPA 285 SOUND BEACH AVENUE OLD GREENWICH FAIRFIELD COUNTY CONNECTICUT	Drawing Title EXPLORATION LOCATION PLAN	Project No. 140265801 Date 9/13/2023 Drawn By MDW Checked By TSD	Figure 5 Sheet 5 of 5

Date: 9/13/2023 Time: 13:17 User: ochasse Style Table: Langan.stb Layout: Layout1 Document Code: FG05-140265801-0201-BL101-0101

LANGAN Project No. 140265801



NOTES

1. ALL BORING AND TEST PIT LOCATIONS ARE APPROXIMATE.
2. ELEVATIONS REFERENCE NAVD88.
3. SURVEY INFORMATION REFERENCES THE SURVEY ENTITLED "BOUNDARY & TOPOGRAPHIC SURVEY" PREPARED BY LANGAN DATED 28 APRIL 2023.
4. BUILDING INFORMATION REFERENCES THE DRAWING ENTITLED "PROPOSED GROUND FLOOR SCHEME D.2" PREPARED BY SILVER PETRUCELLI + ASSOCIATES DATED 18 APRIL 2023.
5. BORINGS LB-01 THROUGH LB-03 WERE DRILLED BY SOILTESTING, INC. USING A CME55 LC TRACK-MOUNTED RIG UNDER THE FULL-TIME OBSERVATION OF A LANGAN FIELD ENGINEER ON 11 APRIL 2023.
6. TEST PITS TP-01 THROUGH TP-04 WERE EXCAVATED BY POLSTER INDUSTRIES USING A CAT 304E MINI EXCAVATOR UNDER THE FULL-TIME OBSERVATION OF A LANGAN FIELD ENGINEER ON 30 AUGUST 2023.
7. INFILTRATION TESTS IT-01 AND IT-02 WERE PERFORMED BY A LANGAN FIELD ENGINEER ON 30 AUGUST 2023.

LEGEND

PROPOSED SUBDIVISION LINE	
PROPOSED BUILDING LINE	
2023 LANGAN BORING LOCATION	LB-01
2023 LANGAN TEST PIT LOCATION	TP-01
2023 LANGAN INFILTRATION TESTING LOCATION	IT-01

SCALE: 1 INCH = 20 FEET

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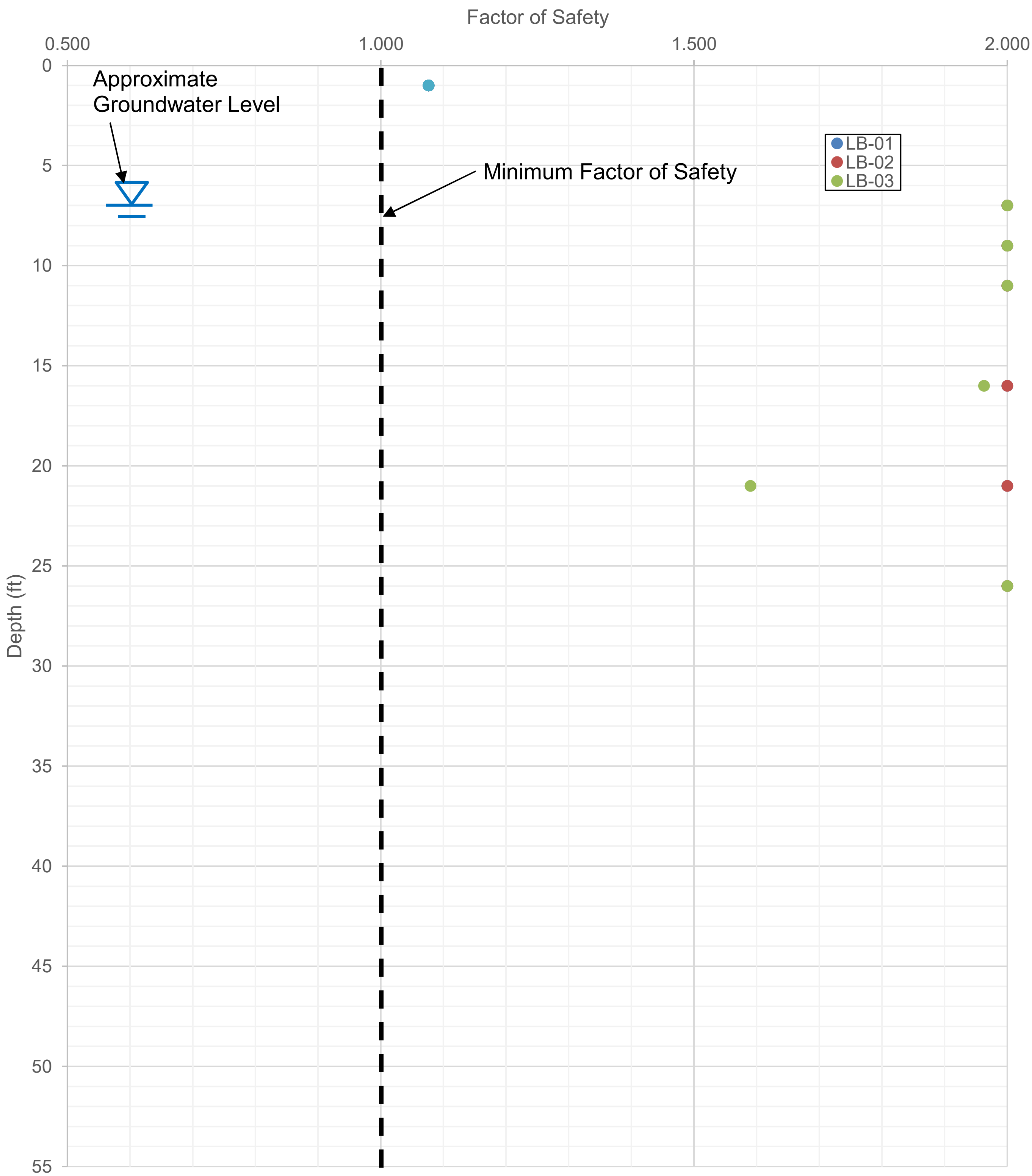
Project
OLD GREENWICH SCHOOL RENO & ADDITION/SPA
285 SOUND BEACH AVENUE
OLD GREENWICH
FAIRFIELD COUNTY CONNECTICUT

Drawing Title
EXPLORATION LOCATION PLAN

Project No. 140265801
Date 9/13/2023
Drawn By MDW
Checked By TSD

Figure 5
Sheet 5 of 5

Date: 9/18/2023 Time: 18:09 User: mwendland Style Table: Langan.stb Layout: Layout1 Document Code: FG05-140265801-0201-BL101-0101



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ABU DHABI ATHENS DOHA DUBAI ISTANBUL PANAMA

Project	Drawing Title	Project No.	Figure No.
OLD GREENWICH SCHOOL OLD GREENWICH FAIRFIELD COUNTY CONNECTICUT	SOIL LIQUEFACTION EVALUATION	140265801 Date: 5/4/2023 Scale: N.T.S Drawn By: TSD	6

