



# Memo

**TO:** Edward Snoble (Jenkins Group)  
**FROM:** Doug Le Do/David Carchedi  
**DATE:** November 26, 2008  
**FILE NO.:** 32608.08  
**RE:** Geotechnical Design Comments/Recommendations  
Naval Submarine Base New London  
Proposed Commissary Improvements  
Groton, Connecticut

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GZA has prepared this memorandum in response to comments in an email sent on Monday, November 24, 2008, to our Geotechnical Report, dated November 7, 2008. Answers to comments are addressed below:

***From Civil Engineer:***

***1. Provide an acceptable Plasticity Index range for the fill materials.***

Fill materials recommended for the site, as described in the "Materials" section of the geotechnical report should be course grained granular soils having less than 10 % passing the No. 200 sieve size. Therefore, there is no plasticity index range associated the proposed fill materials.

***2. Rock coring was only performed at boring B-20. Why was rock not cored at B-16? It is difficult to make determination of rock condition based on a single coring. GZA proposal indicated that five feet of rock will be cored at two of the boring locations if encountered within the proposed drilling depths.***

Due to time constraints in the field during the drilling phase, rock was not cored in boring B-16. However, it is likely that bedrock was encountered in boring B-16 at a depth of approximately 20 feet below existing ground surface. Apparent bedrock outcrop was observed at the ground surface between boring B-14 and Growler Avenue. It should be noted that bedrock in this area is highly irregular and elevations may change dramatically between the test boring locations. If bedrock is encountered during excavation for foundations, it will likely have to be blasted or if small enough may be able to be removed using a hoe ram. Bedrock should be removed to at least one foot below the bottom of footings. While a bearing pressure of 20,000 PSF could be used for rock, it would be difficult

to redesign footings based on field conditions. Therefore, it is recommended that all footings be designed for a bearing pressure of 4,000 PSF.

**From Structural Engineer:**

**1. Page 7 - Seismic paragraph. The analysis performed assumed an earthquake of magnitude 6.5 and maximum ground acceleration of 0.14g. The Soils Engineer shall verify that the required design parameters of  $S_s=21\%g$  and  $S_1=6\%g$  are equivalent to the earthquake magnitude listed. The  $S_s$  and  $S_1$  values are design numbers required to be used by the UFC 3-310-01 for Structural Load Data.**

In our liquefaction analyses, we used conservative design parameters. Therefore we used a Site Class E, maximum ground acceleration of 0.14 g. However, based on the boring information within the proposed building area and in accordance with Section 1613.5.5 of the 2006 International Building Code the average velocity of shear waves for the depth interval of 100 feet below the proposed footings is between 600 to 1,200 ft/sec corresponding to a Site Class D. The following seismic design values, as described in our Geotechnical Report, in accordance with the 2006 International Building Code, Section 1613, should be used at the site:

<u>Definition</u>	<u>Value</u>
Site Class	D
Maximum Considered Earthquake Spectral Response Accelerations for short period ( $S_{ms}$ )	0.223g
Maximum Considered Earthquake Spectral Response Accelerations for 1 second ( $S_{m1}$ )	0.092 g
Shear Wave Velocity ( $v_s$ )	600 to 1,200 ft/sec

**2. Page 8 - Definition. The criteria list must conform to UFC 3-310-01. The required design values for earthquake are  $S_s=21\%g$ , and  $S_1=6\%g$ . Revise criteria as required.**

See answer above.

**3. General Question. The building exterior foundations will be set 3.5' minimum below finished grade. The foundation excavations will extend down to the bottom of foundation elevations and is required to be heavily surface compacted. Is there a minimum distance the heavy surface compaction shall occur beyond the footing edges? A similar condition will occur during the existing building demolition. Does the evacuation and heavy surface compaction need to occur beyond the building element removal?**

Foundation excavation in undistributed natural soils generally extends to a lateral extent of a minimum of about 2 feet from the outside edge of footing. Only the footing area needs to be surface compacted, however, the entire footing excavation is usually treated. To insure that the actual footing footprint is properly compacted, the earthwork specification could call for additional compaction to a two foot lateral distance beyond the footing edges.

All unsuitable materials, including topsoil, asphalt, probable fill, and old foundations and utilities should be removed from the building area to a limit defined by a 1 horizontal to 1 vertical slope extending downward and outward from two feet outside the edges of the exterior footings to firm natural soils. The excavated subgrade should then be heavily

surface compacted with a minimum of six passes of a hand-operated vibratory plate/roller compactor having a drum weight of at least 1,000 pounds. Care must be taken if the soils are wet so as not to cause weaving and softening of the subgrade. Subsequent to the surface compaction, the excavation can be backfilled to the foundation elevation so that footings can be constructed on the newly prepared subgrade and backfilled upon completion. As an alternate, the building area can be backfilled to the base course level and then re-excavated for foundation construction. Where necessary, the excavations should be backfilled with compacted "Sand-Gravel Fill" or "Granular Fill" up to the design elevation of bottom of footings or slabs.

Fill placed outside the building area, beyond the 1H:1V slope defined above, should consist of "Granular Fill" compacted to 92 percent of the modified Proctor density except where it is placed as either the subbase or base course for pavement, or as structural backfill for retaining walls.

**4. General Question. Are there any special requirements for deep excavations and compaction requirements. The demolition at the existing building could lead to deep excavations that require deep fills.**

Due to the sandy glacial outwash subsurface conditions above the groundwater table, OSHA minimum standards for excavations in "Type C soils" (granular soils) require excavation slopes to be no greater than 1 ½ horizontal to 1 vertical ratio. For an excavation of ten feet in depth, an open cut width would be about 40 feet wide at the ground surface. Due to the proximity of the existing roadways and utilities, a temporary earth support system may be required during the demolition of the existing buildings. If excavations extend to below the ground water table, the excavation support must be designed by a Professional Geotechnical Engineer.

One option for earth support for excavation above the water table consists of a system of H-piles, timber lagging, and tieback soil anchors as required. As the soils are excavated, timber lagging is placed between the H-piles and tieback anchors are installed through the H-piles or through wales spanning between the H-piles. Care will have to be taken in the design of the anchors in order to avoid existing utilities and the foundations of adjacent buildings. Interior rakers or cross-lot bracing can be used as an alternate to tiebacks.

An alternative system to the installation of H-piles and lagging would be the use of steel sheet piles in combination with tieback anchors, if required. This option is more applicable for excavations that extend below the groundwater table. Once the sheet piles are driven to the required depth, the anchors are drilled horizontally through the sheet piles and into the retained soil. As stated above, interior rakers or cross-lot bracing can be used as an alternate to tiebacks. In either case, vibration levels and subsidence due to driving of the steel H-piles or sheeting should be monitored.

**5. A recommendation for vapor retarders and/or vapor barriers below interior slabs is needed.**

It is recommended that the ground level building slab be underlined by a minimum 10 mil vapor barrier which conforms to AASTM E 1745, Class A or B. The membrane should have a water-vapor permeance rate no greater than 0.012 perms when tested in accordance with ASTM E 154, Section 7. The vapor barrier shall be placed over prepared base material. It should be noted, that the applicable building code may have other requirements such as foam insulation.

**From Architect:**

**1. Page 1 BACKGROUND references "... expansion of existing commissary building...". A new Commissary is proposed for this site. Expansion on the existing commissary is no longer being considered.**

Agree.

**2. Page 3 "Fine Sand Outwash", line 3 references borings B-16 and B-20 where probable bedrock and bedrock were encountered at a depth of 20 feet and 7 feet respectively. Line 8 indicates that "... and B-20 between depths of approximately 15 feet and 20 feet where loose sands...". The latter appears to be the incorrect reference. Also, if rocking coring was made at B-16 wouldn't bedrock have been confirmed?**

Due to time constraints in the field during the drilling phase, rock was not cored in boring B-16. However, it is likely that bedrock was encountered in boring B-16 at a depth of approximately 20 feet below existing ground surface. Bedrock outcrop was observed at the ground surface between boring B-14 and Growler Avenue. It should be noted that bedrock in this area is highly irregular and elevations may change dramatically between the test boring locations. Refer to question #2 above by the Civil Engineer for additional information. All of the borings listed, encountered "loose sand" between approximately 15 and 20 feet below ground surface.

**3. Page 10, first paragraph, last line, states "...access roadways.". Please clarify.**

This is in regards to access roadways, other than parking lots, where heavier traffic volumes and truck traffic would require a "Heavy Duty" pavement section.

**4. I can find nothing in the report that indicates that soil samples were screened for volatile organic compounds using a photo-ionization meter.**

All soil samples recovered during the exploration program were screened for Total Volatile Organic Compounds (TVOCs) with an OVM Model 580B photo-ionization detector (PID) equipped with a 10.6 eV lamp and jar-head space technique. The PID measures relative levels of TVOCs referenced to an isobutylene-in-air-standard. Although the PID screening cannot be directly used to quantify VOC concentrations or to identify individual compounds, the results can serve as a relative indicator of VOC levels. The PID readings were inadvertently left off of the boring logs due to "not detect" (ND) readings. The TVOC screening results are provided on the revised attached boring logs. All readings were observed to be below the instruments detection limit of 1 part per million vapors (ppmv).

Please do not hesitate to contact us if you have any questions or require further information.

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-10
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±25'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/29/08</u> DATE END <u>10/29/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN. CASING SIZE: 3" OTHER: CLAY BASED DRILLING MUD	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
	10/29/08	11:00	±7'	N/A	0.0hr

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5	ND	S-1	24/18"	0-2'	35-15	Medium dense, brown, fine to coarse SAND, some fine to coarse Gravel, little Silt. (SW)	4"	ASPHALT
					12-10			
	ND	S-2	24/16"	2-4'	12-14	Medium dense, tan, fine to medium SAND, trace Silt (SM)	±2.5'	FILL
					12-14			
	ND	S-3	24/8"	4-6'	29-17			
				20-17	Dense, tan, fine to medium SAND, trace Silt (SM)			
10	ND	S-4	24/13"	9-11'	9-11	Medium dense, tan, fine to coarse SAND, trace Silt (wet)(sm)		SAND
					11-11			
15	ND	S-5	24/10"	14-16'	6-4	Loose, tan, fine SAND, little Silt (wet) (SM)		
					5-7			
20	ND	S-6	24/24"	19-21'	6-6	Medium Dense, tan, fine SAND, little Silt (wet) (SM)		
					6-9			
25	ND	S-7	24/20"	24-26'	8-9	Medium dense, tan, fine SAND, some Silt (wet) (SM)		
					7-8			
							±26'	
30						End of Exploration at ±26'		

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses. 2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
4-10 LOOSE	2-4 SOFT	
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-11
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.02
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±23'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/27/08</u> DATE END <u>10/27/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.	10/27/08	3:00	±7.0'	N/A	0.0hour
CASING SIZE: OTHER: 3 3/4" HSA					

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5	ND	S-1	24/20"	0-2	7/7	Medium dense, tan, fine to medium SAND, trace fine Gravel, little Silt (SM)	5"	ASPHALT	
					6/7				
	ND	S-2	24/22"	2-4	7/8				Medium dense, tan, fine to medium SAND, little Silt (SW)
					9/11				
	ND	S-3	24/20"	4-6	6/6	Medium dense, tan, fine to medium SAND, little Silt (SW)		SAND	
					6/7				
10	ND	S-4	24/22"	9-11'	3/3	Loose, tan, fine to coarse SAND, trace Silt (wet) (SW)	±11'		
					4/4				
END OF EXPLORATION @ 11'									
15									
20									
25									
30									

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-12
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±29'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/28/08</u> DATE END <u>10/28/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.  CASING SIZE: _____ OTHER: <u>3 3/4" HSA</u>	GROUNDWATER READINGS			
	DATE	TIME	WATER	CASING
	10/28/08		Not Encountered	
				STABILIZATION TIME

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5	ND	S-1	24/14"	0-2	1-2	Loose, Light brown, fine SAND, little Silt trace fine Gravel, trace Organics (SM)	6"	TOPSOIL/LOAM	
					3-2				
	ND	S-2	24/12"	2-4	2-3				Loose, tan, fine to medium SAND, little Silt (SM)
					4-7				
10	ND	S-3	24/18"	4-6	7-8	Medium dense, tan, fine SAND, little Silt (SM)		SAND	
					8-8				
10	ND	S-4	24/12"	9-11	23-34	Very dense, light brown, fine SAND, some fine Gravel, trace Silt (SW)	±11'		
					44-60				
						End of Exploration @ 11'			
15									
20									
25									
30									

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-13(OW)
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±25'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/27/08</u> DATE END <u>10/27/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.  CASING SIZE: OTHER: 3 3/4" HSA	GROUNDWATER READINGS			
	DATE	TIME	WATER	CASING
	10/27/08	12:45	±11.5'	N/A
	10/28/08	3:00	±8.61	Well
	10/29/08	2:00	±8.68'	Well

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5	ND	S-1	24/6"	0-2'	30-13	Medium dense, light brown, fine to coarse SAND, little fine Gravel, little Silt (SW)	1"	ASPHALT	
					14-13		12"	PROCESSED ASPHALT	
	ND	S-2	24/6"	2-4'	18-18		Dense, light brown, fine to coarse SAND, little fine Gravel, trace Silt (SW)	±4'	FILL
					20-17				
	ND	S-3	24/12"	4-6'	14-10		Medium dense, tan, fine to coarse SAND, trace Silt (SW)	±7'	FINE TO COARSE SAND
				12-12					
10	ND	S-4	24/6"	9-11'	15-7	Medium dense, tan, fine SAND and Silt (wet) (SM)			
					3-4				
15	ND	S-5	24/9"	14-16'	12-7	Medium dense, tan, fine SAND and Silt (wet) (SM)		FINE SAND	
					7-7				
20	ND	S-6	24/18"	19-21'	4-2	Loose, light gray, fine SAND and Silt (wet) (SM)			
					3-3				
25	ND	S-7	24/20"	24-26'	9-5	Medium dense, gray, fine SAND and Silt (wet) (SM)			
					5-4				
30						END OF EXPLORATION @ 26'			

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	2. 2" DIA PVC Groundwater observation well installed to depth 20', 10' riser & 10' screen with Road Box flush to existing parking grade.
10-30 MEDIUM DENSE	4-8 M. STIFF	3. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-14
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.02
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±29'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/28/08</u> DATE END <u>10/28/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.  CASING SIZE: OTHER: 3 3/4" HSA	GROUNDWATER READINGS			
	DATE	TIME	WATER	CASING
	10/28/08		Not Encountered	
				STABILIZATION TIME

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5	ND	S-1	24/18"	0-2'	3-4	Loose brown, fine SAND, some Silt, little fine Gravel, trace Organic fibers (SM)	6"	TOPSOIL
					5-4			
	ND	S-2	24/1"	2-4'	4-3	Loose, fine to medium SAND, little fine Gravel, little Silt, trace Organic fibers (SM)	±3'	SUBSOIL
					3-2			
	ND	S-3	24/9"	4-6'	3-7	Medium dense, tan, fine to medium SAND, little Silt (SM)		SAND
				10-11				
10	ND	S-4	24/14"	9-11	16-13	Medium dense, tan, fine to medium SAND, little Silt	±11'	
					16-27			
						END OF EXPLORATION @ 11'		
15								
20								
25								
30								

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-15
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.02
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±24'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/28/08</u> DATE END <u>10/29/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.	10/29/08	7:30	±7.0'	N/A	24 Hours
CASING SIZE: 3" OTHER:					

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5	ND	S-1	24/18"	0-2'	18-12	Medium dense, brown, fine to medium SAND, little fine Gravel, trace Silt. (SW)	3"	ASPHALT	
					8-8			±2'	FILL
	ND	S-2	26/20"	2-4'	24-24			Dense, tan, fine to medium SAND, trace fine Gravel, trace Silt (SW)	SAND
					22-12				
	ND	S-3	24/18"	4-6'	26-19			Dense, tan, fine to coarse SAND, trace fine Gravel, trace Silt (SW)	
				18-17					
10	ND	S-4	24/12"	9-11'	9-10	Medium to dense, tan, fine to medium SAND, little Silt (SM)	SAND		
					12-12				
15	ND	S-5	28/12"	14-16'	4-3	Loose, tan, fine SAND, little Silt (wet) (SM)	SAND		
					2-3				
20	ND	S-6	24/14"	19-21'	5-4	Loose, tan, fine SAND, little Silt (wet) (SM)	SAND		
					4-4				
25	ND	S-7	24/18"	24-26'	8-9	Medium to dense, light brown, fine SAND, little Silt (SM)	SAND		
					9-7				
30						End of Exploration at ±26'	SAND		

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses. 2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
4-10 LOOSE	2-4 SOFT	
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-16
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±25'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/27/08</u> DATE END <u>10/27/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.  CASING SIZE:                      OTHER:      3 3/4"HSA	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
	10/27/08	10:15	±10.0'	N/A	0.0 hours

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5	ND	S-1	24/12"	0-2	16-17	Dense, brown, fine to medium SAND, some fine to coarse	3"	ASPHALT
					17-13	Gravel, trace Silt (SW)		±2"
	ND	S-2	24/12"	2-4	28-22	Very dense, tan, fine to coarse SAND, some fine Gravel, trace Silt (SW)	1	SAND
					29-25			
	ND	S-3	24/14"	4-6	29-12	Medium to dense, tan fine to coarse SAND, some fine		
					17-16	Gravel, trace Silt (SW)		
10	ND	S-4	24/16"	9-11'	18-5	Medium to dense, tan, fine to medium SAND some (+) Silt	±13'	SAND AND SILT
					6-7	trace fine Gravel (wet) (SW)		
15	ND	S-5	24/12"	14-16	5-4	Loose, tan, fine SAND and Silt (SM)	±20"	POSSIBLE BEDROCK
					5-6			
20	ND	S-6	24/12"	18-20	14-80	Very dense, gray fine to medium SAND, little Silt. (SM)	±20"	POSSIBLE BEDROCK
					100/0"	END OF EXPLORATION @ 20'		
25								
30								

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4      VERY LOOSE	<2      VERY SOFT	1. Unified classification system noted in parentheses.
4-10      LOOSE	2-4      SOFT	2. Groundwater encountered at depth 10.0' at completion of boring.
10-30      MEDIUM DENSE	4-8      M. STIFF	3. Encountered possible bedrock at 20' with auger and spoon refusal.
30-50      DENSE	8-15      STIFF	4. Weathered rock in tip of spoon.
>50      VERY DENSE	15-30      V. STIFF	5. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
	>30      HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-17
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±23'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/27/08</u> DATE END <u>10/27/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.	10/27/08	2:30	±7.0	n/a	0.0 hours
CASING SIZE: OTHER: 3 3/4" HSA					

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5	ND	S-1	24/14"	0-2'	15-13	Medium dense, brown, fine to medium SAND, little fine to coarse Gravel, trace Silt (SW)	4"	ASPHALT
					11-11			
	ND	S-2	24/8"	2-4'	9-8	Medium dense, brown fine to coarse SAND, little fine to coarse Gravel, trace Silt (SW)		FILL
					17-9			
	ND	S-3	24/8"	4-6'	7-2	Loose, tan, fine to medium SAND, little fine Gravel, trace Silt (SW)	±5'	SAND
				5-8				
10	ND	S-4	24/12"	9-11'	7-3	Loose, tan, fine to coarse SAND, little Silt (wet) (SM)	±11'	
					4-7			
						END OF EXPLORATION @11'		
15								
20								
25								
30								