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APPENDIX A
BORING LOGS

LANGAN

Log of Boring **LB-01**

Project	Old Greenwich School	Project No.	140265801
Location	285 Sound Beach Ave, Old Greenwich, CT	Elevation and Datum	Approx. el. 12.0 (NAVD 88)
Drilling Company	Soiltesting, Inc.	Date Started / Date Finished	4/11/2023 / 4/11/2023
Drilling Equipment	CME55 LC	Completion Depth / Rock Depth	25.9 ft / 25.9 ft
Size and Type of Bit	4-1/4-inch hollow-stem auger	Number of Samples	Disturbed 9; Undisturbed 0; Core 0
Casing Diameter (in)	N/A; Casing Depth (ft) N/A	Water Level (ft.)	First 7.5; Completion 18.3; 24 HR. N/A
Casing Hammer	N/A; Weight (lbs) N/A; Drop (in) N/A	Drilling Foreman	Andy Koval
Sampler	2in OD Split Spoon	Field Engineer	Matthew Wendland
Sampler Hammer	Automatic; Weight (lbs) 140; Drop (in) 30		

Elev. (ft) +12.0	Sample Description	Depth Scale	Number	Type	Recov. (in)	Penetr-resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Casing Depth, Fluid Loss, Drilling Resistance, etc.)
+11.2	Brown Silty fine to medium SAND, trace fine gravel, trace organics, trace roots, trace asphalt, trace plastic debris (moist) [TOPSOIL]	0–1	S-1A	SS	5	2, 6	13	
	Brown fine to coarse SAND, some coarse to fine gravel, some silt, trace organics, trace roots, trace asphalt, trace plastic debris (moist) [FILL]	1–2	S-1B			7, 5		
	Brown fine to coarse SAND, some fine to coarse gravel, some silt, trace roots, trace asphalt (moist) [FILL]	2–4	S-2	SS	10	4, 3, 5, 2	8	
+7.4	Brown fine to coarse SAND, trace fine to coarse gravel, some silt, trace roots, trace asphalt (moist) [FILL]	4–4.6	S-3A	SS	17	2, 4	12	Auger to 4ft. Brown cuttings
+6.0	Light brown to orangish brown Clayey fine SAND, some silt, some coarse to fine gravel, trace organics, trace roots, mottling (moist) [ESTUARINE]	4.6–6	S-3B			8, 14		
	Orangish brown to brown fine to coarse SAND with fine to coarse GRAVEL, trace silt, trace weathered rock fragments (moist) [SW]	6–7	S-4A	SS	18	19, 21	38	
	Light brown fine to coarse SAND with fine to coarse GRAVEL, trace silt (wet) [SW]	7–8	S-4B			17, 17		Water level first at about 7.5ft. Note that water level at completion reading is much deeper at about 18.3ft. This could explain why samples below S-4B are moist - maybe this was not groundwater at 7.5ft
+2.0	Light brown to orangish brown fine to coarse SAND with fine to coarse GRAVEL, trace silt (wet) [SW]	8–10	S-5	SS	13	13, 18, 19, 8	37	Auger to 8ft. Brown cuttings
	Orangish brown to brown Silty fine to coarse SAND, some fine to coarse gravel, weathered rock fragments (wet) [DECOMPOSED ROCK]	10–12	S-6	SS	13	11, 13, 13, 15	26	
	Brown Silty fine to medium SAND, trace coarse gravel, stratification visible (wet) [DECOMPOSED ROCK]	15–17	S-7	SS	8	10, 13, 9, 11	22	Auger to 15ft. Medium augering. Light rig chatter at 10ft

LANGAN

Log of Boring **LB-01**

Project	Project No.
Old Greenwich School	140265801
Location	**Elevation and Datum**
	12.0

Elev. (ft)	Sample Description	Depth Scale	Number	Type	Recov. (in)	Penetr- resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Casing Depth, Fluid Loss, Drilling Resistance, etc.)
-8.0	Brown to reddish brown Silty fine to coarse SAND, some fine to coarse gravel, stratification visible (wet) [DECOMPOSED ROCK]	20	S-8	SS	15	9 / 9 / 9 / 14	18	Auger to 20ft Medium augering. Brown cuttings
	Light gray to dark gray Silty fine SAND, trace fine gravel, stratification visible (wet) [DECOMPOSED ROCK]	25	S-9A	SS	10	7 / 50/5"	50/5"	Auger to 25ft. Medium augering. Brown cuttings
-13.9	Gray fine SAND, some silt, trace fine gravel (wet) [DECOMPOSED ROCK]		S-9B					Boring terminated at 25.92ft. Boring backfilled to grade with cuttings and cement
	End of Boring at 25.9ft.							

Depth Scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45

LANGAN

Log of Boring **LB-02**

Project: Old Greenwich School	Project No.: 140265801
Location: 285 Sound Beach Ave, Old Greenwich, CT	Elevation and Datum: Approx. el. 10.0 (NAVD 88)
Drilling Company: Soiltesting, Inc.	Date Started: 4/11/2023 — Date Finished: 4/11/2023
Drilling Equipment: CME55 LC	Completion Depth: 26.4 ft — Rock Depth: 26.4 ft
Size and Type of Bit: 4-1/4-inch hollow-stem auger	Number of Samples: Disturbed 9 — Undisturbed 0 — Core 0
Casing Diameter (in): N/A — Casing Depth (ft): N/A	Water Level (ft.): First ▽ 7.5 — Completion ▼ 9.2 — 24 HR. ▼ N/A
Casing Hammer: N/A — Weight (lbs): N/A — Drop (in): N/A	Drilling Foreman: Andy Koval
Sampler: 2in OD Split Spoon	Field Engineer: Matthew Wendland
Sampler Hammer: Automatic — Weight (lbs): 140 — Drop (in): 30	

Elev. (ft) +10.0	Sample Description
+9.6	5" asphalt
+8.5	Brown fine to coarse SAND, some fine to coarse gravel, some silt, trace asphalt (moist) [FILL]
	Dark brown to black Sandy SILT, trace fine gravel, some organics (moist) [ESTUARINE]
	Dark grayish brown Clayey fine SAND, some silt, trace fine gravel, trace organics (moist) [ESTUARINE]
+4.0	Dark grayish brown to gray Clayey fine SAND, some silt, mottling (moist) [ESTUARINE]
	Grayish brown to orangish brown Silty fine to coarse SAND, some fine to coarse gravel (moist) [SW]
	Orangish brown fine to coarse SAND, some fine to coarse gravel, some silt, mottled (wet) [SW]
	Orangish brown fine to coarse SAND, some coarse to fine gravel, some silt (wet) [SW]
-1.5	Orangish brown fine to coarse SAND, some fine to coarse gravel, some silt (wet) [SW]
	Light brown fine to coarse SAND, some silt, trace fine to coarse gravel (wet) [SW]
	Brown Silty fine to medium SAND, trace fine gravel, weathered rock fragments (wet) [DECOMPOSED ROCK]
	Brown Silty fine to coarse SAND, trace fine to coarse gravel, stratification visible (wet) [DECOMPOSED ROCK]

Depth Scale	Number	Type	Recov. (in)	Penetr-resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Casing Depth, Fluid Loss, Drilling Resistance, etc.)
0						Boring offset about 8ft east of original marking
1	S-1A	SS	8	14, 5, 6	11	
1.5	S-1B					
2–4	S-2	SS	10	3, 1, 3, 5	4	
4–6	S-3	SS	20	3, 3, 4, 10	7	Auger to 4ft. Medium augering to 2ft. Light rig chatter to 2ft. Brown to dark grayish brown cuttings
6–8	S-4A, S-4B	SS	19	18, 16, 14, 19	30	Groundwater first encountered at 7.5ft. Auger to 8ft. Brown cuttings
8–10	S-5	SS	11	6, 15, 10, 14	25	
10–12	S-6A, S-6B, S-6C	SS	24	18, 14, 8, 15	22	
15–17	S-7	SS	8	11, 15, 11, 9	26	Auger to 15ft. Medium to hard augering. Light rig chatter. Brown cuttings
19–20						Auger to 20ft. Hard augering. Brown cuttings

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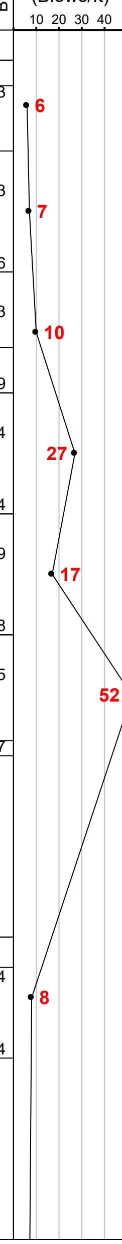
Project	Old Greenwich School	Project No.	140265801
Location		Elevation and Datum	10.0

Material Symbol	Elev. (ft)	Sample Description	Depth Scale	Number	Type	Recov. (in)	Penetr-resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Casing Depth, Fluid Loss, Drilling Resistance, etc.)
	-10.0	Dark brown to reddish brown Silty fine SAND, trace coarse gravel, stratification visible (wet) [DECOMPOSED ROCK]	20–22	S-8	SS	12	5, 7, 10, 8	17	
		Dark gray to gray Silty fine to medium SAND, trace coarse to fine gravel, stratification visible (wet) [DECOMPOSED ROCK]	25–26.4	S-9	SS	11	7, 18, 60/5"	60/5"	Auger to 25ft. Hard augering. Brown cuttings
	-16.4	End of Boring at 26.4ft.							Boring terminated at 26.42ft. Boring backfilled to grade with cuttings and cement. Boring sealed with asphalt

LANGAN Log of Boring **LB-03** Sheet 1 of 2

Project	Old Greenwich School	Project No.	140265801
Location	285 Sound Beach Ave, Old Greenwich, CT	Elevation and Datum	Approx. el. 10.0 (NAVD 88)
Drilling Company	Soiltesting, Inc.	Date Started / Date Finished	4/11/2023 / 4/11/2023
Drilling Equipment	CME55 LC	Completion Depth / Rock Depth	27.0 ft / N/E
Size and Type of Bit	4-1/4-inch hollow-stem auger	Number of Samples	Disturbed 9; Undisturbed 0; Core 0
Casing Diameter (in)	N/A; Casing Depth (ft) N/A	Water Level (ft.)	First 8.0; Completion 9.1; 24 HR. N/A
Casing Hammer	N/A; Weight (lbs) N/A; Drop (in) N/A	Drilling Foreman	Andy Koval
Sampler	2in OD Split Spoon	Field Engineer	Matthew Wendland
Sampler Hammer	Automatic; Weight (lbs) 140; Drop (in) 30		

Elev. (ft) +10.0	Sample Description	Depth Scale	Number	Type	Recov. (in)	Penetr-resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Casing Depth, Fluid Loss, Drilling Resistance, etc.)
+9.6	5" asphalt	0						
	Brown fine to coarse SAND, some fine to coarse gravel, some silt, trace asphalt (moist) [FILL]	0.5	S-1A	SS	12	2, 3		
+8.0	Dark grayish brown Silty fine to coarse SAND, trace coarse to fine gravel, some organics, trace roots (moist) [FILL]	1	S-1B	SS		3	6	
	Gray to orangish gray Clayey fine SAND, some silt, trace organics, trace roots, mottling (moist) [ESTUARINE]	2	S-2	SS	17	2, 3, 4, 6	7	
	Gray to orangish gray Clayey fine SAND, some silt, trace organics, trace fine to coarse gravel, trace roots, mottling (moist) [ESTUARINE]	4	S-3A	SS	16	2, 3, 7	10	Auger to 4ft. Medium augering. Light rig chatter. Brown cuttings
+4.8	Orangish brown Silty fine to medium SAND, trace fine gravel (moist) [SW]	5.25	S-3B			9		
	Grayish brown Gravelly fine to coarse SAND, trace silt (moist) [SW]	6	S-4	SS	13	14, 14, 13, 14	27	
	Light brown fine to coarse SAND, some fine to coarse gravel, trace silt (wet) [SW]	8	S-5	SS	14	9, 9, 8, 8	17	Groundwater first encountered at about 8ft
	Light brown fine to coarse SAND, trace silt (wet) [SW]	10	S-6A	SS	20	13, 25, 27	52	
	Light brown fine to coarse SAND, some fine gravel, some silt (wet) [SW]	11.75	S-6B			17		
	Light brown Silty fine to coarse SAND, some silt, trace fine to coarse gravel (wet) [SW]	15	S-7A	SS	16	2, 4		Auger to 15ft. Grayish brown cuttings
	Light brown Silty fine to medium SAND (wet) [SW]	15.5	S-7B			4, 4	8	
		20						



LANGAN Log of Boring **LB-03** Sheet 2 of 2

Project	Project No.
Old Greenwich School	140265801
Location	**Elevation and Datum**
	10.0

Elev. (ft)	Sample Description	Depth (ft)	Number	Type	Recov. (in)	Penetr-resist BL/6in	N-Value (Blows/ft)	Remarks (Drilling Fluid, Casing Depth, Fluid Loss, Drilling Resistance, etc.)
-10.0	Light brown fine to coarse SAND, some silt, trace fine gravel (wet) [SW]	20	S-8A	SS	16	3 4	7	Auger to 20ft. Grayish brown cuttings
	Grayish brown fine SAND, some silt, trace fine gravel (wet) [SW]	21	S-8B			3 10		
	Grayish brown fine to medium SAND, some fine to coarse gravel, some silt (wet) [SW]	25	S-9A	SS	24	3 4	13	Auger to 25ft. Light rig chatter at 23ft.
-16.3	Gray Silty fine to coarse SAND, trace fine to coarse gravel, weathered rock fragments (wet) [DECOMPOSED ROCK]	26.3	S-9B			9 11		
-17.0	End of Boring at 27ft.	27						Boring terminated at 27ft. Boring backfilled to grade with cuttings and cement. Boring sealed with asphalt

Depth Scale: 20 to 45 ft

APPENDIX B
TEST PIT LOGS

LANGAN

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Log of Test Pit TP-01

Project: Old Greenwich School	Project No.: 140265801	Date: 8/30/2023
Location: 285 Sound Beach Ave, Old Greenwich, CT	Elevation and Datum: Approx. el. 10.0 (NAVD 88)	
Excavation Company: Polster Industries	Depth: 7.0 ft	Water Level - First: 6.0 ▽ / Water Level - Completion: ▼
Excavation Equipment: Not Applicab	Excavation Foreman: Ben	Field Engineer: Olivia Chasse

SYMBOL	Elev. (ft)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
	+10.0		0			
	+9.8	Brown WOODCHIPS (2 inches)				Vertical sidewalls maintained.
	+9.5	Dark brown fine to medium SAND, trace silt, some root, trace fine gravel (dry) [TOPSOIL]				Layer of geofabric below topsoil
	+8.0	Brown fine to coarse SAND, some fine gravel, trace silt, trace root (dry) [FILL]	1			
	+5.5	Orangish brown Silty fine SAND, some fine gravel (moist) [SM]	2, 3, 4			Roots until 2 feet
		Brown to grayish brown fine to coarse SAND, trace silt, some fine gravel (wet) [SP]	5			Infiltration test performed at 4.5ft
	+3.0	Gray fine to coarse SAND, some fine to coarse gravel, trace silt (wet) [SP]	6 ▽			
			7, 8, 9, 10			Bottom of Test Pit at 7ft. Test Pit backfilled with excavated soil in 1 to 2 foot thick lifts compacted with the excavator bucket.