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-18
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.02
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±26'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/29/08</u> DATE END <u>10/29/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN		GROUNDWATER READINGS				
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.		DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING SIZE: 3" OTHER: CLAY BASED DRILLING MUD		10/29/08	1:45	±8'	n/a	0.0 hours

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5	ND	S-1	24/14"	0-2'	15-9	Medium to dense, brown, fine to coarse SAND, little fine Gravel, trace Silt (SW)	4"	ASPHALT
					9-8			
	ND	S-2	24/18"	2-4'	10-10	Medium to dense, brown, fine to coarse SAND, little fine Gravel, trace Silt (SW)	±5'	FILL
					12-12			
	ND	S-3	24/12"	4-6'	12-11	Medium to dense, tan, fine to coarse, SAND, little fine to coarse Gravel, trace Silt (SW)		
				15-17				
10	ND	S-4	24/12"	9-11'	12-11	Medium to dense, tan, fine to coarse SAND, little fine to coarse Gravel, little Silt (SM)		SAND
					11-10			
15	ND	S-5	24/18"	14-16'	4-5	Loose to light brown, fine SAND, little Silt (wet) (SM)		
					4-3			
20	ND	S-6	24/22"	19-21'	4-4	Loose, light gray, fine SAND and Silt (wet) (SM)		
					5-4			
25	ND	S-7	24/20"	24-26'	5-6	Medium to dense, light gray fine SAND and Silt (wet) (SM)		
					6-4			
30						END OF EXPLORATION @ 26'		

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-19
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±28'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/28/08</u> DATE END <u>10/28/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.	10/28/08		Not Encountered		
CASING SIZE:      OTHER:      3 3/4" HSA					

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5	ND	S-1	24/8"	0-2'	29-37	Very dense, light brown/black, fine to medium SAND, little fine to coarse Gravel, little Silt (SW)	4"	ASPHALT	
					5-4				
	ND	S-2	24/14"	2-4'	5-7				Medium dense, brown, fine SAND, little fine Gravel, trace Silt (SW)
					6-4				
10	ND	S-3	24/14"	4-6'	14-15	Dense, light brown, fine to coarse SAND, little Fine to Coarse Gravel, trace Silt (SW)	±6'	SAND	
					22-19				
	ND	S-4	24/12"	9-11'	18-23				Dense, tan, fine to medium SAND, trace fine Gravel, trace Silt (SW)
					21-23		±11'		
END OF EXPLORATION @ 11'									

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4      VERY LOOSE	<2      VERY SOFT	1. Unified classification system noted in parentheses.
4-10      LOOSE	2-4      SOFT	2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
10-30      MEDIUM DENSE	4-8      M. STIFF	
30-50      DENSE	8-15      STIFF	
>50      VERY DENSE	15-30      V. STIFF	
	>30      HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-20
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±29'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/28/08</u> DATE END <u>10/28/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.	10/28/8	11:00	±6'	n/a	0.0 hours
CASING SIZE: 3" OTHER:					

DEPTH	PID	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5	ND	S-1	24/18"	0-2'	3-2	S-1: Loose brwon, fine SAND, little Silt, trace organic fibers (SM)	8"	TOPSOIL
					2-2			
	ND	S-2	24/12"	2-4'	2-2	S-2: Loose, tan, fine SAND trace Silt (SM)	±3'	SUBSOIL
						3-5		
10	ND	S-3	24/16"	4-6'	1-2	S-3: Loose , tan, fine SAND, trace Silt (SM)		SAND
					2-2	S-4: Very dense tan/gray, fine to medium SAND, little fine		
	ND	S-4	24/6"	6-8'	15-0/100'	Gravel, trace Silt	±7'	
15		C-1	92%	7-12'	5min	C-1: Hard, slightly weathered, medium grained, gray GRANITE, medium subvertical foliation, moderately close subhorizontal irregular fractures (RQD=76 %)		BEDROCK
					5min			
					6min			
					8min			
20					10min			
25								
30								

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	2. The headspace of soil samples was screened for Total Volatile Organic Compounds (TVOCs) using an OVM Model 580B photoionization detector equipped with a 10.6 eV lamp. ND indicates reading below the instruments detection limit of +1 ppmv.
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE



**GEOTECHNICAL REPORT  
NAVAL SUBMARINE BASE  
NEW LONDON  
PROPOSED COMMISSARY  
IMPROVEMENTS  
GROTON, CONNECTICUT**

**PREPARED FOR:**

The Jenkins Group, Incorporated  
Itasca, Illinois

**PREPARED BY:**

GZA GeoEnvironmental, Inc.  
Providence, Rhode Island

November, 2008  
File No. 32608.08

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November 7, 2008  
File No. 32608.08



Mr. Edward Snoble  
The Jenkins Group, Incorporated  
Suite 250  
300 Park Boulevard  
Itasca, IL 60143

Re: Geotechnical Report  
Naval Submarine Base New London  
Proposed Commissary Improvements  
Groton, Connecticut

530 Broadway  
Providence  
Rhode Island  
02909  
401-421-4140  
FAX 401-751-8613  
www.gza.net

Dear Mr. Snoble:

GZA GeoEnvironmental, Inc. (GZA) is pleased to provide you with this geotechnical report for the above-referenced project. This report was prepared in accordance with our revised proposal dated July 1, 2008 (revised August 8, 2008). The primary objective of the geotechnical study was to provide subsurface information and foundation design criteria for the construction of the proposed building. The recommendations presented herein are subject to the Limitations and Terms and Conditions in Appendix A.

## BACKGROUND

The project involves the expansion of the existing commissary building and construction of new associated parking areas at the Naval Submarine Base New London located in Groton, Connecticut (see *Figure 1, Locus Plan*). The site is bordered by Growler Ave. to the north, existing commissary parking lots to the south, southwest, and southeast, and the existing commissary building (Building 484) to the east.

A plan of the site, showing the existing site conditions and proposed site improvements, was provided to GZA by The Jenkins Group, Inc. for this study. This drawing was used to develop *Figure 2, Exploration Location Plan*, which shows the location of the subsurface explorations. The site topography is relatively flat and generally consists of paved parking areas. Current elevations across the site range from a high of approximately 29 feet along the northern edge of the site to a low of approximately 23 feet along the south side of the site.

Incorporated into the construction of the approximately 60,000 square foot building, will be the demolition of buildings numbered 411 and 405 currently located to the west of the existing commissary. New paved parking areas are planned for the areas surrounding the new addition. The finish floor elevation of the proposed addition is unknown at this time.



## GEOLOGIC SETTING

Available USGS publications were reviewed in order to obtain an understanding of the area geology. According to the Surficial Materials Map of Connecticut, dated 1992, the site is characterized as Thin Till where till is generally less than 10-15 feet thick and including areas of bedrock outcrop where till is absent. Surficial soils include loose to moderately compact, generally sandy, commonly stony soils. Bedrock geology maps of the area were unavailable to GZA at this time of this study.

## SUBSURFACE EXPLORATIONS

A subsurface exploration program consisting of eleven test borings was conducted as part of this study. Six borings were advanced to depths of approximately 26 feet within the building footprint and five borings were advanced to a depth of approximately 11 feet in the proposed parking area. The exploration locations are shown on the attached *Figure 2, Exploration Location Plan* and boring logs are included in Appendix B. All explorations were observed and logged by a representative of GZA. Elevations of the explorations were interpolated from spot elevations on the base plan provided to GZA and should be considered approximate.

Eleven test borings were conducted as part of this investigation. The borings were designated B-10 through B-20 (see Figure 2, Exploration Location Plan). The test borings were drilled by New Hampshire Boring Inc. of Brockton, Massachusetts between October 27, 2008 and October 29, 2008. The explorations were advanced to depths of 11 to 26 feet below existing grade using hollow stem augers, rotary wash, and mud rotary drilling methods. Split spoon soil samples were generally obtained continuously through fill material, and at five-foot intervals thereafter in conformance with ASTM D-1586, the Standard Penetration Test (SPT), to obtain an indication of the relative density and consistency of the underlying soils. The SPT test consists of driving a 1-3/8-inch inside diameter standard split spoon sampler at least 18 inches long with a 140-pound hammer dropping from a height of 30 inches. The SPT N-value is the number of blows required to drive the sampler from 6 to 18 inches of penetration.

A groundwater observation well was installed at boring B-13(OW) at the center of the proposed building footprint for measurement of the stabilized groundwater level at the site.

## SUBSURFACE CONDITIONS

The generalized subsurface profile in the area surrounding the existing commissary building consists of up to 6 feet of granular fill covered mainly by asphalt pavement and underlain by fine sand outwash deposits to depths of 26 feet or more. The subsurface conditions are discussed in more detail in the following sections.

### **Asphalt**

Asphalt covers the majority of the proposed commissary development. The asphalt was generally 1 to 5 inches thick and was in fair condition.

### **Granular Fill**

Granular fill was encountered below all paved areas. Below the asphalt, fill thicknesses were between 1 and 5 feet thick. The fill material can be described as fine to coarse sand and probably came from onsite cuts during development of naval facility. The fill material was generally in a medium dense to very dense state with SPT N-values ranging from 13 to over 42 blows per foot.

### **Topsoil/Subsoil**

Up to 8 inches of topsoil underlain by between 2 to 4 feet of silty subsoil was encountered in the landscaped areas at the northern portion of the proposed site. Topsoil/subsoil was encountered in borings B-12, B-14, B-20. In general, the top 2 feet of subsoil contains organics (root fibers).

### **Fine Sand Outwash**

Within the proposed commissary building footprint, stratified fine sand outwash deposits were encountered below the fill to depths of 26 feet or more at all boring locations except for B-16 and B-20 where probable bedrock and bedrock were encountered at a depth of 20 feet and 7 feet respectively. The sand deposits in the footprint area were generally in a loose to dense state with SPT N-values ranging from 4 to 37 blows per foot. However, loose sands with SPT N-values between 5 and 9 were encountered at the south west and central portion of the proposed building footprint. In borings B-10, B-13(OW), B-15, B-16, B-18, and B-20 between depths of approximately 15 feet and 20 feet where loose sands were encountered before transitioning into medium dense sands. The abovementioned borings were performed in close proximity to proposed building foundation areas.

In the proposed parking areas surrounding the new commissary building, stratified fine sand outwash deposits below the fill and/or subsoil were encountered to depths of 11 feet or more. The sands were generally in a loose to dense state with SPT N-values ranging between 5 and 44 blows per foot.

### **Bedrock**

Bedrock was encountered at a depth of 7 feet below existing ground surface in boring B-20. A 5 foot rock core was taken at this location to determine the integrity and quality of the bedrock and confirm the depth. The rock core consisted of hard, slightly weathered, medium grained, grey Granite.





Bedrock was inferred at a depth of 20 feet in boring B-16 with split spoon and auger refusals. Bedrock was not cored at this location and was not encountered in any of the other explorations. It should be noted that bedrock in this area is highly irregular and elevations may change dramatically between the test boring locations.

#### **Groundwater**

Groundwater was encountered at all boring locations except for B-12, B-14, and B-19. Groundwater was encountered between 6 and 10 feet below existing ground surface and was inferred at the completion of each exploration. A groundwater monitoring well was installed at boring location B-13(OW) located centrally in the proposed building footprint. The stabilized groundwater level at this location was measured at 8.68 feet below ground surface corresponding to approximate elevation 16.4 feet.

### **LABORATORY TESTING**

#### **Grain-Size Distributions**

Seven grain-size distribution tests were conducted on material obtained from split spoon samples taken from B-13, B-14, B-15, B-17, B-18, and B-19. Two additional grain-size distribution tests were conducted on samples obtained in conjunction with the CBR and Proctor/Compaction tests obtained from grab samples. The results of the tests are included in Appendix C, and are summarized below.

<b>Boring</b>	<b>Sample</b>	<b>Depth (ft)</b>	<b>USCS</b>	<b>Burmister Classification</b>
B-13	S-6	19-21	SM	Fine SAND and Silt
B-13	S-7	24-26	SM	Fine SAND and Silt
B-14	S-1	0-2	SM	Fine to medium SAND and Silt, trace Gravel (Fill)
B-15	S-5	14-16	SW	Fine to medium SAND, little Silt
B-17	S-2	2-4	SW	Fine to medium SAND, little Silt, trace Gravel (Fill)
B-18	S-6	19-21	SM	Fine SAND, some Silt
B-19	S-1	0-2	SW	Fine to coarse SAND, some Silt, some fine Gravel (Fill)

#### **California Bearing Ratio and Proctor/Compaction Tests**

Two bulk samples were obtained from the northeast and southwest corners of the site for California Bearing Ratio (CBR) and Proctor/Compaction tests. The bulk samples generally consisted of sand and are considered representative of the fill material found near the ground surface across much of the site. However, due to the nature of the natural outwash deposits and varying thickness of fill on site, the material encountered at subgrade for pavement areas may differ than that tested for this pavement design.

A grain size analysis and a modified Proctor compaction test were also conducted on these samples. The modified proctor test was run in general accordance with ASTM D 1557 in order to determine the moisture content which the soil samples should be compacted at in preparation for the CBR testing. The CBR samples were prepared at 95 percent of the maximum dry density as determined in the laboratory. The results of the two tests are presented below.



Boring	Sample	Depth (ft)	Dry Density (pcf)	CBR @ 0.1"	CBR @ 0.2"	USCS	Burmister Classification
B-17	S-101	2-3	113	50.5	45	SM	Fine to medium SAND and SILT, trace fine Gravel.
B-12	S-102	2-3	120.6	21.6	19.9	SM	Fine to medium SAND, some Silt, little fine Gravel.

### IMPLICATIONS OF SUBSURFACE CONDITIONS

The naturally deposited sand and gravel outwash is considered competent bearing material for support of shallow foundations provided it remains undisturbed during demolition or other earthwork activities at the site. The existing fill also appears to be competent bearing material for support of shallow foundations, provided it remains undisturbed and is heavily surface compacted prior to construction. If loose fill is encountered, it will need to be excavated and recompacted in lifts. Any debris such as roots, sod, rubbish, and other deleterious or organic matter encountered in the fill will need to be removed. Debris was not encountered in the fill at the boring locations.

Construction will require demolition and removal of existing buildings/foundations, an abandoned underground storage tank, abandoned underground utilities across the site, and the removal of asphalt within the proposed building areas. These areas will need to be backfilled and compacted in accordance with the recommendations section of this report.

The northern side of the site is sparsely vegetated with uneven and sloping terrain within a proposed parking area. Vegetation, topsoil, and other organic material in the area will need to be stripped prior to final site grading.

The finish floor elevation of the new commissary building is unknown at this time and it is anticipated that no significant cutting or filling will be required at the site. At this time, GZA understands that no basement level has been proposed.

Loose sands were encountered in all borings completed within the building area. Fine sands having SPT N-values as low as 5 blows per foot were encountered in borings B-13(OW) and B-15 located within the building area. Since these soils were encountered at or below the water table, there is the potential of liquefaction or settlement of this loose non-liquefied soil during a seismic event. GZA performed an analysis of the liquefaction potential and determined that the loose soils are not susceptible to liquefaction. Results of this analysis are discussed later in this report and included in Appendix D.

Based on the proposed site grades and the findings at the exploration locations, it is not anticipated that bedrock will be encountered within the depth of excavation required for earthwork activities.

Where encountered, groundwater was approximately 6 to 10 feet below existing grades. It is not anticipated that groundwater will be encountered during earthwork activities at the site. In the event that groundwater is encountered, construction dewatering may be required through the use of sump pumps.



## CONCLUSIONS AND RECOMMENDATIONS

The following sections of this report presents geotechnical recommendations for the proposed commissary building and associated parking areas.

### Foundations and Slabs

The existing fill material encountered across the site was generally granular and relatively dense in nature. In general, between approximately 2 and 6 feet of fill was encountered across the site, with the greatest amount of fill encountered at the northern end of the site. Miscellaneous debris and organic material were not observed in the fill material at the boring locations. However, if encountered during construction, any debris encountered in the existing fill such as wood, tires, etc. should be removed.

Foundation support for the proposed buildings may be provided using shallow spread-footing foundations bearing on the natural outwash deposits; heavily surface compacted existing fill encountered at the site, or properly placed and compacted "Granular Fill". Placement of "Granular Fill" within the building areas should be performed in horizontal lifts and compacted with vibratory equipment to at least 95 percent of the maximum dry density as determined by ASTM D-1557 (modified Proctor test). The maximum loose lift thickness should be 12 inches for vibratory rollers and 6 inches for hand-operated equipment. Fill within the building areas should be compacted in horizontal lifts to 6 inches below the slab elevation, and then excavated for foundations. Fill placed outside the building areas, beyond a 1 horizontal to 1 vertical slope extending downward and outward from 2 feet outside the edges of the exterior footings, should consist of "Granular Fill" compacted to 92 percent of the modified Proctor density.

Prior to placement of fill, the entire building footprint should be heavily surface compacted with a minimum of six passes of a vibratory roller having a drum weight of at least 10,000 pounds and a dynamic force of at least 20,000 pounds. Where existing fill is present at the bearing surface for foundations, the fill should be either removed until natural soils are encountered and recompacted in lifts, or heavily surface compacted with appropriate vibratory equipment to match the depth of fill to be compacted.

If silty soils are encountered during the work, they may be susceptible to disturbance from construction operations, particularly under wet working conditions. Material saturated from precipitation or surface runoff may not be able to be properly compacted for reuse as structural fill without drying it first to a workable water content. This may be a concern if work takes place during the wet season.

Boulders or abandoned foundations encountered within excavations for foundations should be removed to a depth of at least 12 inches below the bottom of



footings. Voids that result from boulder or foundation excavations should be filled with compacted "Granular Fill", or crushed stone if the subgrade is wet. Should the footing bearing grades become disturbed during or after excavation, it should be overexcavated and replaced with a minimum of one foot of compacted "Sand-Gravel Fill" if the subgrade is dry, or six inches of "1-1/2-inch Crushed Stone" if the subgrade is wet, in order to stabilize the subgrade and facilitate pumping of groundwater.

A net allowable bearing pressure of 4,000 pounds per square foot (psf) should be used for design of footings on the outwash deposits, heavily surface compacted existing fill, or compacted "Granular Fill". For footings less than 3 feet wide, the allowable bearing pressure should be reduced proportionately, and in no case should continuous footings be less than 18 inches wide, nor isolated footings be less than 24 inches wide. Interior footings should be constructed at least 18 inches below the bottom of the slab to develop sufficient bearing capacity. For frost protection, exterior footings should extend at least 3-feet-6-inches below final exterior grade. Where the bottom of interior slab is near or above the final exterior ground surface elevation, the slab and foundation wall should be insulated with rigid foam in accordance with applicable building codes.

If construction schedules require earthwork during the winter or spring months, it may be advantageous to initially over-excavate all footing excavations in silty soils by six inches and place a working mat of 1½-inch crushed stone underlain by a layer of filter fabric (Mirafi 140N). The crushed stone may prevent the subgrade from becoming disturbed due to rain or snow which may saturate the silty soils before concrete can be placed, and may eliminate the need to re-excavate areas which become disturbed. It is recommended that contract specifications and budgeting reflect the need for the use of crushed stone and filter fabric to stabilize wet subgrades.