LANGAN Log of Test Pit **TP-02** Sheet 1 of 1

Project	Project No.	Date
Old Greenwich School	140265801	8/30/2023

Location	Elevation and Datum
285 Sound Beach Ave, Old Greenwich, CT	Approx. el. 10.0 (NAVD 88)

Excavation Company	Depth	Water Level - First	Water Level - Completion
Polster Industries	7.5 ft	6.5	

Excavation Equipment	Excavation Foreman	Field Engineer
	Ben	Olivia Chasse

Elev. (ft)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
+10.0		0			
+9.8	Brown WOODCHIPS (2 inches)				
+9.3	Dark brown fine to medium SAND, some silt, some root, trace fine gravel (dry) [TOPSOIL]				Vertical sidewalls mostly maintained. Some sidewall cave-in.
+8.0	Gray fine to medium SAND, trace silt, some fine gravel (dry) [FILL]	1			
+7.0	Gray Silty fine to medium SAND, some fine gravel, trace root, trace organics (moist) [ESTUARINE]	2			Layer of geofabric observed below topsoil. Roots to 2.5ft
+5.5	Orangish brown fine to medium SAND, some silt, some fine to coarse gravel (wet) [SP]	3, 4			
+3.5	Gray Silty SAND, trace gravel (moist) [SM]	5, 6			Infiltration test performed at 5.5ft
+2.5	Gray fine to coarse SAND, trace silt, some fine to coarse gravel (wet) [SP]	7			
		8, 9, 10			Bottom of Test Pit at 7.5ft. Test Pit backfilled with excavated soil in 1 to 2 foot thick lifts compacted with the excavator bucket.

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Log of Test Pit TP-03

Project: Old Greenwich School	Project No.: 140265801	Date: 8/30/2023
Location: 285 Sound Beach Ave, Old Greenwich, CT	Elevation and Datum: Approx. el. 10.0 (NAVD 88)	
Excavation Company: Polster Industries	Depth: 6.2 ft	Water Level - First: 5.5 ▽; Water Level - Completion: ▼
Excavation Equipment:	Excavation Foreman: Ben	Field Engineer: Olivia Chasse

Elev. (ft)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
+10.0		0			
+9.9	Brown WOODCHIPS (1 inch)				
+9.6	Dark brown fine to medium SAND, trace silt, trace fine gravel, some roots (dry) [TOPSOIL]				Vertical sidewalls maintained
+8.0	Brown fine to medium SAND, trace silt, trace fine gravel, some root (dry) [FILL]	1			Layer of geofabric observed below topsoil.
+6.5	Orangish brown fine to medium SAND, some silt, some fine to coarse gravel (dry) [SM]	2–3			Roots to 2ft
	Brown fine to coarse SAND, trace silt, some fine to coarse gravel (moist) [SP]	4			
+3.8	Gray fine to coarse SAND, some fine to coarse gravel, trace silt (wet) [SP]	5–6			Water seeping through sidewalls at about 5.5ft.
		7–10			Bottom of Test Pit at 6.2ft. Test Pit backfilled with excavated soils in 1 to 2 foot thick lifts compacted by the excavator bucket.

LANGAN Log of Test Pit **TP-04**

Project: Old Greenwich School	Project No.: 140265801	Date: 8/30/2023
Location: 285 Sound Beach Ave, Old Greenwich, CT	Elevation and Datum: Approx. el. 10.0 (NAVD 88)	
Excavation Company: Polster Industries	Depth: 7.5 ft	Water Level - First: 6.5; Water Level - Completion:
Excavation Equipment:	Excavation Foreman: Ben	Field Engineer: Olivia Chasse

Elev. (ft)	DESCRIPTION	Depth Scale	SAMPLE Number	SAMPLE Type	REMARKS
+10.0	Brown WOODCHIPS (6 inches)	0			Vertical sidewalls mostly maintained.
+9.5	Dark brown fine to medium SAND, trace silt, trace gravel, trace root (dry) [TOPSOIL]				
+9.0	Brown fine to coarse SAND, trace silt, some fine gravel (dry) [FILL]	1			Layer of geofrabric observed below topsoil.
	Light brown fine to medium SAND, some silt, some fine gravel (dry) [FILL]	2			
+7.0	Gray SILT, some fine sand, trace fine gravel (moist) [ESTUARINE]	3			
	Gray silty fine to coarse SAND, some organics, some fine gravel, trace mica fragments (wet) [ESTUARINE]	6.5			
+3.0	Gray fine to coarse SAND, trace silt, some fine gravel (wet) [SP]	7			
+2.5		7.5			Bottom of Test Pit at 7.5ft. Test Pit backfilled with excavated soil in 1 to 2 foot thick lifts compacted with the excavator bucket.

APPENDIX C
TEST PIT PHOTOGRAPHS

LANGAN

Photo 1: TP-01

Photo 2: TP-01

Photo 3: TP-02

Photo 4: TP-02

Photo 5: TP-02

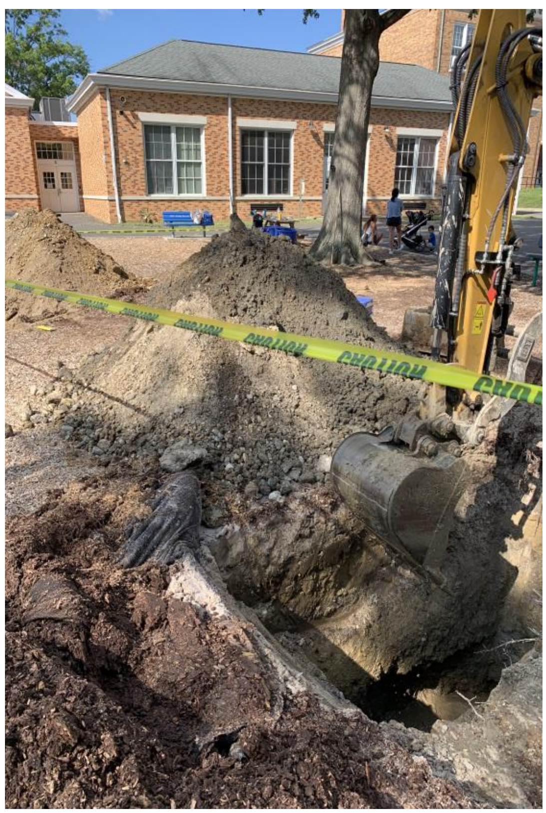

Photo 6: TP-02

Photo 7: TP-03

Photo 8: TP-03

Photo 9: TP-03

Photo 10: TP-03

Photo 11: TP-04

Photo 12: TP-04

Photo 13: TP-04

Photo 14: TP-04

APPENDIX D
INFILTRATION TESTING RESULTS

LANGAN

INFILTRATION TESTS

IT -01 performed in TP-01

PROJECT	Old Greenwich School	**PROJECT NO.**	140265801
LOCATION	285 Sound Beach Ave, Old Greenwich, CT	**DATE**	8/30/2023
INSPECTOR	Olivia Chasse	**WEATHER**	Rain/Cloudy, 70s

PRESOAK	**TIME**	**DEPTH OF HOLE (INCH)**	**ELEVATION AND DATUM**			
Start	9:23	12	**Surface Elevation**	Approx.	10	(NAVD88)
End	11:35	12	**Top of Hole Elevation**	Approx.	6.5	(NAVD88)
			Bottom of Hole Elevation	Approx.	5.5	(NAVD88)

METHOD OF INFILTRATION TEST

TP-01 was advanced to a depth of about 3.5 feet below existing grades. A 12-inch deep and about 6-inch diameter hole was dug by hand with a post hole digger. An about 4-inch diameter and 30-inch long PVC pipe was then placed in the hole. Before running infiltration tests, the hole was presoaked for about 2 hours and 12 minutes. For each infiltration test, the hole was filled with about 24-inches of water. Then, after one hour, the depth to water was measured to calculate the total drop of water over that time period. The tables below outline the calculations for determining the average rate in which the water dissipated.

	TIME (MIN)	DEPTH TO WATER (IN)	DROP (IN)	RATE (IN/MIN)	RATE (IN/HOUR)	SOIL CONDITIONS
TEST 1	0	18	-	-	-	Brown to grayish brown fine to coarse SAND, trace silt, some fine gravel
	60	21	3	0.05	3	
				Rate:	**3 in/hr**	

	TIME (MIN)	DEPTH TO WATER (IN)	DROP (IN)	RATE (IN/MIN)	RATE (IN/HOUR)	SOIL CONDITIONS
TEST 2	0	17	-	-	-	Brown to grayish brown fine to coarse SAND, trace silt, some fine gravel
	60	19.5	2.5	0.0416667	2.5	
				Rate:	**2.5 in/hr**	

	TIME (MIN)	DEPTH TO WATER (IN)	DROP (IN)	RATE (IN/MIN)	RATE (IN/HOUR)	SOIL CONDITIONS
TEST 3	0	6	-	-	-	Brown to grayish brown fine to coarse SAND, trace silt, some fine gravel
	60	8.75	2.75	0.0458333	2.75	
				Rate:	**2.75 in/hr**	

	TIME (MIN)	DEPTH TO WATER (IN)	DROP (IN)	RATE (IN/MIN)	RATE (IN/HOUR)	SOIL CONDITIONS
TEST 4	0	6	-	-	-	Brown to grayish brown fine to coarse SAND, trace silt, some fine gravel
	60	10.25	4.25	0.0708333	4.25	
				Rate:	**4.25 in/hr**	

Average Rate:	**3.1**	**in/hr**
Reduced by Factor of 2:	**1.6**	**in/hr**

LANGAN

INFILTRATION TESTS

IT -02 performed in TP-02

PROJECT	Old Greenwich School	**PROJECT NO.**	140265801
LOCATION	285 Sound Beach Ave, Old Greenwich, CT	**DATE**	8/30/2023
INSPECTOR	Olivia Chasse	**WEATHER**	Rain/Cloudy, 70s

PRESOAK	**TIME**	**DEPTH OF HOLE (INCH)**	**ELEVATION AND DATUM**			
Start	9:51	12	**Surface Elevation**	Approx.	10	(NAVD88)
End	11:40	12	**Top of Hole Elevation**	Approx.	5.5	(NAVD88)
			Bottom of Hole Elevation	Approx.	4.5	(NAVD88)

METHOD OF INFILTRATION TEST

TP-02 was advanced to a depth of about 4.5 feet below existing grades. A 12-inch deep and about 6-inch diameter hole was dug by hand with a post hole digger. An about 4-inch diameter and 30-inch long PVC pipe was then placed in the hole. Before running infiltration tests, the hole was presoaked for about 1 hour and 49 minutes. For each infiltration test, the hole was filled with about 24-inches of water. Then, after one hour, the depth to water was measured to calculate the total drop of water over that time period. The tables below outline the calculations for determining the average rate in which the water dissipated.

	TIME (MIN)	DEPTH TO WATER (IN)	DROP (IN)	RATE (IN/MIN)	RATE (IN/HOUR)	SOIL CONDITIONS
TEST 1	0	6	-	-	-	Gray silty SAND, trace gravel
	60	17	11	0.1833333	11	
				Rate:	**11 in/hr**	

	TIME (MIN)	DEPTH TO WATER (IN)	DROP (IN)	RATE (IN/MIN)	RATE (IN/HOUR)	SOIL CONDITIONS
TEST 2	0	6	-	-	-	Gray silty SAND, trace gravel
	60	11	5	0.0833333	5	
				Rate:	**5 in/hr**	

	TIME (MIN)	DEPTH TO WATER (IN)	DROP (IN)	RATE (IN/MIN)	RATE (IN/HOUR)	SOIL CONDITIONS
TEST 3	0	6	-	-	-	Gray silty SAND, trace gravel
	60	12.25	6.25	0.1041667	6.25	
				Rate:	**6.25 in/hr**	

	TIME (MIN)	DEPTH TO WATER (IN)	DROP (IN)	RATE (IN/MIN)	RATE (IN/HOUR)	SOIL CONDITIONS
TEST 4	0	6	-	-	-	Gray silty SAND, trace gravel
	60	11.75	5.75	0.0958333	5.75	
				Rate:	**5.75 in/hr**	

Average Rate:	**7.0**	**in/hr**
Reduced by Factor of 2:	**3.5**	**in/hr**

APPENDIX E
LABORATORY TESTING RESULTS

Client:	Langan Engineering				
Project:	Old Greenwich School				
Location:	Old Greenwich, CT			Project No:	GTX-317070
Boring ID:	---	Sample Type:	---	Tested By:	ckg
Sample ID:	---	Test Date:	04/17/23	Checked By:	ank
Depth :	---	Test Id:	712172		

Moisture Content of Soil and Rock - ASTM D2216

Boring ID	Sample ID	Depth	Description	Moisture Content,%
LB-01	S- 2	2-4'	Moist, dark brown silty sand with gravel	8.8
LB-01	S- 4A	6-7'	Moist, brown gravel with silt and sand	5.1
LB-02	S- 2	2-4'	Moist, dark gray silty sand	34.2
LB-03	S- 3A	4-5.25'	Moist, brownish gray silty clay with sand	23.9
LB-03	S- 8A	20-20.75'	Moist, dark gray silty sand	18.9

Notes: Temperature of Drying : 110º Celsius

Client:	Langan Engineering				
Project:	Old Greenwich School				
Location:	Old Greenwich, CT			Project No:	GTX-317070
Boring ID:	LB-02	Sample Type:	jar	Tested By:	cam
Sample ID:	S-2	Test Date:	04/17/23	Checked By:	ank
Depth :	2-4'	Test Id:	712175		
Test Comment:	---				
Visual Description:	Moist, dark gray silty sand				
Sample Comment:	---				

Moisture, Ash, and Organic Matter - ASTM D2974

Boring ID	Sample ID	Depth	Description	Moisture Content,%	Ash Content,%	Organic Matter,%
LB-02	S-2	2-4'	Moist, dark gray silty sand	34	96.4	3.6