Settlements of foundations bearing on the outwash deposits, heavily surface compacted existing fill, or compacted "Granular Fill" are anticipated to be less than 1 inch, and may be expected to occur during construction. The maximum differential settlement between adjacent column bays is expected to be less than ½ inch.

Interior slabs-on-grade may be supported on the outwash deposits, heavily surface compacted existing fill, or compacted "Granular Fill" provided a minimum 6-inch thick base course of "Sand-Gravel Fill" is placed directly below the slab. The base course should be compacted to 95 percent of the maximum dry density as determined by ASTM D-1557 (modified Proctor test). Exterior slabs-on-grade should be constructed over compacted base and subbase courses as outlined below in the pavement section of this report.

### **Seismic**

The naturally deposited sands found on the site were in a loose state between a depth of 14 and 21 feet and required liquefaction analyses. These analyses were performed assuming a design earthquake of magnitude 6.5 and maximum ground acceleration of 0.14 g (Site Class E). Analyses were made using the simplified procedure



by Seed and Idriss as updated by NCEER<sup>1</sup>. The analysis resulted in factors of safety against liquefaction ranging between 1.18 and 1.44 within the loose sand layer. Generally, a factor of safety less than 1.1 is used for liquefaction; therefore, the site soils are not considered liquefaction susceptible. However, factors of safety between 1.1 and 1.4 suggest that settlement of the loose, non-liquefied soil may occur during a seismic event. The magnitude of this settlement was estimated to be up to 0.36 inches occurring within the loose sand layers encountered between 14 and 21 feet below ground surface. The predicted settlement will vary across the site depending upon actual site and seismic conditions. If seismically induced settlement does take place at depth, the soils above the affected soil tend to ravel and then arch such that the vertical movement at the foundation level will be moderate and reduced to some percentage of the lower level settlement. The vertical movement at the building will likely be very small and well within the structural tolerances. Damage to building due to an earthquake will be expected to be minor to non-existent.

<u>Definition</u>	<u>Value</u>
Site Class	D
Maximum Considered Earthquake Spectral Response Accelerations for short period ( $S_{ms}$ )	0.223g
Maximum Considered Earthquake Spectral Response Accelerations for 1 second ( $S_{m1}$ )	0.092 g
Shear Wave Velocity ( $v_s$ )	600 to 1,200 ft/sec

### **Retaining Walls**

Site retaining walls may be required to meet the proposed grades. It is recommended that the foundation bearing pressure not exceed 4,000 psf, and that a minimum 4-foot wide horizontal bench be provided at the top and base of the wall where sloping ground is present. It is also recommended that the wall be backfilled with free draining "Granular Fill" compacted to at least 95 percent of the maximum dry density (ASTM D1557). The backfill, however, should not be compacted above 93 percent within 5 feet of the wall stem. For wall design, a moist unit weight of 135 pcf and an internal angle of friction of 32 degrees are recommended for the backfill. A drainage system should be provided to prevent the buildup of hydrostatic pressures behind the wall. The wall should also be designed for any surcharge loads that may occur over the life of the wall, including construction traffic.

For unevenly backfilled foundation walls, an equivalent fluid pressure of 65 psf is recommended if the top of the wall will be supported by a floor level prior to backfilling. If the wall is backfilled prior to constructing the floor level, an equivalent fluid pressure of 45 psf is recommended. In either case, the backfill should not be compacted above 93 percent of the Modified Proctor value within 5 feet of the wall stem.

<sup>1</sup> NCEER (1996). "Summary Report", Proceedings, National Center for Earthquake Engineering Research (NCEER) Workshop on Evaluation of Liquefaction Resistance of Soils, T. L. Youd and I. M. Idriss, eds., NCEER-97-0022.

### **Demolition of Existing Buildings and Utilities**

All soils disturbed during the demolition and removal of the existing buildings, septic system(s) and utilities should be excavated and replaced with compacted lifts of structural fill. The backfilling and compaction of the disturbed areas should be performed in accordance with the recommendations provided in this report. It is recommended that a geotechnical engineer be retained during the demolition phase of the project to observe the remediation of the disturbed soils.

### **Drainage**

Groundwater is not likely to be encountered during construction and the need for permanent underdrainage or perimeter drainage is not anticipated.

Roof drain and surface water runoff should be directed away from the building areas. During construction, run-off from precipitation should be diverted away from excavations so as to avoid ponding. Sumping of ponded rainfall from excavations may be required. Should bearing soil exposed in foundation excavations become saturated and disturbed during construction, it should be removed and replaced with compacted "Granular Fill" or "Crushed Stone", as discussed previously.

### **Underground Utilities**

Underground pipes and utilities should be placed on bedding in accordance with the manufacturer's specifications. "Granular Fill" should be placed in lifts on the sides and above the utilities and compacted to at least 92 percent of the maximum dry density as determined in accordance with ASTM D-1557 (modified Proctor test). Compaction should be performed with hand-operated equipment with lift thickness depending on the size of equipment used. Should utilities be placed below building slabs and foundations, backfill material should be compacted to at least 95 percent of the maximum dry density.

It is anticipated that existing underground utilities will be encountered during the excavation for foundations of the new commissary. Existing underground utilities should be re-located out of the building area prior to foundation construction.

### **Paved Areas**

The proposed pavement area should be cleared and grubbed and any topsoil or asphalt present within 3 feet of the final grade should be excavated. Any relatively loose and/or silty subsoil should also be removed within at least 2 feet of the proposed final paved elevation to limit frost heave. The subgrade should then be heavily surface compacted with a minimum of six passes of a vibratory roller having a drum weight of at least 10,000 pounds and a dynamic force of at least 20,000 pounds prior to placement of site fill and pavement. If working under wet conditions, care must be taken so as not to cause weaving and softening of the subgrade. Excavated material may be suitable for reuse in landscaped areas across the site. Existing asphalt can be ground in place and recycled for use as base course below paved areas.





In paved areas where only light car traffic is anticipated, a minimum of 10 inches of compacted free-draining "Granular Fill" subbase should be placed immediately below a 6-inch thick "Sand-Gravel Fill" base course. The base course should be increased to 14 inches for heavy-duty areas with truck traffic. Subbase and base courses should be compacted in 1-foot (maximum) lifts to at least 95 percent of the maximum dry density as determined in accordance with ASTM D-1557 (modified Proctor test). Fill below the subbase should be compacted to at least 92 percent of the maximum dry density. It is recommended that at least 3½ inches (2 inch binder and 1½ inch surface) of asphalt be provided for parking areas and that at least 4 inches (2½ inch binder and 1½ inch surface) be provided for access roadways.

It may be advantageous to grind up the existing asphalt in place and recycle it for base course material. Based on the findings at the boring locations, it appears that the majority of the near surface natural and fill soils should meet the requirements for "Granular Fill" and therefore will act as the subbase course if properly surface compacted.

The following are the recommended flexible layered pavement sections:

Flexible Pavement Layer Thickness		
Pavement Layer	Standard Duty (Cars)	Heavy Duty (Trucks)
Finish Course	1½ inches	1½ inches
Binder Course	2 inches	2½ inches
Base Course	6 inches	6 inches
Subbase Course	10 inches	14 inches

For areas to be paved with Portland cement based concrete, a 6-inch-thick slab on grade is recommended, with a minimum 8-inch-thick "Sand-Gravel Fill" base course and a 12-inch-thick "Granular Fill" subbase. The concrete should have a minimum unconfined compressive strength of 4,000 pounds per square inch, with air entrainment of 4 to 6 percent. The thickness is based on a modulus of subgrade reaction of 150 pounds per cubic inch. Grade 60 six-inch by six-inch W5.5 x W5.5 welded wire fabric ( $A_s = 0.11$  inches<sup>2</sup>/foot) reinforcement is recommended to minimize crack openings.

Concrete pavement should have expansion joints at a maximum spacing of 80 feet with a joint filler thickness based on the thermal expansion. All expansion joints should be sealed with an AASHTO approved elastomeric joint sealer. Slabs separated by an expansion joint should be tied together with dowels that are 2-foot 6-inches long at a spacing of 18 inches. Dowels must be sleeved on one side of the joint to allow for movement without cracking. In addition to expansion joints, contraction (crack control) joints should be constructed at a spacing of approximately 15 feet in both directions.

**Materials**

All fill should be free from ice, snow, roots, sod, rubbish, and other deleterious or organic matter. Gradation requirements for the above-mentioned fills should meet the requirements described below.



Sieve Size	Percent Finer By Weight			
	Sand-Gravel Fill	Granular Fill	¾-Inch Crushed Stone	1½-Inch Crushed Stone
*	100	100	-	-
1½-inch	-	-	-	100
1¼-inch	-	-	-	85-100
¾-inch	-	-	90-100	10-40
½-inch	50-85	-	10-50	0-8
No. 4	40-75	-	0-5	-
No. 10	30-60	30-95	-	-
No. 40	10-35	10-70	-	-
No. 100	5-20**	-	-	-
No. 200	0-8	0-10	-	<1

\* The maximum recommended stone size is 4 inches where used as a base course below slabs and pavement; elsewhere, maximum stone sizes should be 2/3 of the loose lift thickness.

\*\* The amount passing the No. 100 sieve should be between forty percent (40%) and seventy percent (70%) of that amount passing the No. 40 sieve.

Some of the onsite soils (subsoil) contain more than 10 percent silt and may not meet the above-referenced gradation specifications. These materials may still be reused, however, they may be particularly difficult to work with when wet, and may require discing or harrowing to reduce the moisture content prior to compaction. Compaction using a sheepsfoot roller may also be necessary. It is not recommended that the silty materials be used where free-draining materials are desired, such as retaining wall backfill and pavement base and subbase layers.

**CONTRACT DOCUMENT REVIEW AND CONSTRUCTION SERVICES**

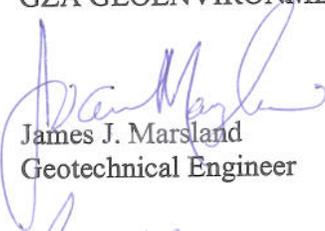
It is recommended that GZA be retained for the design and construction phases of the project. Such services would include preparation or review of earthwork specifications, review of foundation drawings, and the monitoring of earthwork construction to assess compliance with these recommendations.

We trust that this report addresses the pertinent geotechnical issues for this project. Please do not hesitate to contact the undersigned if there are any questions.



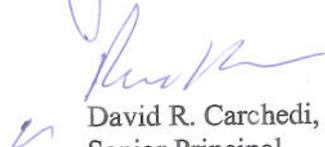
Very truly yours,

GZA GEOENVIRONMENTAL, INC.

  
James J. Marsland  
Geotechnical Engineer



Doug Le Do  
Project Manager

  
David R. Carchedi, PhD, P.E.  
Senior Principal

JJM/DLD/DRC:jm

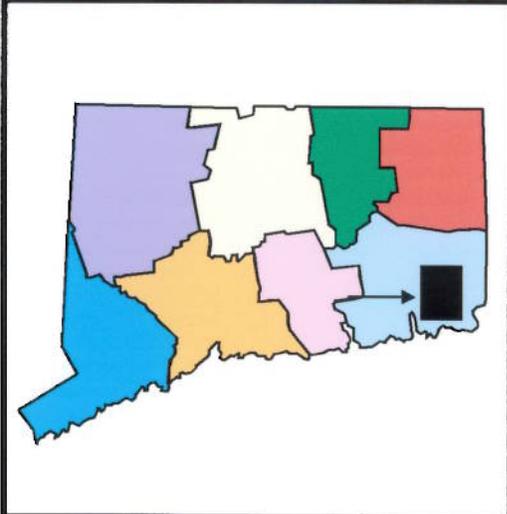
Attachments: Figure 1: Locus Plan  
Figure 2: Exploration Location Plan  
Appendix A: Limitations and Terms and Conditions  
Appendix B: Subsurface Exploration Logs  
Appendix C: Laboratory Data  
Appendix D: Liquefaction Calculations  
Appendix E: Pavement Design

## **FIGURES**

(CORE FILE: G:\JOBS\GEO\32608\LOCUS CDR)

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FILE NO. 3



FROM USGS NEW LONDON, CT QUADRANGLE MAP  
 (DIGITAL TOPOGRAPHIC MAPS PROVIDED BY MAPTECH, INC.)  
 (CONTOUR ELEVATIONS ARE IN METERS ABOVE NGVD, AT 3 METER INTERVALS)

APPROXIMATE SCALE IN FEET



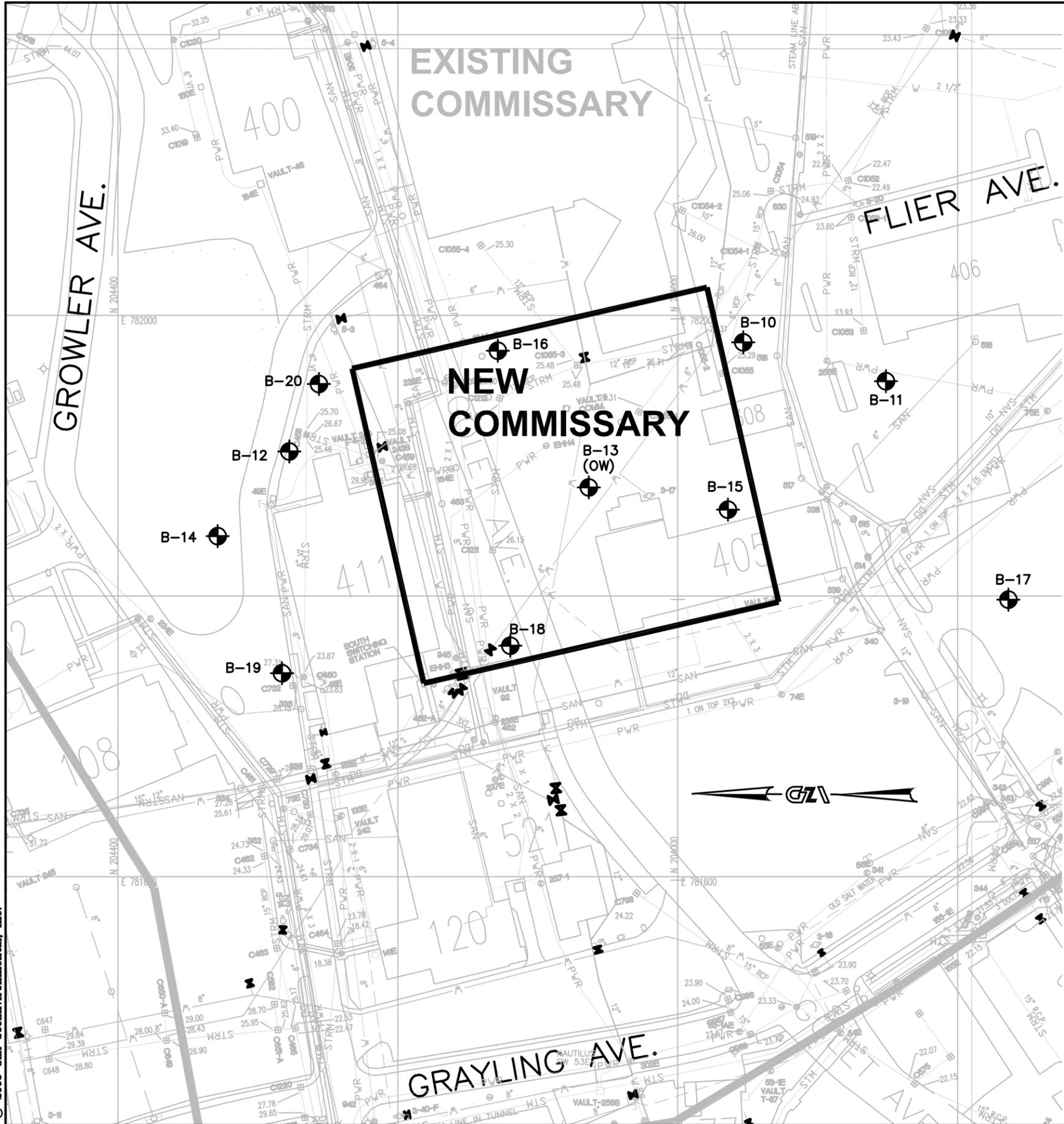
NAVAL SUBMARINE BASE  
 NEW LONDON

GROTON, CONNECTICUT

**LOCUS PLAN**

OCTOBER 2008

FIGURE NO. 1

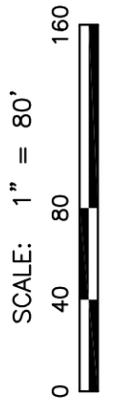


**GENERAL NOTES**

1. BASE MAP DEVELOPED FROM AN AUTOCAD DRAWING PROVIDED BY THE JENKINS GROUP, INC.
2. THE LOCATION OF THE EXPLORATIONS WERE APPROXIMATELY DETERMINED BY LINE OF SIGHT AND TAPE MEASUREMENTS, FROM EXISTING TOPOGRAPHIC FEATURES. THESE LOCATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.

**LEGEND**

**B-1**  BORINGS PERFORMED BY NEW HAMPSHIRE BORING, INC. BETWEEN OCTOBER 27 AND OCTOBER 29, 2008, OBSERVED BY GZA PERSONNEL. (OW) INDICATES OBSERVATION MONITORING WELL INSTALLED.

PROPOSED COMMISSARY NSBNL GROTON, CONNECTICUT		REV. NO.	DESCRIPTION	BY	DATE
		SCALE: 1" = 80' 			
PROPOSED EXPLORATION LOCATION PLAN		PROJ MGR:	DLD	OPERATOR:	DLD
		DESIGNED BY:	MJP	REVIEWED BY:	DRC
		 GZA GeoEnvironmental, Inc. Engineers and Scientists 530 BROADWAY PROVIDENCE, RI 02909			
JOB NO. <b>32608.08</b>		FIGURE NO. <b>2</b>			

**APPENDIX A**

**LIMITATIONS/TERMS AND CONDITIONS**

## GEOTECHNICAL LIMITATIONS

### Explorations

1. The analyses and recommendations submitted in this report are based in part upon the data obtained from subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.
2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual soil transitions are probably more erratic. For specific information, refer to the boring logs.
3. Water level readings have been made in the drill holes and monitoring wells at times and under conditions stated on the boring logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors occurring since the time measurements were made.

### Review

4. In the event that any changes in the nature, design or location of the proposed building are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by GZA GeoEnvironmental, Inc (GZA). It is recommended that this firm be provided the opportunity for a general review of final design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications.

### Construction

5. It is recommended that this firm be retained to provide soil engineering services during construction of the excavation and foundation phases of the work. This is to observe compliance with the design concepts, specifications, and recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to start of construction.

### Use of Report

6. This report has been prepared for the exclusive use The Jenkins Group, Incorporated for specific application to the Proposed Commissary Improvements located in Groton, Connecticut in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made.
7. This soil and foundation engineering report has been prepared for this project by GZA. This report is for design purposes only and is not sufficient to prepare an accurate bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to design considerations only.
8. This report may contain comparative cost estimates for the purpose of evaluating alternative foundation schemes. These estimates may also involve approximate quantity evaluations. It should be noted that quantity estimates may not be accurate enough for construction bids. Since GZA has no control over labor and materials cost and design, the estimates of construction costs have been made on the basis of experience. GZA does not guarantee the accuracy of cost estimates as compared to contractor's bids for construction costs.



TERMS AND CONDITIONS FOR PROFESSIONAL SERVICES  
INCLUDING SITE INVESTIGATION, REMEDIATION,  
GEOTECHNICAL, CONSTRUCTION, AND TESTING

© 2007 by GZA GeoEnvironmental, Inc.

Client: The Jenkins Group, Inc.

File No: 09-154

Site: Proposed Commissary Improvements

These Terms and Conditions, together with GZA's Proposal, make up the Agreement between GZA and you, Client, named above.

***BEFORE SIGNING THE PROPOSAL, BE SURE YOU READ AND UNDERSTAND THE PARAGRAPHS ENTITLED "INDEMNIFICATION" AND "LIMITATION OF REMEDIES" WHICH DEAL WITH THE ALLOCATION OF RISK BETWEEN YOU AND GZA.***

1. **Services.** GZA will perform the services set forth in its Proposal and any amendments or change orders authorized by you. Any request or direction from you that would require extra work or additional time for performance or would result in an increase in GZA's costs will be the subject of a negotiated amendment or change order.
2. **Standard of Care; Warranties.**
  - a. GZA will perform the services with the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services at the same time under similar conditions in the same or similar locality.
  - b. GZA warrants that its construction services will be of good quality, free of faults and defects and in conformance with the Proposal.
  - c. **EXCEPT AS SET FORTH IN SUBSECTIONS 2a AND 2b, ABOVE, NO WARRANTY, EXPRESS OR IMPLIED, INCLUDING WARRANTY OF MARKETABILITY OR FITNESS FOR A PARTICULAR PURPOSE, IS MADE OR INTENDED BY GZA'S PROPOSAL OR BY ANY OF GZA'S ORAL OR WRITTEN REPORTS.**
  - d. GZA assigns to you any manufacturers' warranties of equipment or materials purchased from others, to the extent they are assignable, and your sole recourse will be against the manufacturer. Full risk of loss of materials and equipment will pass to you upon delivery to the Site, and you will be responsible for insuring and otherwise protecting them against theft and damage.
3. **Payment.**
  - a. Except as otherwise stated in the Proposal, you will compensate GZA for the services at the rates set forth in the applicable Proposal, amendment or change order; reimburse its expenses, which will include a communication fee calculated as a percentage of labor invoiced; and pay any sales or similar taxes thereon.
  - b. Any retainer specified in GZA's Proposal shall be due prior to the start of services and will be applied to the final invoice for services.
  - c. GZA will submit invoices periodically, and payment will be due within 20 days from invoice date. Overdue payments will bear interest at 1½ percent per month or, if lower, the maximum lawful rate. GZA may terminate its services upon 10 days' written notice anytime your payment is overdue on this or any other project and you will pay for all services through termination, plus termination costs. You will reimburse GZA's costs of collecting overdue invoices, including reasonable attorneys' fees.
4. **Your Responsibilities.**
  - a. Except as otherwise agreed, you will secure the approvals, permits, licenses and consents necessary for performance of the services. If you are the owner or operator of the Site, you will provide GZA with all documents, plans, information concerning underground structures (including but not limited to utilities, conduits, pipes, and tanks), information related to hazardous materials or other environmental or geotechnical conditions at the Site and other information that may be pertinent to the services or, if you are not the owner or operator of the Site, you agree to make reasonable efforts to obtain these same documents and provide them to GZA. Unless otherwise indicated in writing, GZA will be entitled to rely on documents and information you provide.
  - b. If you use the services of a construction manager at the Site, you agree to use best and reasonable efforts to include in your agreement(s) with the construction contractor provisions obligating the latter:
    - (i) to indemnify and hold harmless, to the fullest extent permitted by law, you and GZA, its officers, employees and principals, for or on account of any claims, liabilities, costs and expenses, including attorneys' fees, arising out of or relating to the design or implementation of construction means, methods, procedures, techniques, and sequences of construction, including safety precautions or programs, of the contractor, or any of its subcontractors or any engineer engaged by it;

- (ii) to name you and GZA as additional insureds under general liability and builder's risk insurance coverages maintained by the contractor, or any of its subcontractors; and (iii) to require that all of its subcontractors agree and be bound to the obligations set forth in (i) and (ii) above.
- c. In the event that you are unable to secure such provisions in the agreement(s) with the construction contractor, you shall promptly notify GZA and GZA shall have the opportunity to negotiate with you reasonable substitute risk allocation and insurance indemnities and protections.
- 5. Right of Entry; Site Restoration.** You grant GZA and its subcontractor(s) permission to enter the Site to perform the services. If you do not own the Site, you represent and warrant that the owner has granted permission for GZA to enter the Site and perform the services; you will provide reasonable verification on request; and you will indemnify GZA for any claims by the Site owner related to alleged trespass by GZA or its subcontractors. GZA will exercise reasonable care to limit damage to landscaping, paving, systems and structures at the Site that may occur and you agree to compensate GZA for any restoration it is asked to perform, unless otherwise indicated in the Proposal.
- 6. Underground Facilities.** GZA's only responsibility under this Section will be to provide proper notification to the applicable state utility "Call-Before-You-Dig" program. You further agree to assume responsibility for and to defend, indemnify and hold harmless GZA with respect to personal injury and property damages due to GZA's interference with subterranean structures including but not limited to utilities, conduits, pipes, and tanks (i) that are not correctly shown on any plans and information you or governmental authorities provide to GZA, or (ii) that are not correctly marked by the appropriate utility.
- 7. Reliance.** The services, information, and other data furnished by you shall be at your expense, and GZA may rely upon all information and data that you furnish, including the accuracy and completeness thereof. You acknowledge that the quality of the services provided by GZA is directly related to the accuracy and completeness of the information and data that you furnish to GZA. GZA's REPORTS ARE PREPARED FOR AND MADE AVAILABLE FOR YOUR SOLE USE. YOU ACKNOWLEDGE AND AGREE THAT USE OF OR RELIANCE UPON THE REPORT OR THE FINDINGS IN THE REPORT BY ANY OTHER PARTY, OR FOR ANY OTHER PROJECT OR PURPOSE, SHALL BE AT YOUR OR SUCH OTHER PARTY'S SOLE RISK AND WITHOUT ANY LIABILITY TO GZA.
- 8. Lab Tests and Samples.** GZA is entitled to rely on the results of laboratory tests using generally accepted methodologies. GZA may dispose of samples in accordance with applicable laws 30 days after submitting test results to you unless you request in writing for them to be returned to you or to be held longer, in which case you will compensate GZA for storage and/or shipping beyond 30 days.
- 9. GZA Professionals.** GZA employees or consultants may act as licensed, certified or registered professionals (including but not limited to Professional Engineers, Licensed Site or Environmental Professionals, or Certified Industrial Hygienists collectively referred to in this section as "GZA Professionals") whose duties may include the rendering of independent professional opinions. You acknowledge that a federal, state or local agency or other third party may audit the services of GZA or other contractor/consultant(s), which audit may require additional services, even though GZA and such GZA Professionals have each performed such services in accordance with the standard of care set forth herein. You agree to compensate GZA for all services performed in response to such an audit, or to meet additional requirements resulting from such an audit, at the rates set forth in the applicable Proposal, amendment or change order.
- 10. Hazardous Materials; GZA "Not a Generator".** Before any hazardous or contaminated materials are removed from the Site, you will sign manifests naming you as the generator of the waste (or, if you are not the generator, you will arrange for the generator to sign). You will select the treatment or disposal facility to which any waste is taken. GZA will not be the generator or owner of, nor will it possess, take title to, or assume legal liability for any hazardous or contaminated materials at or removed from the Site. GZA will not have responsibility for or control of the Site or of operations or activities at the Site other than its own. GZA will not undertake, arrange for or control the handling, treatment, storage, removal, shipment, transportation or disposal of any hazardous or contaminated materials at or removed from the Site, other than any laboratory samples it collects or tests. You agree to defend, indemnify and hold GZA harmless for any costs or liability incurred by GZA in defense of or in payment for any legal actions in which it is alleged that GZA is the owner, generator, treater, storer or disposer of hazardous waste.
- 11. Limits on GZA's Responsibility.** GZA will not be responsible for the acts or omissions of contractors or others at the Site, except for its own subcontractors and employees. GZA will not supervise, direct or assume control over or the authority to stop any contractor's work, nor shall GZA's professional activities nor the presence of GZA or its employees and subcontractors be construed to imply that GZA has authority over or responsibility for the means, methods, techniques, sequences or procedures of construction, for work site health or safety precautions or programs, or for any failure of contractors to comply with contracts, plans, specifications or laws. Any opinions by GZA of probable costs of labor, materials, equipment or services to be furnished by others are strictly estimates and are not a guarantee that actual costs will be consistent with the estimates.
- 12. Changed Conditions.**

- a. You recognize the uncertainties related to environmental and geotechnical services, which often require a phased or exploratory approach, with the need for additional services becoming apparent during the initial services. You also recognize that actual conditions encountered may vary significantly from those anticipated, that laws and regulations are subject to change, and that the requirements of regulatory authorities are often unpredictable.
- b. If changed or unanticipated conditions or delays make additional services necessary or result in additional costs or time for performance, GZA will notify you and the parties will negotiate appropriate changes to the scope of services, compensation and schedule.
- c. If no agreement can be reached, GZA will be entitled to terminate its services and to be equitably compensated for the services already performed. GZA will not be responsible for delays or failures to perform due to weather, labor disputes, intervention by or inability to get approvals from public authorities, acts or omissions on your part, or any other causes beyond GZA's reasonable control, and you will compensate GZA for any resulting increase in its costs.

**13. Documents and Information.** All documents, data, calculations and work papers prepared or furnished by GZA are instruments of service and will remain GZA's property. Designs, reports, data and other work product delivered to you are for your use only, for the limited purposes disclosed to GZA. Any delayed use, use at another site, use on another project, or use by a third party will be at the user's sole risk, and without any liability to GZA. Any technology, methodology or technical information learned or developed by GZA will remain its property. Provided GZA is not in default under this Agreement, GZA's designs will not be used to complete this project by others, except by written agreement relating to use, liability and compensation.

**14. Electronic Media.** In accepting and utilizing any drawings, reports and data on any form of electronic media generated by GZA, you covenant and agree that all such electronic files are instruments of service of GZA, who shall be deemed the author and shall retain all common law, statutory law and other rights, including copyrights. In the event of a conflict between the signed documents prepared by GZA and electronic files, the signed documents shall govern. You agree not to reuse these electronic files, in whole or in part, for any purpose or project other than the project that is the subject of this Agreement. Any transfer of these electronic files to others or reuse or modifications to such files by you without the prior written consent of GZA will be at the user's sole risk and without any liability to GZA.

**15. Confidentiality; Subpoenas.** Information about this Agreement and GZA's services and information you provide to GZA regarding your business and the Site, other than information available to the public and information acquired from third parties, will be maintained in confidence and will not be disclosed to others without your consent, except as GZA reasonably believes is necessary: (a) to perform its services; (b) to comply with professional standards to protect public health, safety and the environment; and (c) to comply with laws and court orders. GZA will make reasonable efforts to give you prior notice of any disclosure under (b) or (c) above. Information available to the public and information acquired from third parties will not be considered confidential. You will reimburse GZA for responding to any subpoena or governmental inquiry or audit related to the services, at the rates set forth in the applicable Proposal, amendment or change order.

**16. Insurance.** During performance of the services, GZA will maintain workers compensation, commercial general liability, automobile liability, and professional liability/contractor's pollution liability insurance. GZA will furnish you certificates of such insurance on request.

**17. Indemnification.** You agree to hold harmless, indemnify, and defend GZA and its affiliates and subcontractors and their employees, officers, directors and agents (collectively referred to in this paragraph as "GZA") against all claims, suits, fines and penalties, including mandated cleanup costs and attorneys' fees and other costs of settlement and defense, which claims, suits, fines, penalties or costs arise out of or are related to this Agreement or the services, except to the extent they are caused by GZA's negligence or willful misconduct.

**18. Limitation of Remedies.**

- a. To the fullest extent permitted by law and notwithstanding anything else in this Agreement to the contrary, the aggregate liability of GZA and its affiliates and subcontractors and their employees, officers, directors and agents (collectively referred to in this paragraph as "GZA") for all claims arising out of this Agreement or the services is limited to \$50,000 or, if greater, 10% of the compensation received by GZA under this Agreement.
- b. You may elect to increase the limit of liability by paying an additional fee, such fee to be negotiated prior to the execution of this Agreement.
- c. Any claim will be deemed waived unless received by GZA within one year of substantial completion of the services.
- d. GZA will not be liable for lost profits, loss of use of property, delays, or other special, indirect, incidental, consequential, punitive, exemplary or multiple damages.
- e. GZA will not be liable to you or the Site owner for injuries or deaths suffered by GZA's or its subcontractors' employees.
- f. You will look solely to GZA for your remedy for any claim arising out of or relating to this Agreement, including any claim arising out of or relating to alleged negligence or errors or omissions of any GZA principal, officer, employee or agent.

**19. Disputes.**

- a. All disputes between you and GZA shall be subject to non-binding mediation.
- b. Either party may demand mediation by serving a written notice stating the essential nature of the dispute, the amount of time or money claimed, and requiring that the matter be mediated within forty-five (45) days of service of notice.
- c. The mediation shall be administered by the American Arbitration Association in accordance with its most recent Construction Mediation Rules, or by such other person or organization as the parties may agree upon.
- d. No action or suit may be commenced unless mediation has occurred but did not resolve the dispute, or unless a statute of limitation period would expire if suit were not filed prior to such forty-five (45) days after service of notice.

**20. Miscellaneous.**

- a. Massachusetts law shall govern this Agreement.
- b. The above terms and conditions regarding Limitation of Remedies and Indemnification shall survive the completion of the services under this Agreement and the termination of the contract for any cause.
- c. Any amendment to these Terms and Conditions must be in writing and signed by both parties.
- d. Having received these Terms and Conditions, your oral authorization to commence services, your actions, or your use of the Report or Work Product constitutes your acceptance of them.
- e. This Agreement supersedes any contract terms, purchase orders or other documents issued by you.
- f. Neither party may assign or transfer this Agreement or any rights or duties hereunder without the written consent of the other party.
- g. Your failure or the failure of your successors or assigns to receive payment or reimbursement from any other party for any reason whatsoever shall not absolve you, your successors or assigns of any obligation to pay any sum to GZA under this agreement.
- h. These Terms and Conditions shall govern over any inconsistent terms in GZA' s Proposal.
- i. The provisions of this Agreement are severable; if any provision is unenforceable it shall be appropriately limited and given effect to the extent it is enforceable.
- j. The covenants and agreements contained in this Agreement shall apply to, inure to the benefit of and be binding upon the parties hereto and upon their respective successors and assigns.

**APPENDIX B**

**SUBSURFACE EXPLORATION LOGS**

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-10
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±25'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/29/08</u> DATE END <u>10/29/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN. CASING SIZE: 3" OTHER: CLAY BASED DRILLING MUD	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
	10/29/08	11:00	±7'	N/A	0.0hr

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION		
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"					
5		S-1	24/18"	0-2'	35-15	Medium dense, brown, fine to coarse SAND, some fine to coarse	4"	ASPHALT		
					12-10	Gravel, little Silt. (SW)				
		S-2	24/16"	2-4'	12-14				±2.5'	FILL
					12-14	Medium dense, tan, fine to medium SAND, trace Silt (SM)				
		S-3	24/8"	4-6'	29-17					
10					20-17	Dense, tan, fine to medium SAND, trace Silt (SM)				
		S-4	24/13"	9-11'	9-11	Medium dense, tan, fine to coarse SAND, trace Silt (wet)(sm)		SAND		
					11-11					
	S-5	24/10"	14-16'	6-4	Loose, tan, fine SAND, little Silt (wet) (SM)					
15					5-7					
		S-6	24/24"	19-21'	6-6	Medium Dense, tan, fine SAND, little Silt (wet) (SM)				
					6-9					
20										
		S-7	24/20"	24-26'	8-9	Medium dense, tan, fine SAND, some Silt (wet) (SM)				
					7-8					
25										
30										

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-11
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.02
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±23'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/27/08</u> DATE END <u>10/27/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.	10/27/08	3:00	±7.0'	N/A	0.0hour
CASING SIZE: OTHER: 3 3/4" HSA					

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5		S-1	24/20"	0-2	7/7	Medium dense, tan, fine to medium SAND, trace fine Gravel, little Silt (SM)	5"	ASPHALT	
					6/7				
		S-2	24/22"	2-4	7/8				Medium dense, tan, fine to medium SAND, little Silt (SW)
					9/11				
		S-3	24/20"	4-6	6/6				Medium dense, tan, fine to medium SAND, little Silt (SW)
					6/7				
10		S-4	24/22"	9-11'	3/3	Loose, tan, fine to coarse SAND, trace Silt (wet) (SW)	±11'	SAND	
					4/4				
15						END OF EXPLORATION @ 11'			
20						END OF EXPLORATION @ 11'			
25						END OF EXPLORATION @ 11'			
30						END OF EXPLORATION @ 11'			

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-12
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO. <u>New Hampshire Boring</u>	BORING LOCATION <u>See Exploration Location Plan</u>
FOREMAN <u>Vinny Casaletto</u>	GROUND SURFACE ELEV. <u>±29'</u> DATUM <u>Project Datum</u>
GZA ENG. <u>Jim Marsland</u>	DATE START <u>10/28/08</u> DATE END <u>10/28/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.  CASING SIZE:                      OTHER:      3 3/4" HSA	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
	10/28/08		Not Encountered		

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5		S-1	24/14"	0-2	1-2	Loose, Light brown, fine SAND, little Silt trace fine Gravel, trace Organics (SM)  Loose, tan, fine to medium SAND, little Silt (SM)  Medium dense, tan, fine SAND, little Silt (SM)	6"	TOPSOIL/LOAM	
					3-2				
		S-2	24/12"	2-4	2-3				
					4-7				
		S-3	24/18"	4-6	7-8				
					8-8				
10		S-4	24/12"	9-11	23-34	Very dense, light brown, fine SAND, some fine Gravel, trace Silt (SW)	±11'	SAND	
					44-60				
15						End of Exploration @ 11'			
20									
25									
30									

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4      VERY LOOSE	<2      VERY SOFT	1. Unified classification system noted in parentheses.
4-10      LOOSE	2-4      SOFT	
10-30      MEDIUM DENSE	4-8      M. STIFF	
30-50      DENSE	8-15      STIFF	
>50      VERY DENSE	15-30      V. STIFF	
	>30      HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-13(OW)
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±25'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/27/08</u> DATE END <u>10/27/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.  CASING SIZE: OTHER: 3 3/4" HSA	GROUNDWATER READINGS			
	DATE	TIME	WATER	CASING
	10/27/08	12:45	±11.5'	N/A
	10/28/08	3:00	±8.61	Well
	10/29/08	2:00	±8.68'	Well