Notes: Moisture content determined by Method A and reported as a percentage of oven-dried mass;
dried to a constant mass at temperature of 105º C
Ash content and organic matter determined by Method C; dried to constant mass at temperature 440º C

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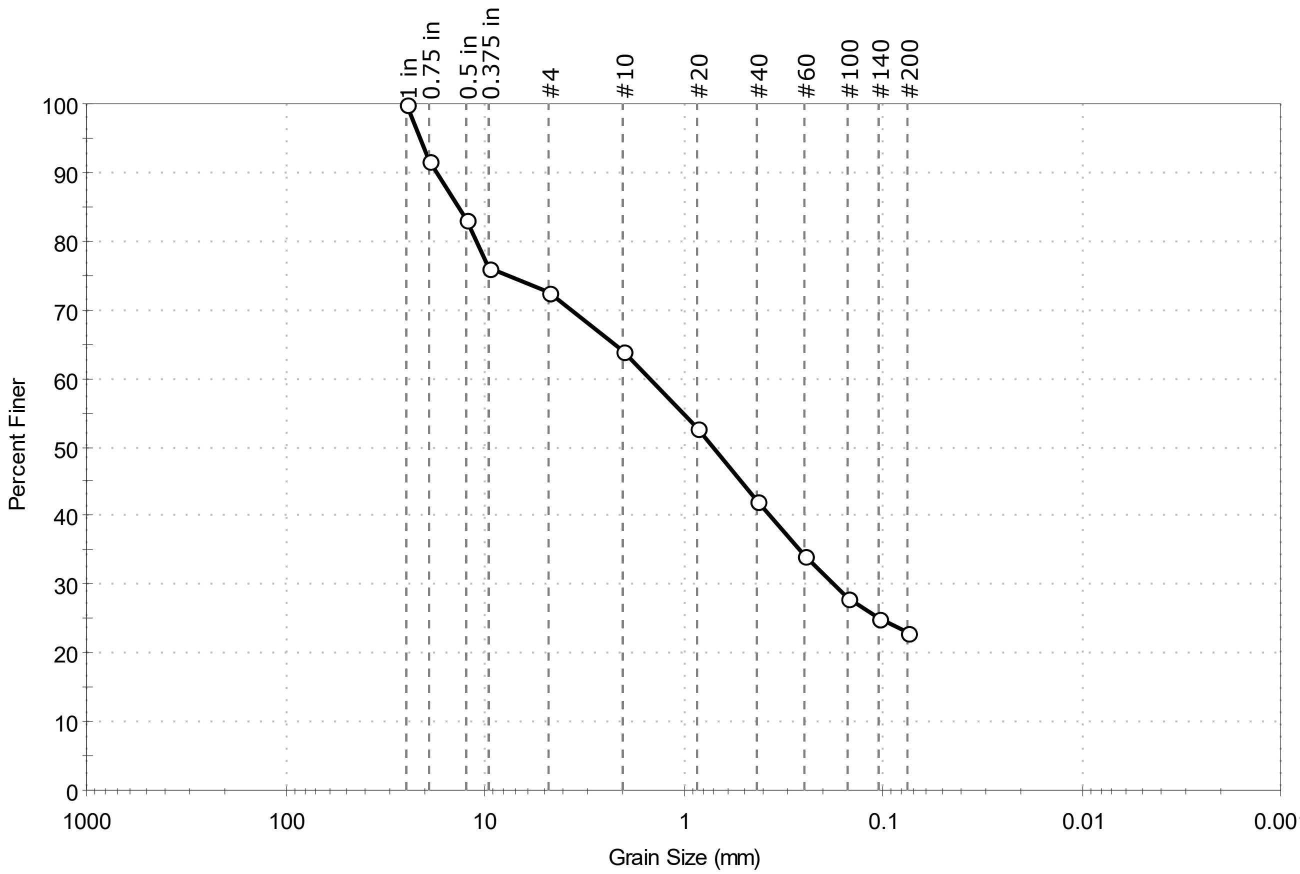
Client:	Langan Engineering			
Project:	Old Greenwich School			
Location:	Old Greenwich, CT		Project No:	GTX-317070
Boring ID:	LB-01	Sample Type: jar	Tested By:	ckg
Sample ID:	S-2	Test Date: 04/18/23	Checked By:	ank
Depth :	2-4'	Test Id: 712165		
Test Comment:	---			
Visual Description:	Moist, dark brown silty sand with gravel			
Sample Comment:	---			

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	27.4	49.7	22.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	92		
0.5 in	12.50	83		
0.375 in	9.50	76		
#4	4.75	73		
#10	2.00	64		
#20	0.85	53		
#40	0.42	42		
#60	0.25	34		
#100	0.15	28		
#140	0.11	25		
#200	0.075	23		

Coefficients

D_{85} =13.6167 mm
D_{30} =0.1751 mm
D_{60} =1.4693 mm
D_{15} =N/A
D_{50} =0.7058 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-b (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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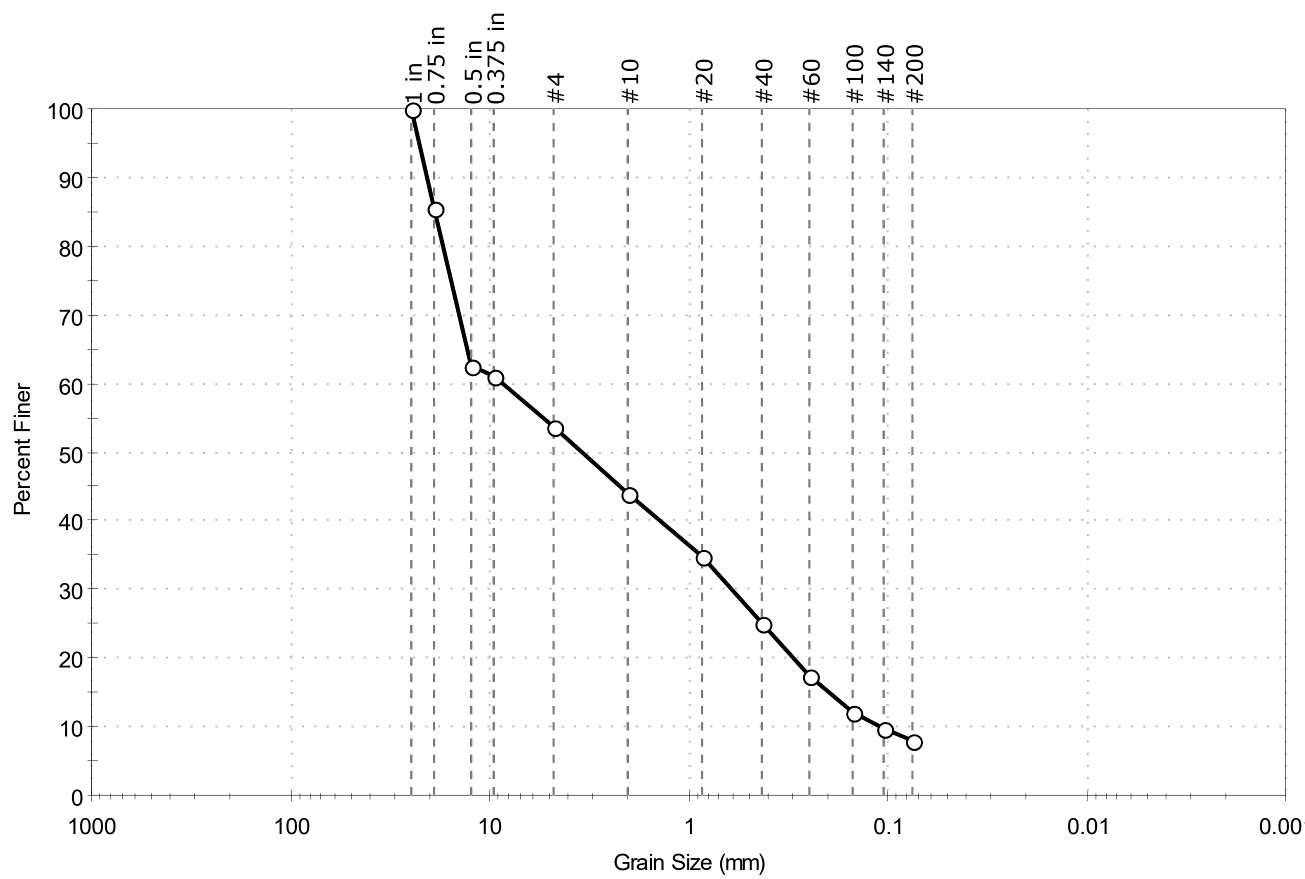
Client:	Langan Engineering				
Project:	Old Greenwich School				
Location:	Old Greenwich, CT			Project No:	GTX-317070
Boring ID:	LB-01	Sample Type:	jar	Tested By:	ckg
Sample ID:	S-4A	Test Date:	04/18/23	Checked By:	ank
Depth :	6-7'	Test Id:	712166		
Test Comment:	---				
Visual Description:	Moist, brown gravel with silt and sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	46.2	45.8	8.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	86		
0.5 in	12.50	63		
0.375 in	9.50	61		
#4	4.75	54		
#10	2.00	44		
#20	0.85	35		
#40	0.42	25		
#60	0.25	17		
#100	0.15	12		
#140	0.11	10		
#200	0.075	8.0		