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5		S-1	24/6"	0-2'	30-13	Medium dense, light brown, fine to coarse SAND, little fine Gravel, little Silt (SW) Dense, light brown, fine to coarse SAND, little fine Gravel, trace Silt (SW) Medium dense, tan, fine to coarse SAND, trace Silt (SW)	1"	ASPHALT
					14-13		12"	PROCESSED ASPHALT
		S-2	24/6"	2-4'	18-18		±4'	FILL
					20-17			
		S-3	24/12"	4-6'	14-10			
10					12-12	Medium dense, tan, fine SAND and Silt (wet) (SM)	±7'	FINE TO COARSE SAND
		S-4	24/6"	9-11'	15-7			
					3-4			
15		S-5	24/9"	14-16'	12-7	Medium dense, tan, fine SAND and Silt (wet) (SM)		FINE SAND
					7-7			
20		S-6	24/18"	19-21'	4-2	Loose, light gray, fine SAND and Silt (wet) (SM)		
					3-3			
25		S-7	24/20"	24-26'	9-5	Medium dense, gray, fine SAND and Silt (wet) (SM)		
					5-4			
30						END OF EXPLORATION @ 26'	±26'	

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	1. 2" DIA PVC Groundwater observation well installed to depth 20', 10' riser & 10' screen with Road Box flush to existing parking grade.
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-14
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.02
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±29'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/28/08</u> DATE END <u>10/28/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.  CASING SIZE: OTHER: 3 3/4" HSA	GROUNDWATER READINGS			
	DATE	TIME	WATER	CASING
	10/28/08		Not Encountered	
				STABILIZATION TIME

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5		S-1	24/18"	0-2'	3-4	Loose brown, fine SAND, some Silt, little fine Gravel, trace Organic fibers (SM)	6"	TOPSOIL	
		S-2	24/1"	2-4'	4-3		±3'	SUBSOIL	
					3-2				
		S-3	24/9"	4-6'	3-7		Medium dense, tan, fine to medium SAND, little Silt (SM)		
10					10-11			SAND	
		S-4	24/14"	9-11	16-13	Medium dense, tan, fine to medium SAND, little Silt	±11'		
					16-27				
15						END OF EXPLORATION @ 11'			
20									
25									
30									

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-15
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.02
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±24'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/28/08</u> DATE END <u>10/29/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.	10/29/08	7:30	±7.0'	N/A	24 Hours
CASING SIZE: 3" OTHER:					

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION		
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"					
5		S-1	24/18"	0-2'	18-12	Medium dense, brown, fine to medium SAND, little fine Gravel, trace Silt. (SW)	3"	ASPHALT		
					8-8					
		S-2	26/20"	2-4'	24-24			Dense, tan, fine to medium SAND, trace fine Gravel, trace Silt (SW)	±2'	FILL
					22-12					
	S-3	24/18"	4-6'	26-19	Dense, tan, fine to coarse SAND, trace fine Gravel, trace Silt (SW)					
				18-17	Silt (SW)					
10	8					Medium to dense, tan, fine to medium SAND, little Silt (SM)	SAND			
	17	S-4	24/12"	9-11'	9-10					
	19				12-12					
	22									
15	16					Loose, tan, fine SAND, little Silt (wet) (SM)	SAND			
	14									
		S-5	28/12"	14-16'	4-3					
					2-3					
20	29	S-6	24/14"	19-21'	5-4	Loose, tan, fine SAND, little Silt (wet) (SM)	SAND			
	22				4-4					
	20									
	27									
25	22					Medium to dense, light brown, fine SAND, little Silt (SM)	SAND			
		S-7	24/18"	24-26'	8-9					
					9-7					
30						End of Exploration at ±26'				

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

GZA GEOENVIRONMENTAL INC. 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG					PROJECT New Commissary Building Naval Submarine Base New London Groton, Connecticut		REPORT OF BORING NO. B-16 SHEET 1 of 1 FILE NO. 32608.08 CHKD BY DLD		
BORING CO. <u>New Hampshire Boring</u>					BORING LOCATION <u>See Exploration Location Plan</u>				
FOREMAN <u>Vinny Casaletto</u>					GROUND SURFACE ELEV. <u>±25'</u>		DATUM <u>Project Datum</u>		
GZA ENG. <u>Jim Marsland</u>					DATE START <u>10/27/08</u>		DATE END <u>10/27/08</u>		
SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN					GROUNDWATER READINGS				
CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.					DATE	TIME	WATER	CASING	STABILIZATION TIME
CASING SIZE: OTHER: 3 3/4"HSA					10/27/08	10:15	±10.0'	N/A	0.0 hours
DEPTH	CASING BLOWS	SAMPLE			SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION		
		NO	PEN./REC	DEPTH (FT)				BLOWS/6"	
5		S-1	24/12"	0-2	16-17	Dense, brown, fine to medium SAND, some fine to coarse Gravel, trace Silt (SW) Very dense, tan, fine to coarse SAND, some fine Gravel, trace Silt (SW) Medium to dense, tan fine to coarse SAND, some fine Gravel, trace Silt (SW)	3"	ASPHALT	
					17-13		±2"	FILL	
		S-2	24/12"	2-4	28-22		SAND		
					29-25				
		S-3	24/14"	4-6	29-12				
					17-16				
10		S-4	24/16"	9-11'	18-5	Medium to dense, tan, fine to medium SAND some (+) Silt trace fine Gravel (wet) (SW)	1		
					6-7				
15						Loose, tan, fine SAND and Silt (SM)	±13'		
		S-5	24/12"	14-16	5-4		SAND AND SILT		
					5-6				
20		S-6	24/12"	18-20	14-80	Very dense, gray fine to medium SAND, little Silt. (SM)	2,3	±20"	
					100/0"				
25						END OF EXPLORATION @ 20'		POSSIBLE BEDROCK	
30									
GRANULAR SOILS BLOWS/FT DENSITY		COHESIVE SOILS BLOWS/FT DENSITY		REMARKS:					
0-4	VERY LOOSE	<2	VERY SOFT	1. Unified classification system noted in parentheses.					
4-10	LOOSE	2-4	SOFT	2. Groundwater encountered at depth 10.0' at completion of boring.					
10-30	MEDIUM DENSE	4-8	M. STIFF	3. Encountered possible bedrock at 20' with auger and spoon refusal.					
30-50	DENSE	8-15	STIFF	4. Weathered rock in tip of spoon.					
>50	VERY DENSE	15-30	V. STIFF						
		>30	HARD						
NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL. 2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE									
GZA								BORING NO. B-16	

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-17
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±23'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/27/08</u> DATE END <u>10/27/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN	GROUNDWATER READINGS			
	DATE	TIME	WATER	CASING

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.	10/27/08	2:30	±7.0	n/a	0.0 hours
--	----------	------	------	-----	-----------

CASING SIZE: OTHER: 3 3/4" HSA

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION	
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"				
5		S-1	24/14"	0-2'	15-13	Medium dense, brown, fine to medium SAND, little fine to coarse Gravel, trace Silt (SW)	4"	ASPHALT	
		S-2	24/8"	2-4'	9-8				
					17-9				Medium dense, brown fine to coarse SAND, little fine to coarse Gravel, trace Silt (SW)
		S-3	24/8"	4-6'	7-2				
10					5-8	Loose, tan, fine to medium SAND, little fine Gravel, trace Silt (SW)	±5'	SAND	
		S-4	24/12"	9-11'	7-3				Loose, tan, fine to coarse SAND, little Silt (wet) (SM)
					4-7				
15						END OF EXPLORATION @11'			
20									
25									
30									

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4 VERY LOOSE	<2 VERY SOFT	1. Unified classification system noted in parentheses.
4-10 LOOSE	2-4 SOFT	
10-30 MEDIUM DENSE	4-8 M. STIFF	
30-50 DENSE	8-15 STIFF	
>50 VERY DENSE	15-30 V. STIFF	
	>30 HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-18
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.02
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±26'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/29/08</u> DATE END <u>10/29/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN. CASING SIZE: 3"      OTHER: CLAY BASED DRILLING MUD	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
	10/29/08	1:45	±8'	n/a	0.0 hours

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5		S-1	24/14"	0-2'	15-9	Medium to dense, brown, fine to coarse SAND, little fine Gravel, trace Silt (SW)	4"	ASPHALT
					9-8			
		S-2	24/18"	2-4'	10-10			
					12-12			
		S-3	24/12"	4-6'	12-11			
10					15-17	Medium to dense, tan, fine to coarse SAND, little fine to coarse Gravel, trace Silt (SW)	±5'	SAND
		S-4	24/12"	9-11'	12-11			
					11-10			
15						Loose to light brown, fine SAND, little Silt (wet) (SM)		
		S-5	24/18"	14-16'	4-5			
20					4-3	Loose, light gray, fine SAND and Silt (wet) (SM)		
		S-6	24/22"	19-21'	4-4			
25					5-4	Medium to dense, light gray fine SAND and Silt (wet) (SM)		
		S-7	24/20"	24-26'	5-6			
30					6-4	END OF EXPLORATION @ 26'		

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4      VERY LOOSE	<2      VERY SOFT	1. Unified classification system noted in parentheses.
4-10      LOOSE	2-4      SOFT	
10-30      MEDIUM DENSE	4-8      M. STIFF	
30-50      DENSE	8-15      STIFF	
>50      VERY DENSE	15-30      V. STIFF	
	>30      HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-19
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO. <u>New Hampshire Boring</u>	BORING LOCATION <u>See Exploration Location Plan</u>
FOREMAN <u>Vinny Casaletto</u>	GROUND SURFACE ELEV. <u>±28'</u> DATUM <u>Project Datum</u>
GZA ENG. <u>Jim Marsland</u>	DATE START <u>10/28/08</u> DATE END <u>10/28/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN  CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.  CASING SIZE:                      OTHER:      3 3/4" HSA	GROUNDWATER READINGS				
	DATE	TIME	WATER	CASING	STABILIZATION TIME
	10/28/08		Not Encountered		

DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5		S-1	24/8"	0-2'	29-37	Very dense, light brown/black, fine to medium SAND, little fine to coarse Gravel, little Silt (SW) Medium dense, brown, fine SAND, little fine Gravel, trace Silt (SW) Dense, light brown, fine to coarse SAND, little Fine to Coarse Gravel, trace Silt (SW)	4"	ASPHALT
					5-4			
		S-2	24/14"	2-4'	5-7			
					6-4			
10		S-3	24/14"	4-6'	14-15	Dense, tan, fine to medium SAND, trace fine Gravel, trace Silt (SW)	±6'	FILL
					22-19			
		S-4	24/12"	9-11'	18-23			
15					21-23	END OF EXPLORATION @ 11'	±11'	SAND
20								
25								
30								

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4      VERY LOOSE	<2      VERY SOFT	1. Unified classification system noted in parentheses.
4-10     LOOSE	2-4      SOFT	
10-30   MEDIUM DENSE	4-8      M. STIFF	
30-50   DENSE	8-15     STIFF	
>50     VERY DENSE	15-30   V. STIFF	
	>30      HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

<b>GZA GEOENVIRONMENTAL INC.</b> 530 BROADWAY, PROVIDENCE, RHODE ISLAND GEOTECH/GEOHYDROLOGICAL CONSULTANTS GEOTECHNICAL BORING LOG	PROJECT	REPORT OF BORING NO.	B-20
	New Commissary Building	SHEET	1 of 1
	Naval Submarine Base New London	FILE NO.	32608.08
	Groton, Connecticut	CHKD BY	DLD

BORING CO.	<u>New Hampshire Boring</u>	BORING LOCATION	<u>See Exploration Location Plan</u>
FOREMAN	<u>Vinny Casaletto</u>	GROUND SURFACE ELEV.	<u>±29'</u> DATUM <u>Project Datum</u>
GZA ENG.	<u>Jim Marsland</u>	DATE START	<u>10/28/08</u> DATE END <u>10/28/08</u>

SAMPLER: UNLESS OTHERWISE NOTED, SAMPLER CONSISTS OF A 2" SPLIT SPOON DRIVEN USING A 140 lb. HAMMER FALLING 30 IN

CASING: UNLESS OTHERWISE NOTED, CASING DRIVEN USING A 300 lb HAMMER FALLING 24 IN.

CASING SIZE: 3"      OTHER:

DATE	TIME	GROUNDWATER READINGS		STABILIZATION TIME
		WATER	CASING	
10/28/8	11:00	±6'	n/a	0.0 hours

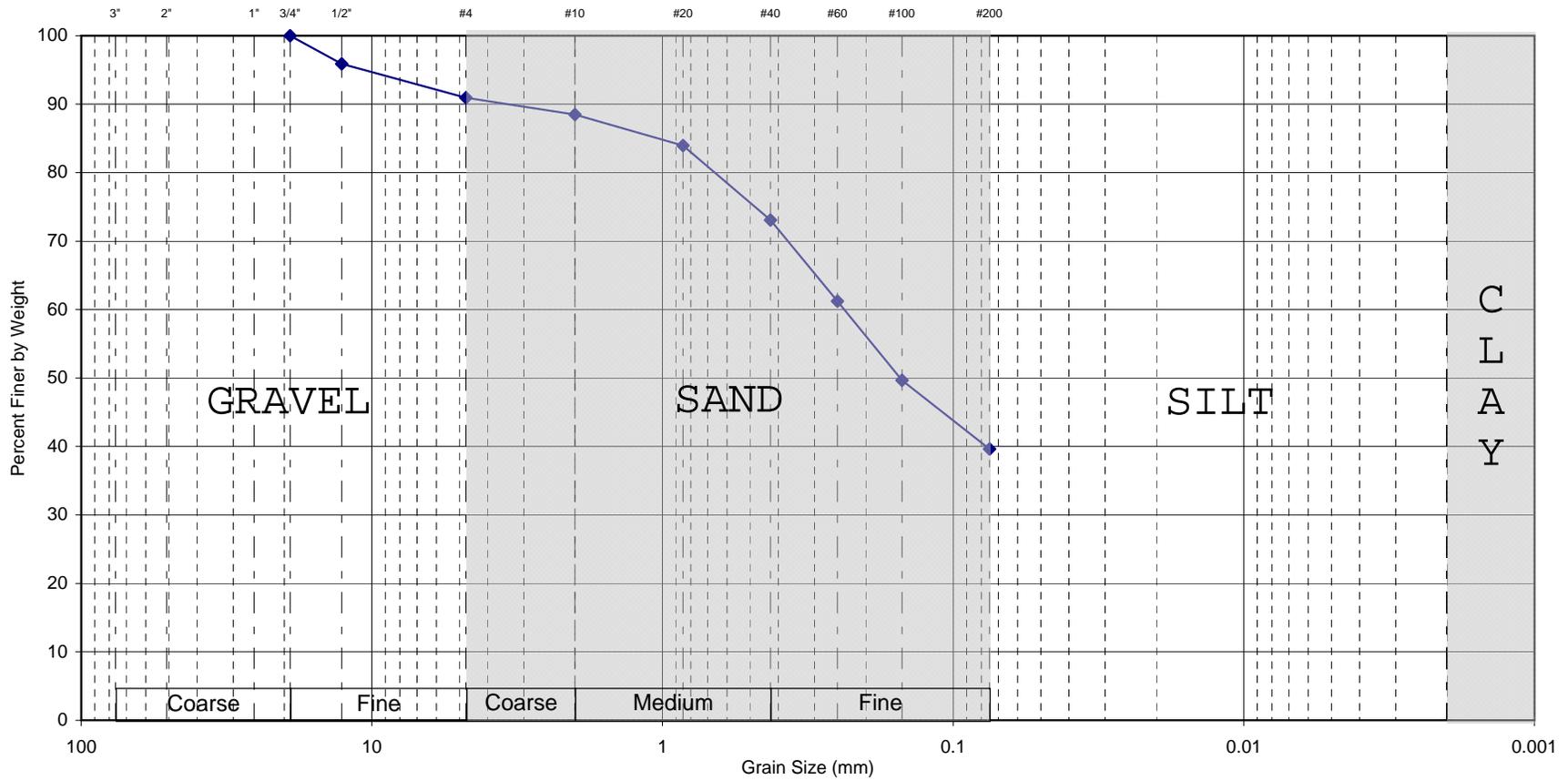
DEPTH	CASING BLOWS	SAMPLE				SAMPLE DESCRIPTION BURMISTER CLASSIFICATION	R K	STRATUM DESCRIPTION
		NO	PEN./REC	DEPTH (FT)	BLOWS/6"			
5		S-1	24/18"	0-2'	3-2	S-1: Loose brwon, fine SAND, little Silt, trace organic fibers (SM)	8"	TOPSOIL
				2-2				
		S-2	24/12"	2-4'	2-2	S-2: Loose, tan, fine SAND trace Silt (SM)	±3'	SUBSOIL
				3-5				
	S-3	24/16"	4-6'	1-2	S-3: Loose , tan, fine SAND, trace Silt (SM)	±7'	SAND	
			2-2	S-4: Very dense tan/gray, fine to medium SAND, little fine				
	S-4	24/6"	6-8'	15-0/100'	Gravel, trace Silt			
	C-1	92%	7-12'	5min	C-1: Hard, slightly weathered, medium grained, gray GRANITE, medium subvertical foliation, moderately close subhorizontal irregular fractures (RQD=76 %)			
10				5min		±12'	BEDROCK	
				6min				
				8min				
				10min				
15						END OF EXPLORATION @ 12'		
20								
25								
30								

GRANULAR SOILS BLOWS/FT DENSITY	COHESIVE SOILS BLOWS/FT DENSITY	REMARKS:
0-4      VERY LOOSE	<2      VERY SOFT	1. Unified classification system noted in parentheses.
4-10      LOOSE	2-4      SOFT	
10-30      MEDIUM DENSE	4-8      M. STIFF	
30-50      DENSE	8-15      STIFF	
>50      VERY DENSE	15-30      V. STIFF	
	>30      HARD	

NOTES: 1) STRATIFICATION LINES REPRESENT APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITIONS MAY BE GRADUAL.  
2) WATER LEVEL READINGS HAVE BEEN MADE AT TIMES AND UNDER CONDITIONS STATED, FLUCTUATIONS OF GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE

**APPENDIX C**  
**LABORATORY DATA**

### U.S. STANDARD SIEVE AND HYDROMETER



Gravel  
9.1%

Sand  
51.3%

Fines  
39.6%

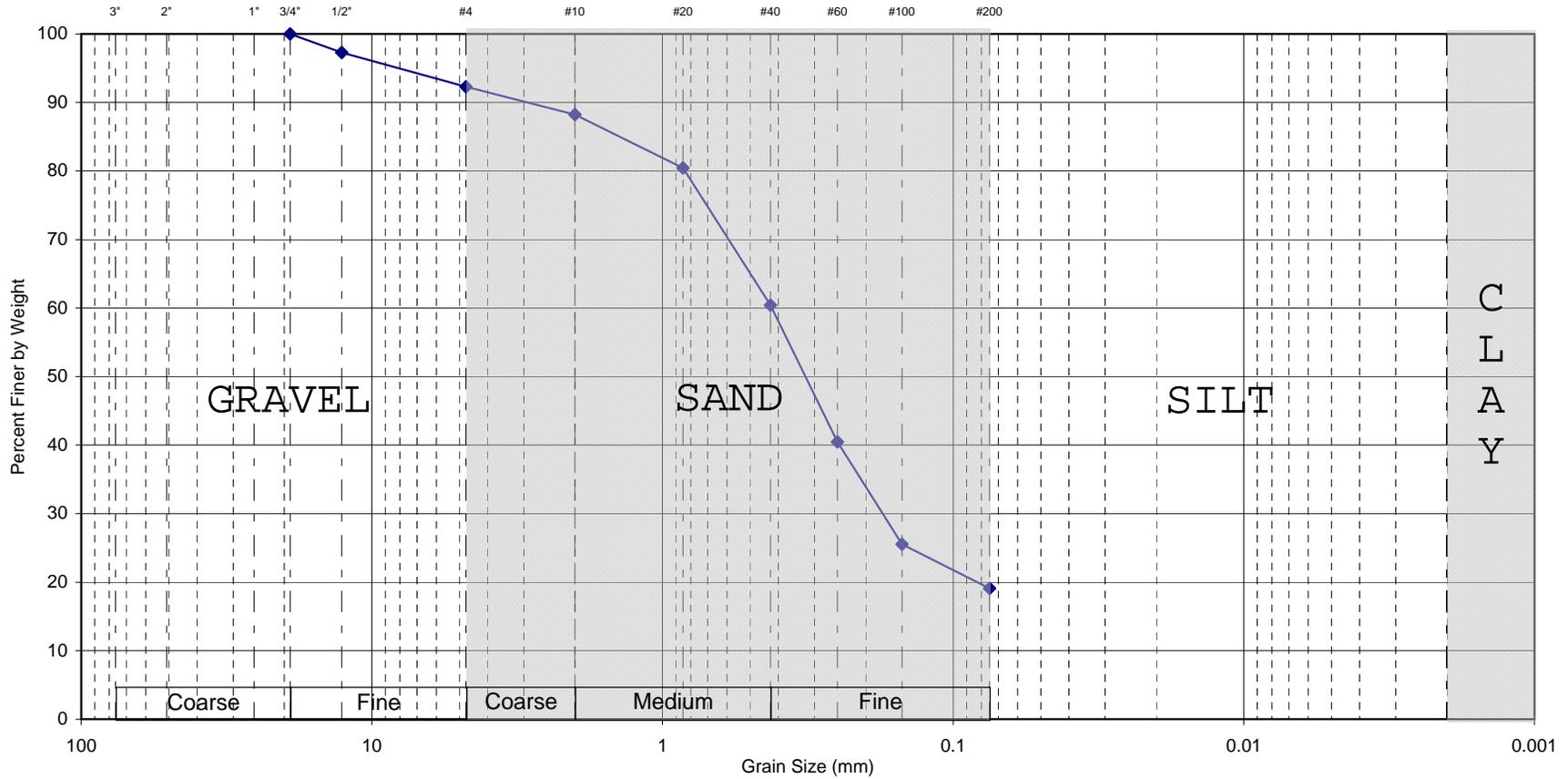
Lab #	Exploration	Sample	Depth (ft)	Description	WC	LL	PL	PI
6	B-14	S-1	0-2'	Brown f-m SAND and SILT, trace Gravel	13.2			



New London Sub Base  
Groton, CT  
GZA File # 32608.02

Tested by: PEC      Date: 11/4/08  
 Reviewed by: MBP      Date: 11/4/08

### U.S. STANDARD SIEVE AND HYDROMETER



Gravel  
7.7%

Sand  
73.2%

Fines  
19.1%

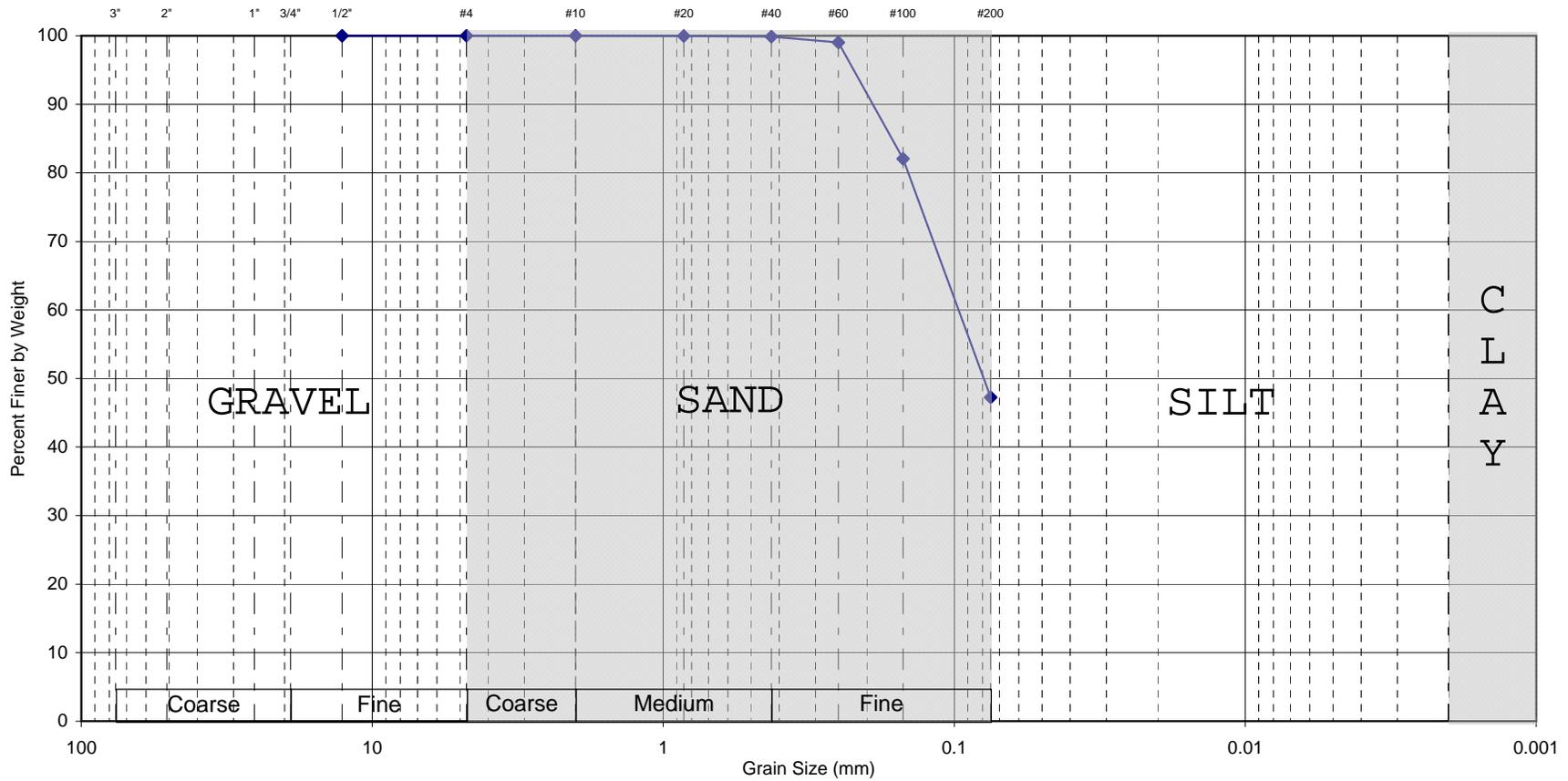
Lab #	Exploration	Sample	Depth (ft)	Description	WC	LL	PL	PI
5	B-17	S-2	2-4'	Brown f-m SAND, little Silt, trace Gravel	10.9			



New London Sub Base  
Groton, CT  
GZA File # 32608.02

Tested by: PEC      Date: 11/4/08  
 Reviewed by: MBP      Date: 11/4/08

**U.S. STANDARD SIEVE AND HYDROMETER**



Gravel  
0.0%

Sand  
52.8%

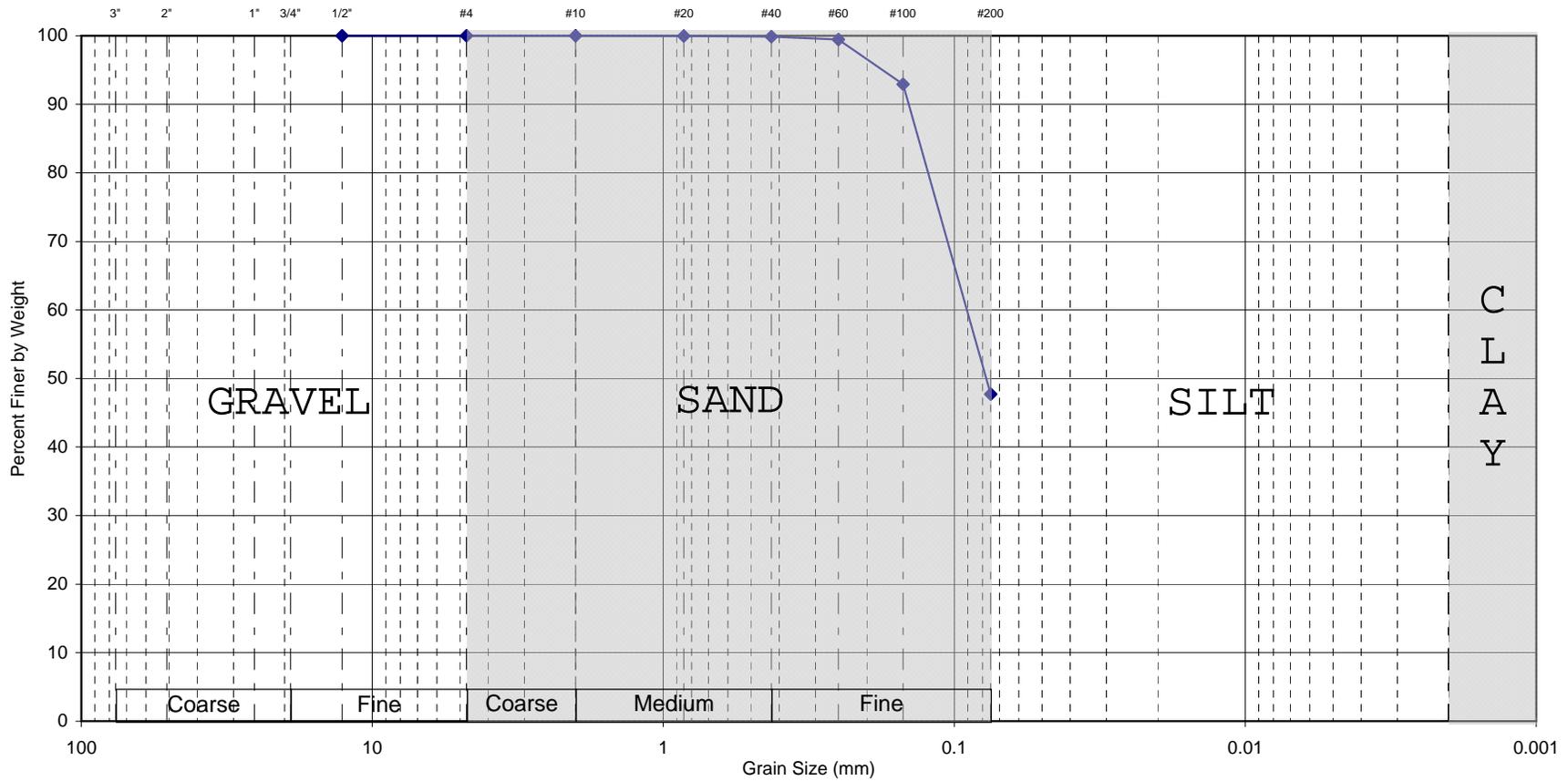
Fines  
47.2%

Lab #	Exploration	Sample	Depth (ft)	Description	WC	LL	PL	PI
4	B-13	S-7	24-26'	Gray fine SAND and SILT	35.2			



New London Sub Base  
 Groton, CT  
 GZA File # 32608.02  
 Tested by: PEC Date: 11/4/08  
 Reviewed by: MBP Date: 11/4/08

### U.S. STANDARD SIEVE AND HYDROMETER



Gravel  
0.0%

Sand  
52.3%

Fines  
47.7%

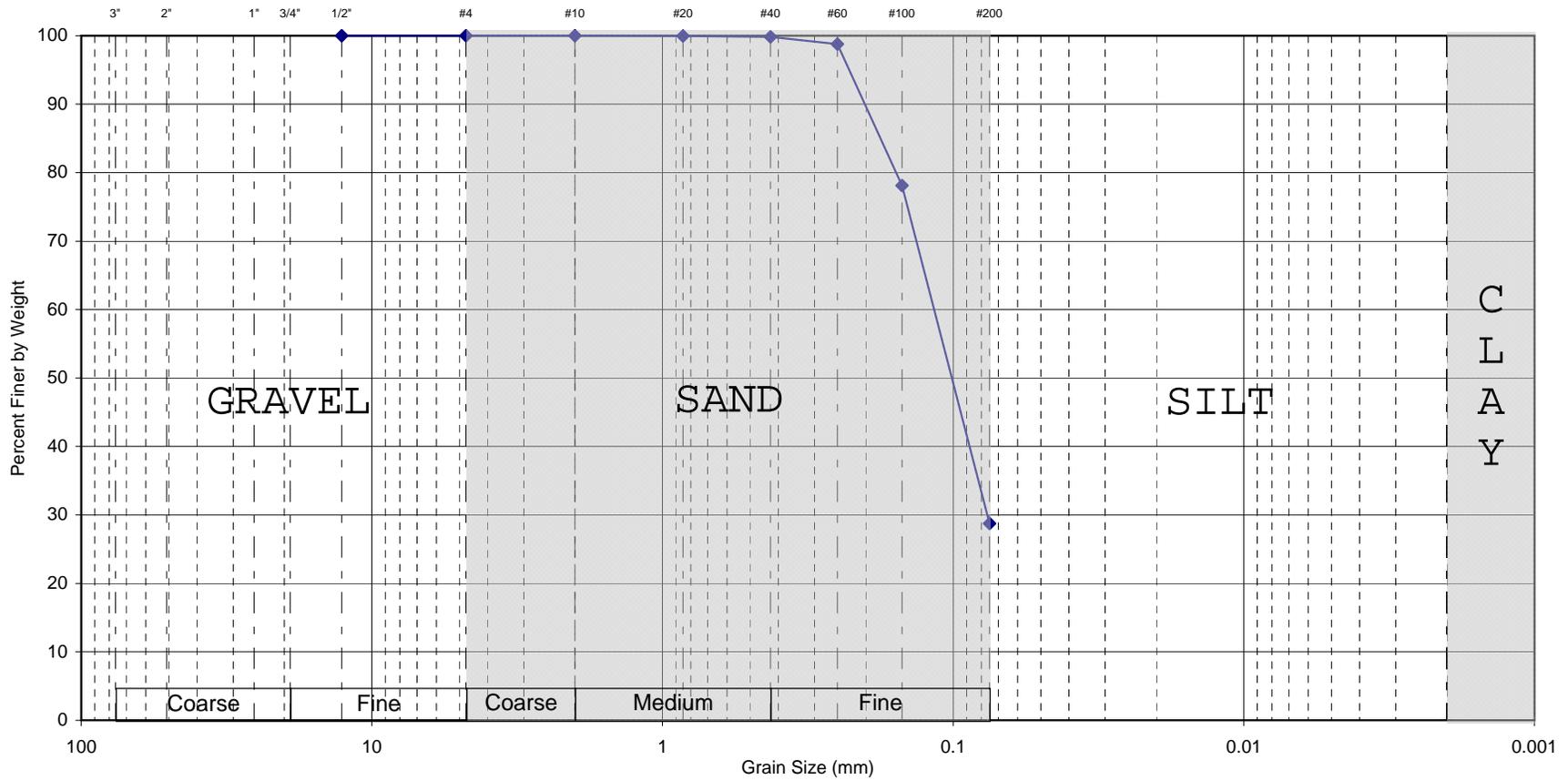
Lab #	Exploration	Sample	Depth (ft)	Description	WC	LL	PL	PI
3	B-13	S-6	19-21'	Gray fine SAND and SILT	33.2			



New London Sub Base  
Groton, CT  
GZA File # 32608.02

Tested by: PEC      Date: 11/4/08  
 Reviewed by: MBP      Date: 11/4/08

### U.S. STANDARD SIEVE AND HYDROMETER



Gravel  
0.0%

Sand  
71.2%

Fines  
28.8%

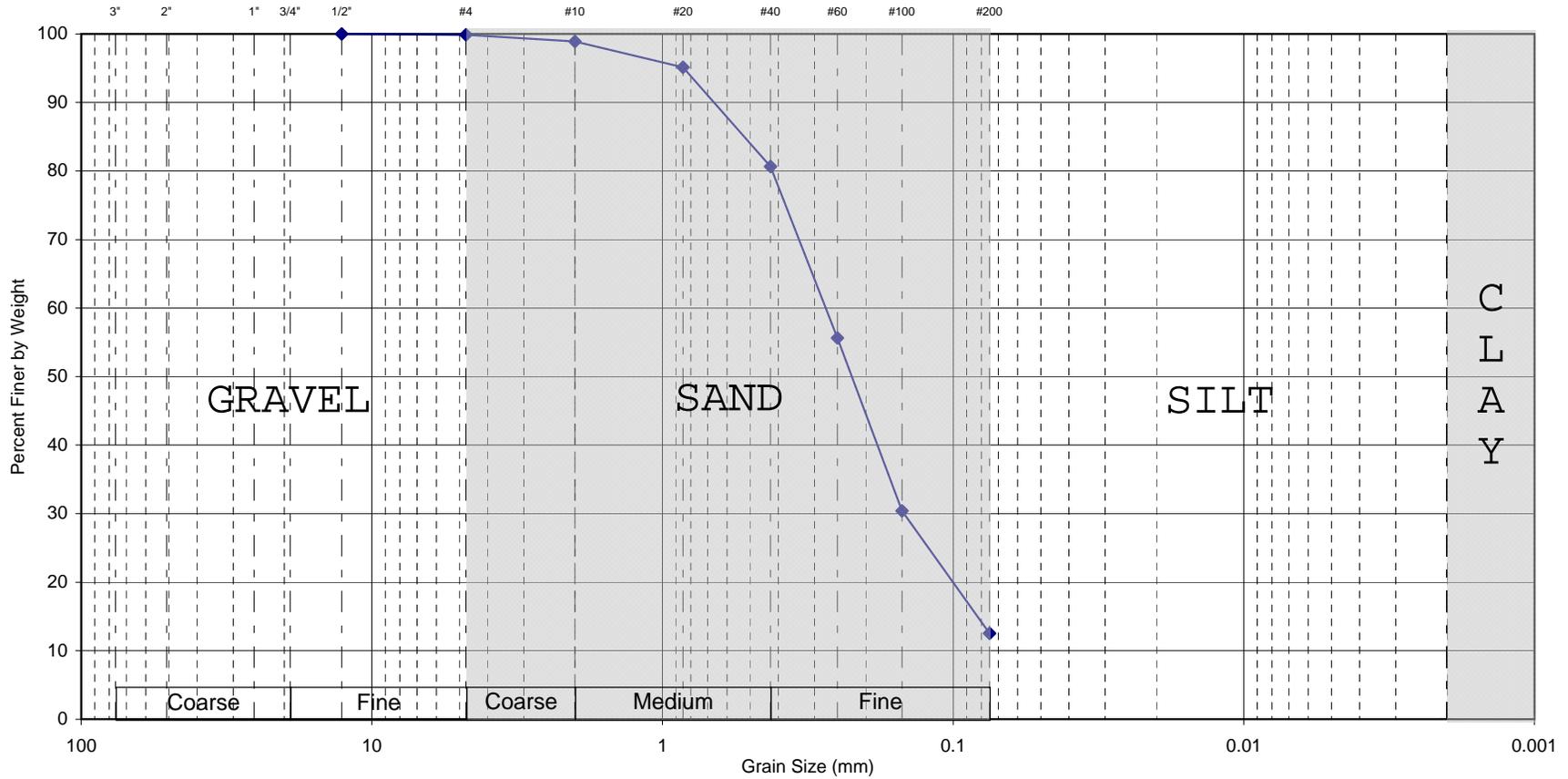
Lab #	Exploration	Sample	Depth (ft)	Description	WC	LL	PL	PI
2	B-18	S-6	19-21'	Gray-brown fine SAND, some Silt	33.4			



New London Sub Base  
Groton, CT  
GZA File # 32608.02

Tested by: PEC      Date: 11/4/08  
 Reviewed by: MBP      Date: 11/4/08

### U.S. STANDARD SIEVE AND HYDROMETER



Gravel  
0.1%

Sand  
87.3%

Fines  
12.5%

Lab #	Exploration	Sample	Depth (ft)	Description	WC	LL	PL	PI
1	B-15	S-5	14-16'	Brown f-m SAND, little Silt	23.7			



New London Sub Base  
Groton, CT  
GZA File # 32608.02

Tested by: PEC      Date: 11/4/08  
 Reviewed by: MBP      Date: 11/4/08

## LABORATORY TESTING DATA SHEET

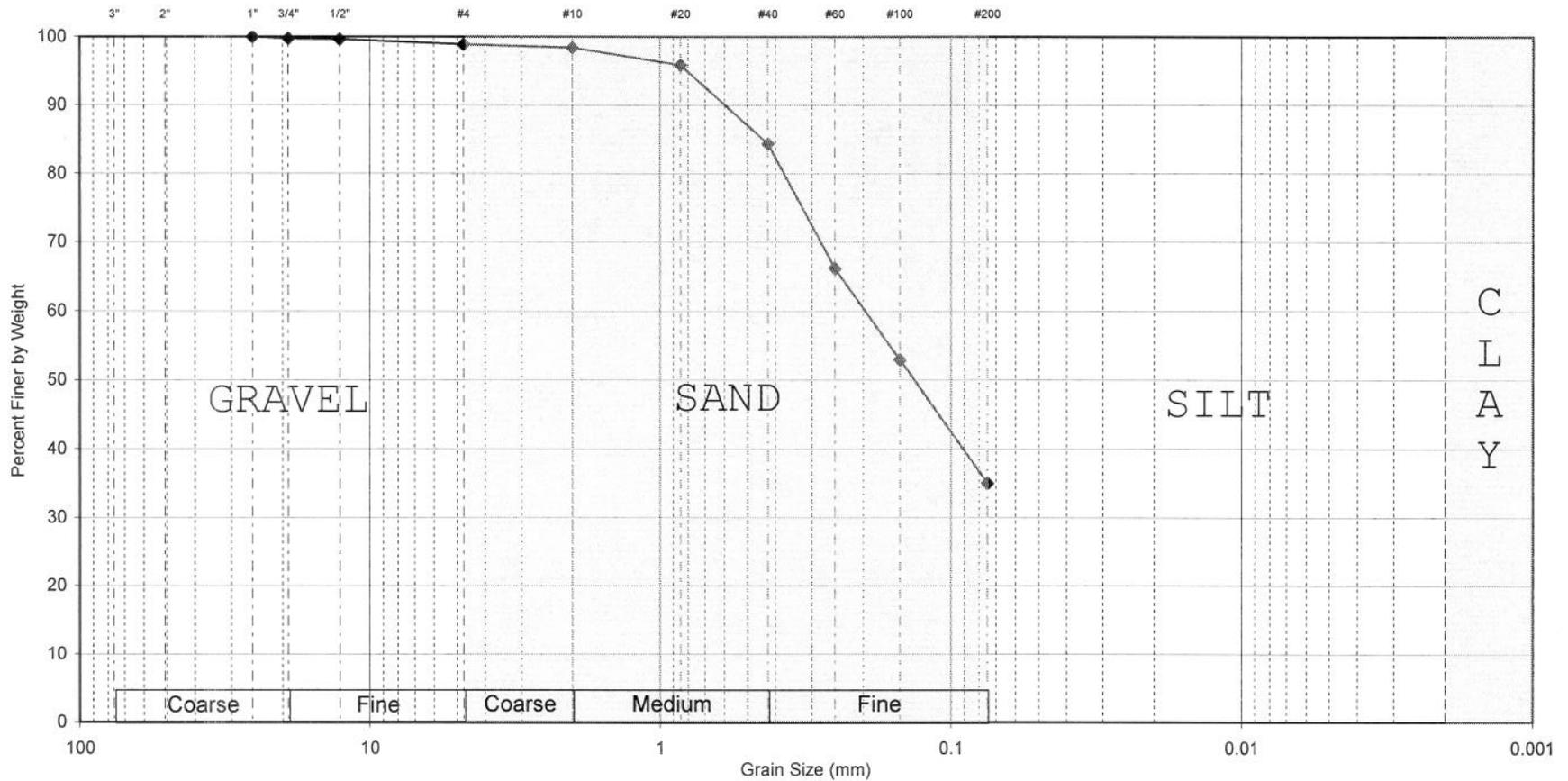
Project Name New London Sub Base  
 Project No. 32608.08  
 Project Engineer D. Le Do

Project Location Groton, CT  
 Assigned By J. Marsland  
 Date 11/7/2008

Reviewed By *Matthew Kelly*  
 Date Reviewed 11/7/08

Boring/ Test Pit No.	Sample No.	Depth ft.	Lab No.	Identification Tests						Density	Strength Tests							Laboratory Log and Soil Description	
				Natural Water Content %	LL %	PL %	Sieve -200 %	Hyd -2 $\mu$ %	Org. %	$\gamma_d$ MAX (pcf) W <sub>opt</sub> (%)	CBR Water Content %	CBR Dry unit wt. pcf	CBR @ 0.1" @ 0.2"	$\bar{\sigma}_c$ psf	Failure Criteria	$\sigma_1 - \sigma_3$ or $\tau$ psf	Strain %		
S-101		3'	8				35			<u>119.0</u> 11.0	11.0	113.0	50.5% 45.0%						Brown f-m SAND and SILT, trace Gravel
S-102		3'	9				21			<u>127.0</u> 9.5	9.5	120.6	21.6% 19.9%						Brown f-m SAND some Silt, little fine Gravel

U.S. STANDARD SIEVE AND HYDROMETER



Gravel  
1.1%

Sand  
63.9%

Fines  
35.0%

Lab #	Exploration	Sample	Depth	Description	WC	LL	PL	PI
8	S-101	Auger Cuttings	3'	Brown f-m SAND and SILT, trace Gravel				



New London Sub Base  
Groton, CT  
GZA File # 32608.02  
Tested by: PEC Date: 11/4/08  
Reviewed by: MBP Date: 11/5/08

# ASTM D-1557 MODIFIED COMPACTION TEST

Project New London Sub Base  
Location Groton, CT

File Number 32608.08  
Test Number MC 8  
Boring S-101  
Depth 3'

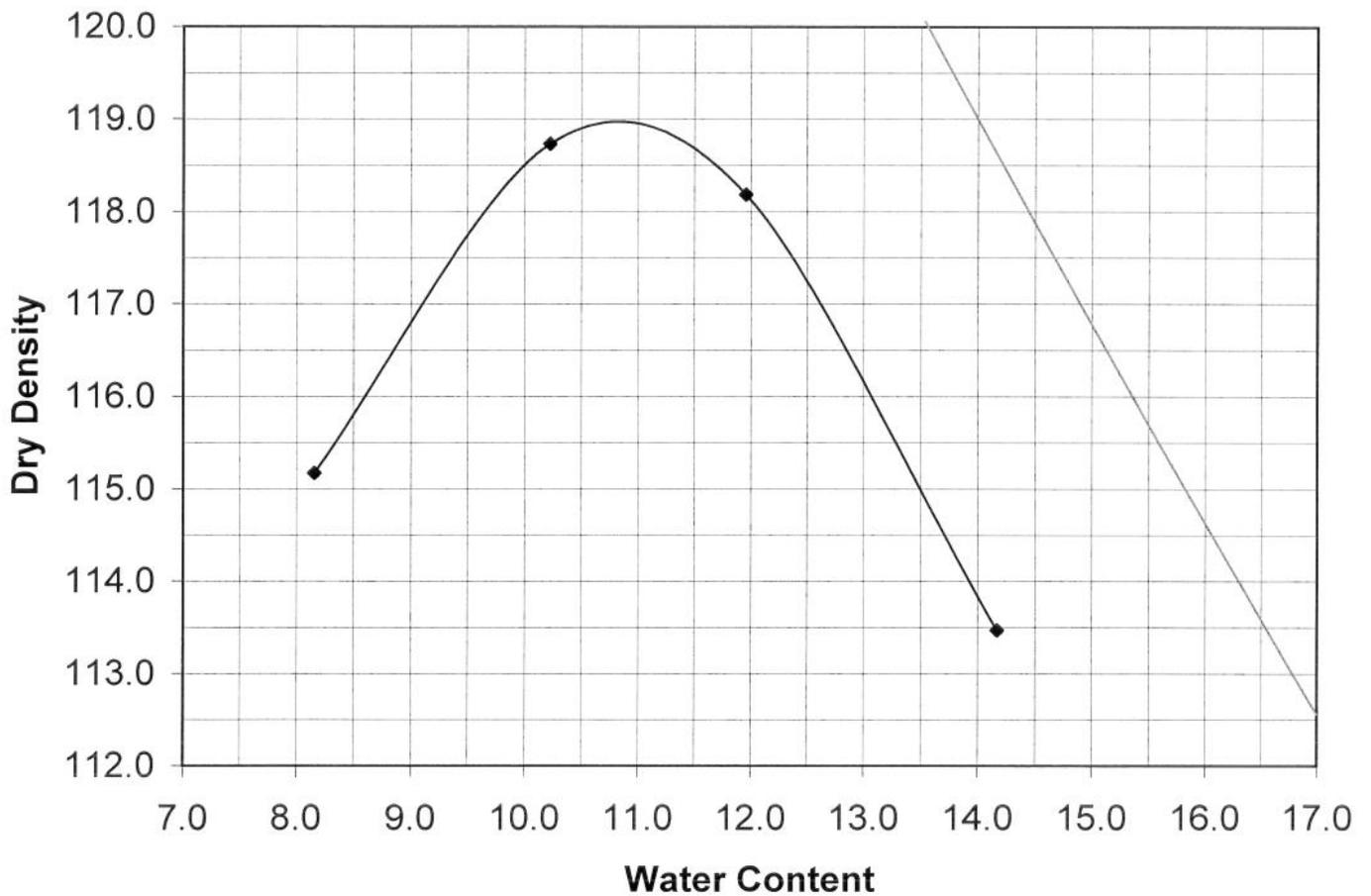
Date 11/4/08  
Technician PEC  
Reviewer MBP  
Sample Auger Cuttings

Soil Description Brown f-m SAND and SILT, trace Gravel

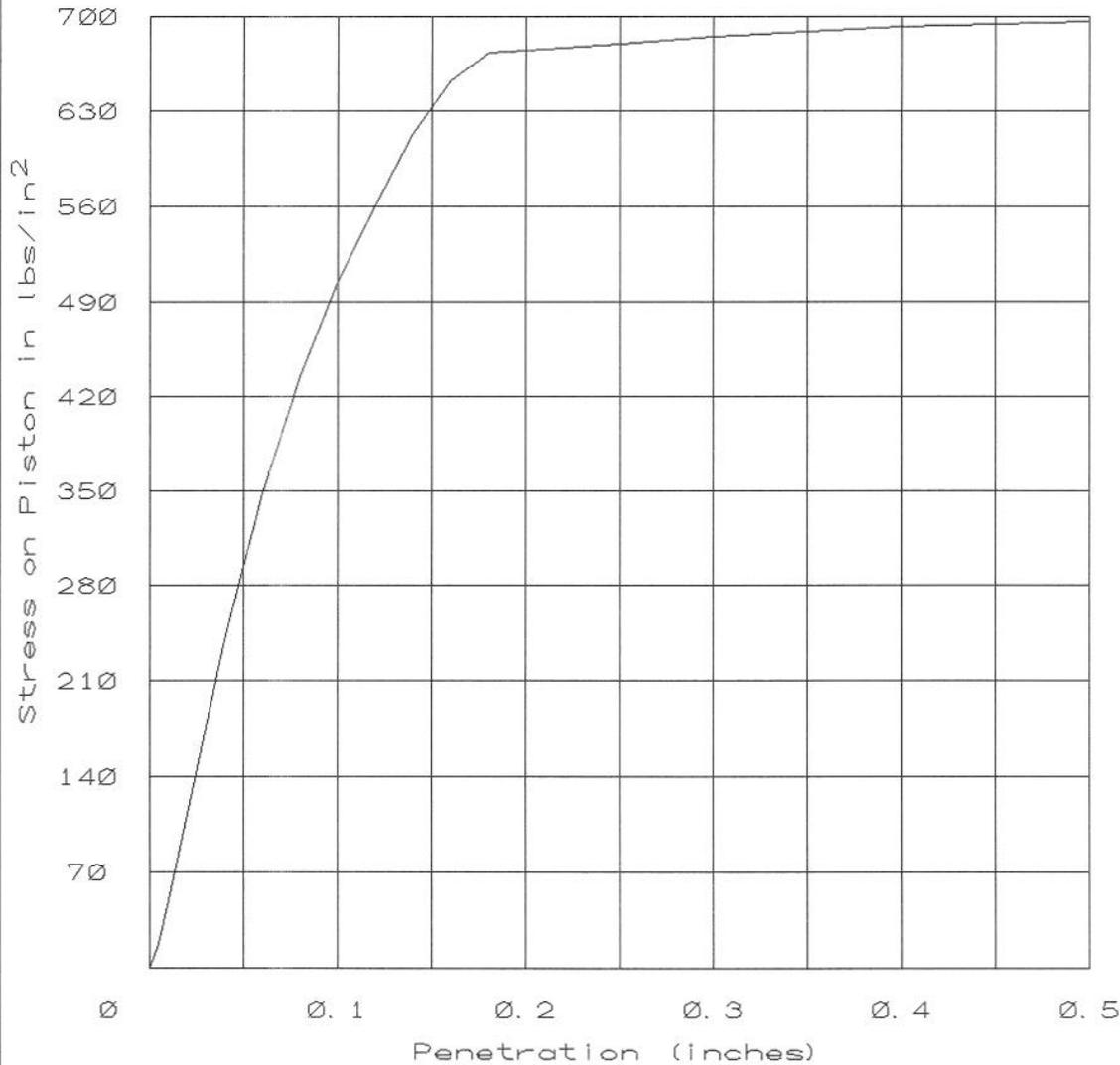
Optimum Water Content % 11.0      Maximum Dry Unit Weight (pcf) 119.0  
Method A

## Compaction Curve

ZAV = 2.60



Soil Description: Brown f-m SAND  
and SILT, trace Gravel  
CBR @ 0.1" = 50.5      CBR @ 0.2" = 45.0



Test Number	8
Exploration No	S-101
Depth (ft)	3'
Initial Moisture Content (%)	11.0
Initial Dry Unit Weight (PCF)	113.0
Sample Condition	SOAKED
Swell (%)	.008
Final Moisture (%) Top 1 Inch	15.4
Final Average Moisture (%)	13.4
Liquid Limit (%)	N/A
Plastic Limit (%)	N/A
Strain Rate (inches/min)	.045

New London Sub Base  
Groton, CT

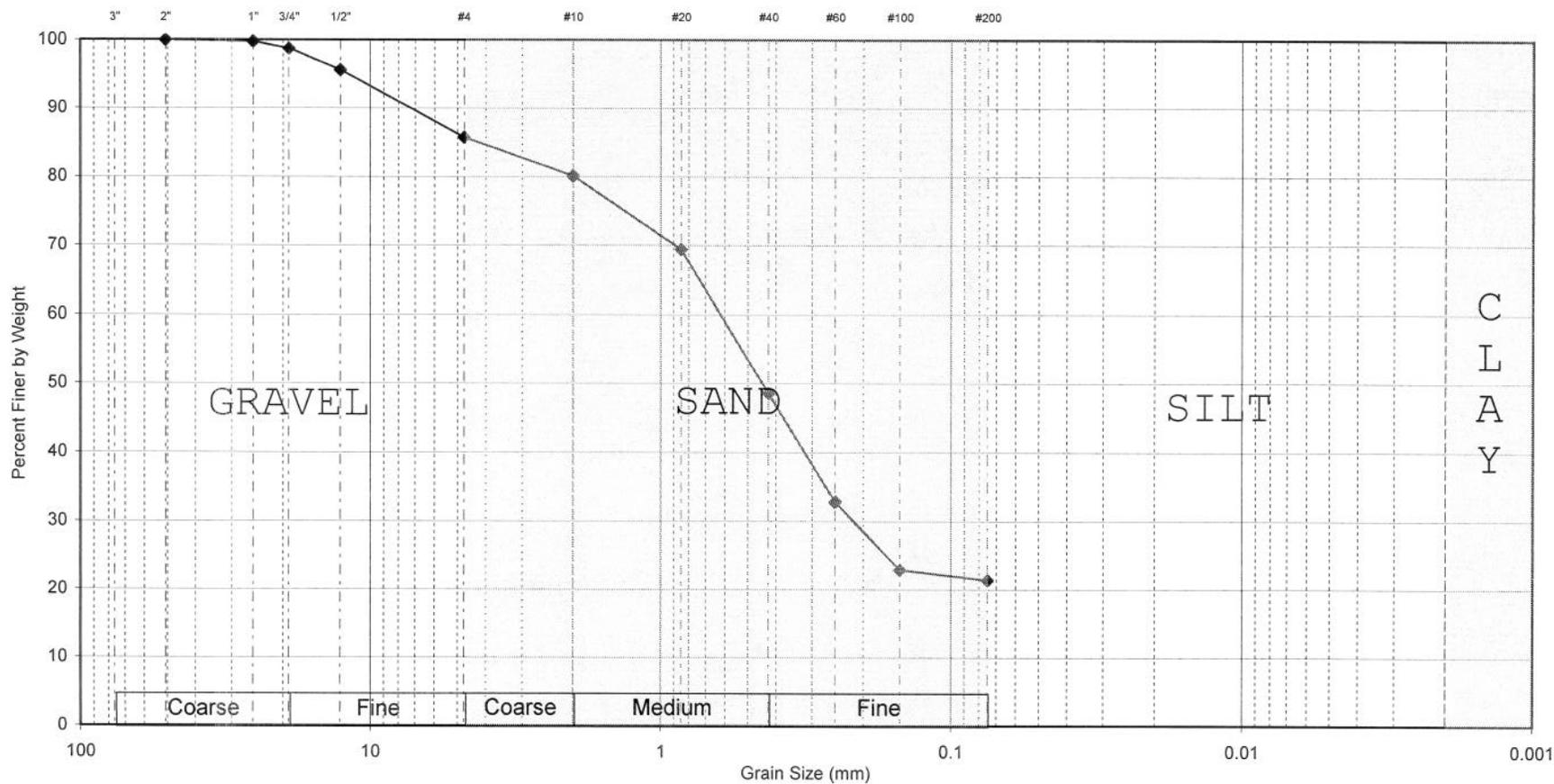
## STRESS - PENETRATION CURVES (CBR)