Coefficients

D_{85} =18.7755 mm D_{30} =0.6018 mm

D_{60} =8.5663 mm D_{15} =0.1979 mm

D_{50} =3.4094 mm D_{10} =0.1107 mm

C_u =77.383 C_c =0.382

Classification

ASTM N/A

AASHTO Stone Fragments, Gravel and Sand (A-1-a (1))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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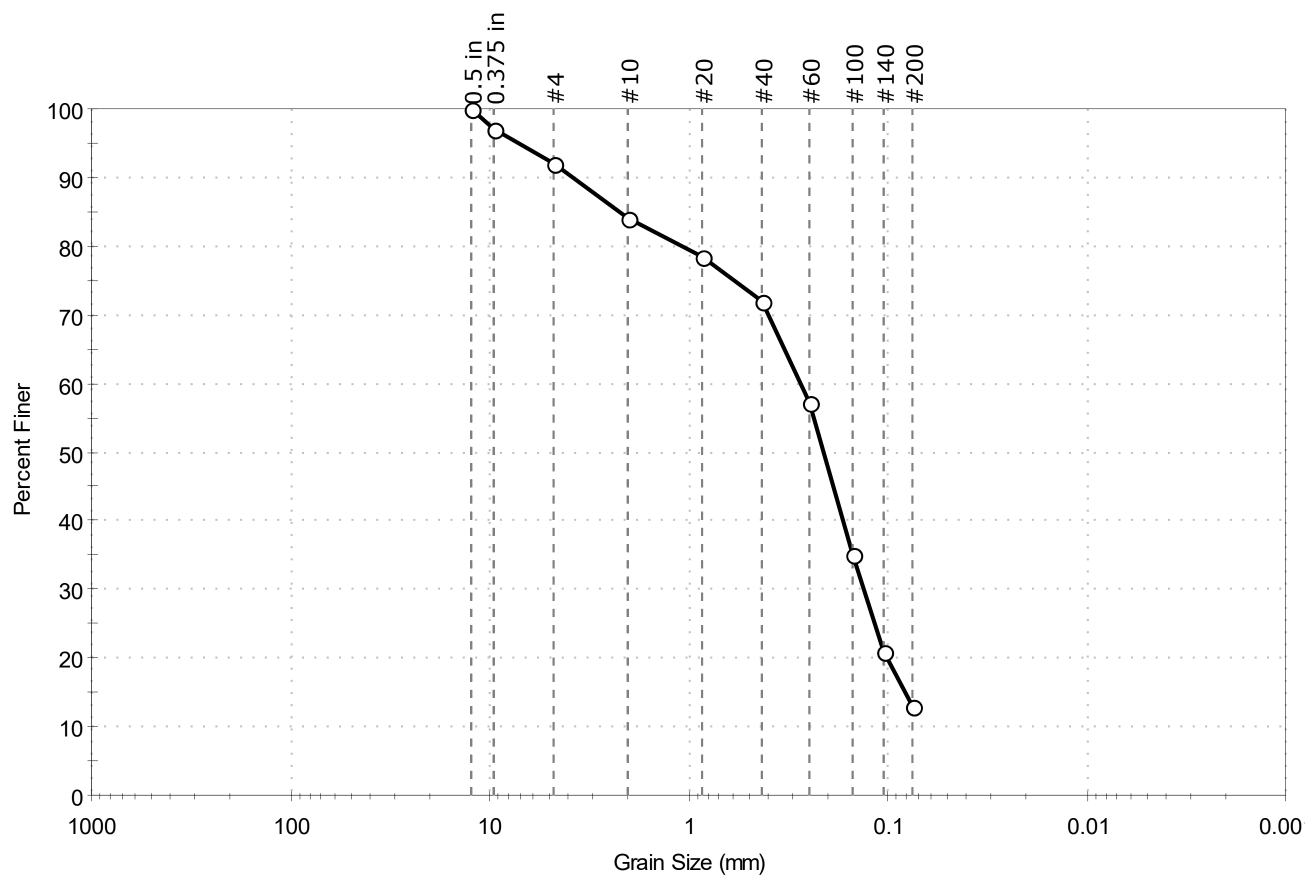
Client:	Langan Engineering		
Project:	Old Greenwich School		
Location:	Old Greenwich, CT	Project No:	GTX-317070
Boring ID: LB-03	Sample Type: jar	Tested By:	ckg
Sample ID: S-8A	Test Date: 04/18/23	Checked By:	n/a
Depth : 20-20.75'	Test Id: 712167		

Test Comment: ---
Visual Description: Moist, dark gray silty sand
Sample Comment: ---

Particle Size Analysis - ASTM D6913



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	7.9	79.0	13.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.5 in	12.50	100		
0.375 in	9.50	97		
#4	4.75	92		
#10	2.00	84		
#20	0.85	79		
#40	0.42	72		
#60	0.25	57		
#100	0.15	35		
#140	0.11	21		
#200	0.075	13		

Coefficients

D_{85} =2.1884 mm D_{30} =0.1322 mm
D_{60} =0.2755 mm D_{15} =0.0817 mm
D_{50} =0.2111 mm D_{10} =N/A
C_u =N/A C_c =N/A

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR
Sand/Gravel Hardness : HARD