Tech: MST      Date: 11/7/08

Reviewer:MBP      File No:32608.00

GZA GeoEnvironmental, Inc.  
Engineers and Scientists

### U.S. STANDARD SIEVE AND HYDROMETER



Gravel  
14.3%

Sand  
64.3%

Fines  
21.4%

Lab #	Exploration	Sample	Depth	Description	WC	LL	PL	PI
9	S-102	Auger Cuttings	3'	Brown f-m SAND, some Silt, little fine Gravel				



New London Sub Base  
 Groton, CT  
 GZA File # 32608.02  
 Tested by: PEC Date: 11/4/08  
 Reviewed by: MBP Date: 11/5/08

# ASTM D-1557 MODIFIED COMPACTION TEST

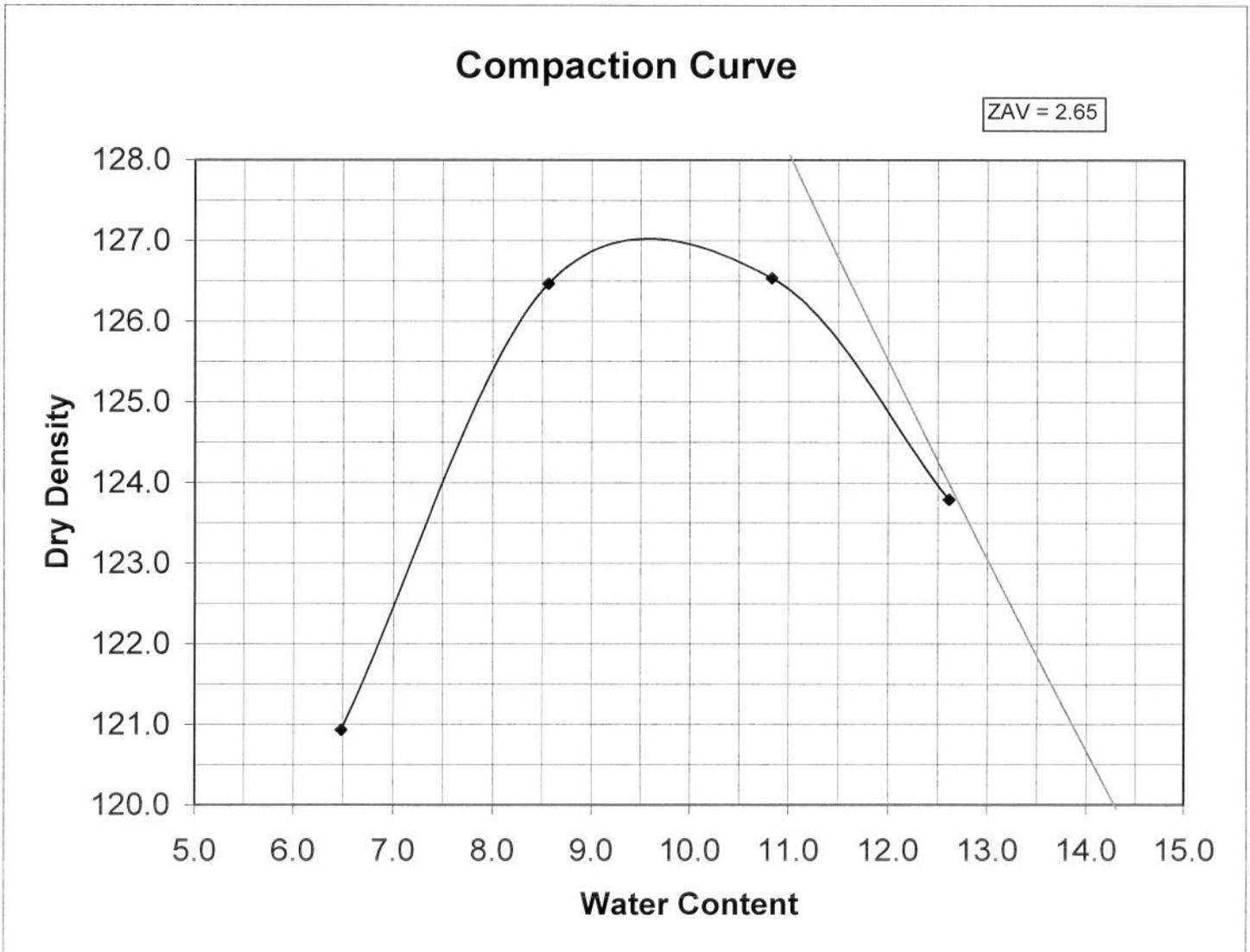
Project New London Sub Base  
Location Groton, CT

File Number 32608.08  
Test Number MC 9  
Boring S-102  
Depth 3'

Date 11/4/08  
Technician PEC  
Reviewer MBP  
Sample Auger Cuttings

Soil Description Brown f-m SAND, some Silt, little fine Gravel

Optimum Water Content % 9.5      Maximum Dry Unit Weight (pcf) 127.0  
Method A

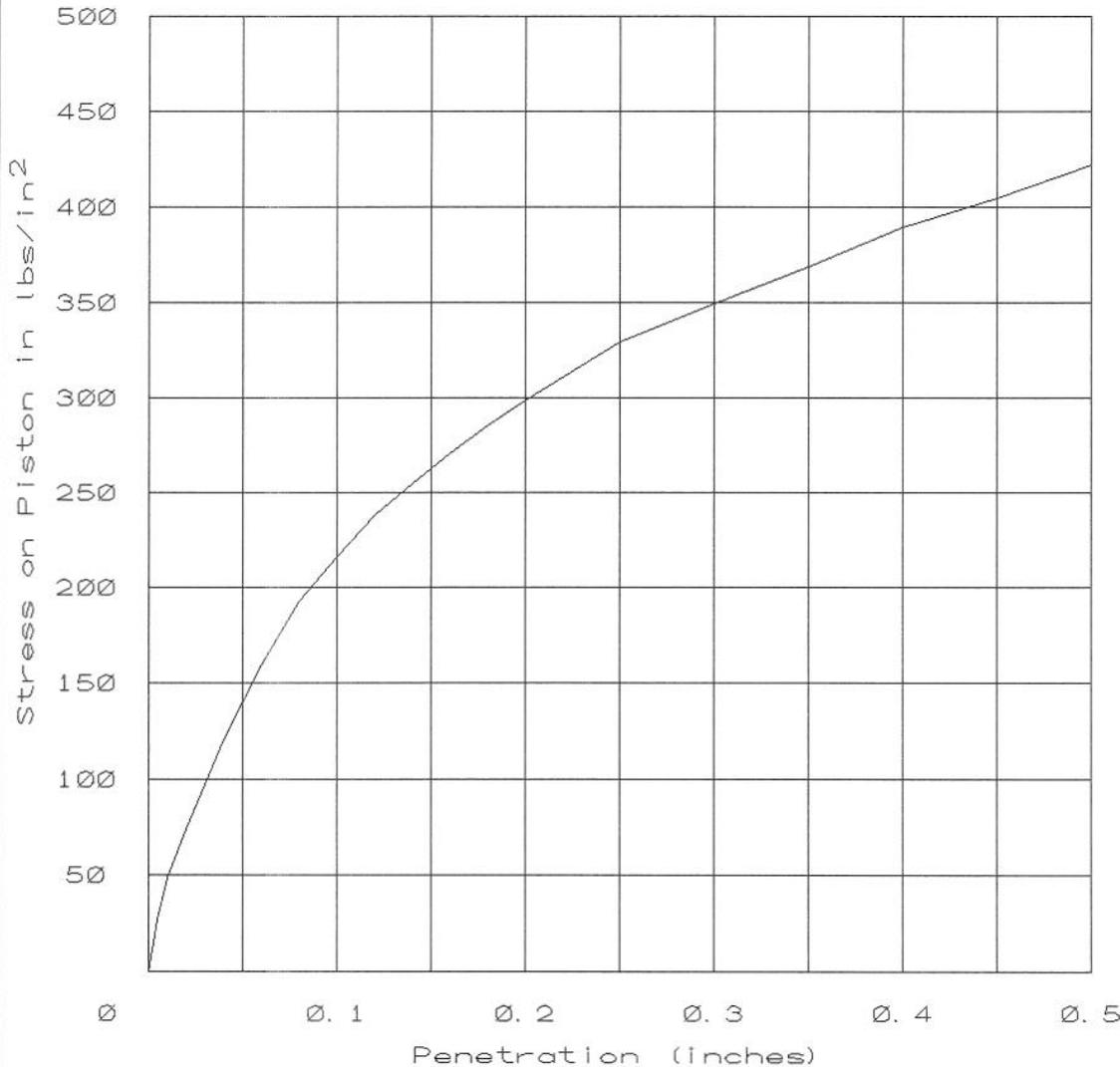


Soil Description: Brown f-m SAND

some Silt, little fine Gravel

CBR @ 0.1" = 21.6

CBR @ 0.2" = 19.9



Test Number	9
Exploration No	S-102
Depth (ft)	3'
Initial Moisture Content (%)	9.5
Initial Dry Unit Weight (PCF)	120.6
Sample Condition	SOAKED
Swell (%)	.008
Final Moisture (%) Top 1 Inch	13.6
Final Average Moisture (%)	11.5
Liquid Limit (%)	N/A
Plastic Limit (%)	N/A
Strain Rate (inches/min)	.045

New London Sub Base  
Groton, CT

## STRESS - PENETRATION CURVES (CBR)

Tech: MST

Date: 11/7/08

Reviewer:MBP

File No:32608.08

GZA GeoEnvironmental, Inc.  
Engineers and Scientists

**APPENDIX D**  
**LIQUEFACTION CALCULATIONS**

## LIQUEFACTION CALCULATIONS (Borings B-13 (OW) and B-15)

### New London Submarine Base

by J. Marsland on 11/4/08

From NCEER 1997

$(N_1)_{60} = N_m C_N C_E C_B C_R C_S$			
CE	1.0	(Safety Hammer)	
CB	1.0		
CS	1.1	sampler without liner	

$(N_1)_{60} - CS = \text{Alpha} + \text{Beta} * (N_1)_{60}$	
where	
Alpha = 0	for FC <= 5%
Alpha = $\exp[1.76 - (190/FC^2)]$	for 5% < FC < 35%
Alpha = 5.0	for FC >= 35%
Beta = 1.0	for FC <= 5%
Beta = $[0.99 + (FC1.5/1000)]$	for 5% < FC < 35%
Beta = 1.2	for FC >= 35%

$CRR_{7.5} = \frac{1}{1/(34 \cdot (N_1)_{60}) + (N_1)_{60}/135 + 50/(10 \cdot (N_1)_{60} + 45)^2} - 1/200$	
--	--

$CRR_{6.5} = CRR_{7.5} * 10^{2.24/M^{2.56}}$	
where	M = 6.5 (for Massachusetts)

$\gamma t$  (pcf) = 115.0  
Groundwater depth = 8.5 feet (approximate for borings)

#### Capacity - B-13 (OW)

Depth (ft)	N	$\sigma'_{vo}$ (psf)	CN	Cr	$(N_1)_{60}$	Silt Content	Alpha	Beta	$(N_1)_{60} - CS$	$CRR_{7.5}$	CAPACITY $CRR_{6.5}$	DEMAND CSR	FS Liq	Volumetric Strain (%)	Change in Settlement (in)	Total Settlement (in)
0																0.18
1.0	27	115.0	1.7000	0.75	37.9	19	3.45	1.07	44.1	0.5000	0.7210	0.0910	NA	0.00	0.00	0.18
5.0	22	575.0	1.7000	0.75	30.9	13	1.72	1.03	33.6	0.5000	0.7210	0.0901	NA	0.00	0.00	0.18
10.0	10	1056.4	1.4061	0.80	12.4	13	1.72	1.03	14.5	0.1553	0.2239	0.0970	2.31	0.00	0.00	0.18
15.0	14	1319.4	1.2581	0.85	16.5	12.5	1.72	1.03	18.8	0.2004	0.2890	0.1152	2.51	0.00	0.00	0.18
20.0	5	1582.4	1.1488	0.95	6.0	28.8	4.62	1.14	11.5	0.1265	0.1824	0.1266	1.44	0.30	0.18	0.18
25.0	10	1845.4	1.0638	0.95	11.1	47	5.00	1.20	18.3	0.1957	0.2821	0.1335	2.11	0.00	0.00	0.00

$\gamma t$  (pcf) = 115.0  
Groundwater depth = 8.5 feet

#### Capacity - B-15

Depth (ft)	N	$\sigma'_{vo}$ (psf)	CN	Cr	$(N_1)_{60}$	Silt Content	Alpha	Beta	$(N_1)_{60} - CS$	$CRR_{7.5}$	CAPACITY $CRR_{6.5}$	DEMAND CSR	FS Liq	Volumetric Strain (%)	Change in Settlement (in)	Total Settlement (in)
0																0.36
1.0	20	115.0	1.700	0.75	28.1	19	3.45	1.07	33.6	0.5000	0.7210	0.0910	NA	0.00	0.00	0.36
5.0	37	575.0	1.700	0.75	51.9	13	1.72	1.03	55.4	0.5000	0.7210	0.0901	NA	0.00	0.00	0.36
10.0	22	1056.4	1.406	0.80	27.2	13	1.72	1.03	29.9	0.4591	0.6620	0.0970	6.83	0.00	0.00	0.36
15.0	5	1319.4	1.258	0.85	5.9	12.5	1.72	1.03	7.8	0.0943	0.1360	0.1152	1.18	0.60	0.36	0.36
20.0	9	1582.4	1.149	0.95	10.8	28.8	4.62	1.14	17.0	0.1807	0.2606	0.1266	2.06	0.00	0.00	0.00
25.0	18	1845.4	1.064	0.95	20.0	47	5.00	1.20	29.0	0.4109	0.5924	0.1335	4.44	0.00	0.00	0.00

$\gamma t$  (pcf) = 115.0  
Groundwater depth = 8.5 feet

- Blue font indicates laboratory tested for silt content, all other silt contents were estimated to the nearest 5 %.
- CSR values on this sheet were obtained from the attached CSR Calculation table. They need to be modified if the spreadsheet is altered.
- Manual input using attached chart prepared by Ishihara.
- Data Not Applicable - Above the GW Table

**APPENDIX E**  
PAVEMENT DESIGN



**GZA GeoEnvironmental, Inc.**  
 530 Broadway  
 Providence, Rhode Island 02909  
 (401) 421-4140

Project No. 32608.08  
 Project Name: New Commissary NSBNL  
 Location: Groton, CT

November 2008  
 Sheet 1 of 3  
 By: JJM  
 Checked By: DLD

**Problem:** Pavement design for the New Commissary Naval Submarine Base New London, Groton, CT.

- References:**
- 1.) "AASHTO Guide for Design of Pavement Structures", 1993, Chapter 4.
  - 2.) "Standard Handbook for Civil Engineering", Third ed., Merrit, 1983, p.16-52.
  - 3.) "Soils Manual for Design of Asphalt Pavement Structures", The Asphalt Institute, 2nd ed., 1963.

**Parameters:**

**Assumed Design Criteria:**

	<u>Standard Duty Pavement</u>	<u>Heavy Duty Pavement</u>
	<u>Parking Area Pavement</u>	<u>Roadway Pavement</u>
Design Life:	20 years	20 years
18-Kip ESAL:	50 , 000	300 , 000
Serviceability:	3.0	3.0
Reliability:	85%	85%



GZA GeoEnvironmental,  
 Inc.  
 140 Broadway  
 Providence, Rhode Island 02903  
 (401) 421-4140

Project No. 32608.08  
 Project Name: Naval Sub Base New London  
 Location: Groton, CT  
 November 2008  
 Sheet 2 of 3  
 By: JJM  
 Checked By: DLD

**Design:**

**AASHTO Guide for Pavement Structures: "Low Volume Road Design", Part II, Chapter 4**

In order to account for seasonal effects (Freeze/Thaw) without test road data and to account for low volumes, use assumed data:

- a. Climatic Region II, Wet, freeze-thaw cycle (Figure 4.1)
- b. Roadbed soil quality:

Roadbed soil quality esimated to be "Fair" (AASHTO Part II, Section 4.2.2).

Resilent Modulus:  $M_r := 4500$  psi (Table 4.3)

- c. Recommended Structural Numbers based on above data, for a reliability of 85%. (Based upon 75% reliabilty, from Table).

Standard Duty:  $SN_s := 2.4$  (Table 4.7)

Heavy Duty:  $SN_h := 2.9$

- d. Layer Coefficients:

Asphalt Plant Mix:  $a_{surf} := 0.44$  (estimated from " Standard Handbook for Civil

Sand and Gravel Base Course:  $a_b := 0.07$  Engineering")

Granular Fill Subbase:  $a_{sub} := 0.05$

**Determine Subbase Thickness Based on "Flexible Pavement Design Catalog":**

Standard Duty Pavement

Recommended asphalt thickness:  $D_{surf} := 3.5$  inches

Recommended base course thickness:  $D_b := 6$  inches

$$SN := a_{surf} \cdot D_{surf} + a_b \cdot D_b + a_{sub} \cdot D_{sub}$$



GZA GeoEnvironmental,  
Inc.

140 Broadway  
Providence, Rhode Island 02903  
(401) 421-4140

Project No. 32608.08  
Project Name: Naval Sub Base New London  
Location: Groton, CT

October 2008  
Sheet 3 of 3  
By: JJM  
Checked By: DLD

$$D_{\text{sub}} := \frac{SN_s - a_{\text{surf}} \cdot D_{\text{surf}} - a_b \cdot D_b}{a_{\text{sub}}}$$

$$D_{\text{sub}} = 8.8 \quad \text{inches}$$

Recommend round to 10 inches

#### Heavy Duty Pavement

Recommended asphalt thickness:  $D_{\text{surf}} := 4.0 \quad \text{inches}$

Recommended base course thickness:  $D_b := 6 \quad \text{inches}$

$$SN := a_{\text{surf}} \cdot D_{\text{surf}} + a_b \cdot D_b + a_{\text{sub}} \cdot D_{\text{sub}}$$

$$D_{\text{sub}} := \frac{SN_h - a_{\text{surf}} \cdot D_{\text{surf}} - a_b \cdot D_b}{a_{\text{sub}}}$$

$$D_{\text{sub}} = 14 \quad \text{inches}$$

#### Recommendations:

For standard duty pavement areas use 3.5" pavement (1-1/2" finish course and 2" binder course), and 6" "Sand-Gravel" base course, and 10-inch "Granular Fill" subbase. For heavy duty pavement, use 4" pavement (1-1/2" finish course and 2-1/2" finish course), 6" "Sand-Gravel" base course, and 14 inch "Granular Fill" subbase.