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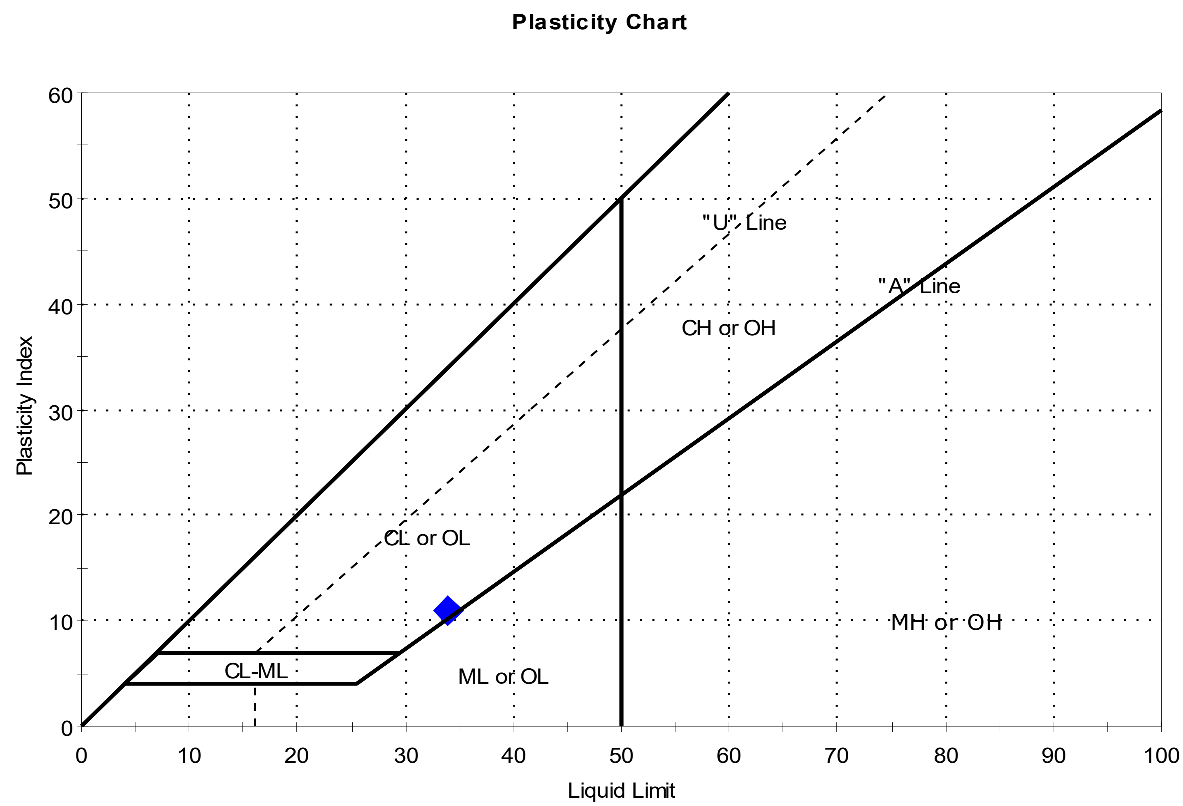
Client:	Langan Engineering		
Project:	Old Greenwich School		
Location:	Old Greenwich, CT	Project No:	GTX-317070
Boring ID: LB-02	Sample Type: jar	Tested By:	cam
Sample ID: S-2	Test Date: 04/20/23	Checked By:	ank
Depth : 2-4'	Test Id: 712163		
Test Comment:	---		
Visual Description:	Moist, dark gray clayey sand		
Sample Comment:	---		

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-2	LB-02	2-4'	34	34	23	11	1	

Sample Prepared using the WET method

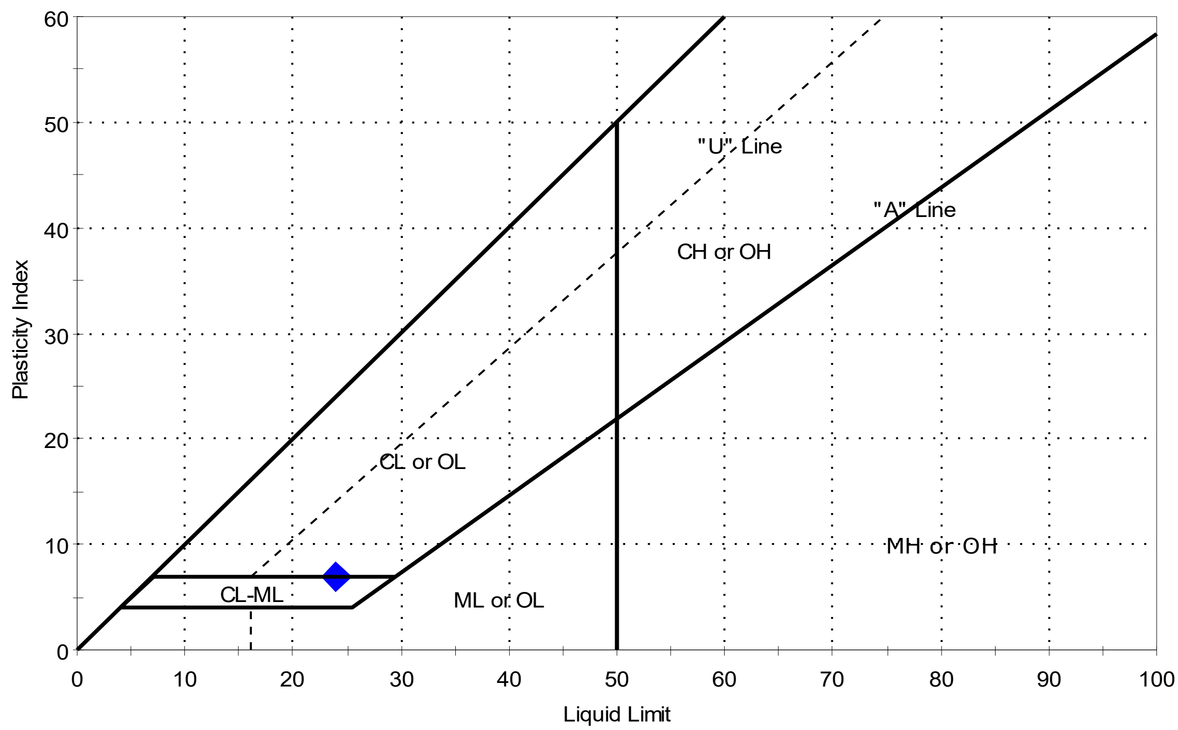
Dry Strength: VERY HIGH

Dilatancy: SLOW

Toughness: LOW

Client:	Langan Engineering				
Project:	Old Greenwich School				
Location:	Old Greenwich, CT			Project No:	GTX-317070
Boring ID:	LB-03	Sample Type:	jar	Tested By:	cam
Sample ID:	S-3A	Test Date:	04/20/23	Checked By:	ank
Depth :	4-5.25'	Test Id:	712164		
Test Comment:	---				
Visual Description:	Moist, brownish gray silty clayey sand				
Sample Comment:	---				

Atterberg Limits - ASTM D4318



Symbol	Sample ID	Boring	Depth	Natural Moisture Content,%	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index	Soil Classification
◆	S-3A	LB-03	4-5.25'	24	24	17	7	1	

Sample Prepared using the WET method

Dry Strength: VERY HIGH

Dilatancy: SLOW

Toughness: LOW