GEOTECHNICAL DESIGN REPORT
ROUTES 173/220 INTERSECTION IMPROVEMENTS
MAINEDOT WIN 17888.00
LIBERTY, MAINE

by

Haley & Aldrich, Inc.
Portland, Maine

for

Maine Department of Transportation
Augusta, Maine

File No. 38170-020
3 September 2013

HALEY & ALDRICH

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3 September 2013
File No. 38170-020

Maine Department of Transportation
16 State House Station
Augusta, Maine 04333-0016

Attention: Kitty Breskin, P.E.
Senior Geotechnical Engineer

Subject: Geotechnical Design Report
Routes 173/220 Intersection Improvements
MaineDOT WIN 17888.00
Liberty, Maine

Ladies and Gentlemen:

We are pleased to submit herewith our report titled, "Geotechnical Design Report, Routes 173/220 Intersection Improvements, MaineDOT WIN 17888.00, Liberty, Maine," prepared in accordance with our proposal, dated 7 August 2013 and with the provisions of our GCA Agreement with the Maine Department of Transportation (MaineDOT), No. 20110614000000006492.

This Geotechnical Design Report (GDR) is a compilation of the results of the subsurface investigation and geotechnical laboratory testing programs previously completed by MaineDOT. The GDR also presents the results of geotechnical engineering evaluations and design recommendations completed and developed by Haley & Aldrich, Inc. (Haley & Aldrich).

Thank you for allowing us the opportunity to help support MaineDOT on this unique project. We look forward to providing continued assistance to MaineDOT during the bidding and construction phases of the project.

PROJECT BACKGROUND

The intersection of Routes 173 and 220 (Pinnacle Road) is located approximately 1 mile southeast of Route 3 in Liberty, Maine (Town) as shown on Figure 1, Project Locus. The terminus of Route 220 is located on an existing dam (Dam), which was constructed circa 1820. The upstream and downstream sides of the Dam consist of near vertical, dry-laid block retaining walls, which are generally coincident with the edges of Route 220. Water passes through the Dam via a 6-ft diameter corrugated metal pipe (CMP) that is approximately 8-ft long. The CMP transitions to an approximate 4-ft wide by 6-ft tall, dry-laid block opening (box culvert), extending approximately 30 ft to the outlet (east side of Route 220). We understand the invert elevation of the CMP/box culvert is El. 502.2 (upstream) and El. 501.2 (downstream). The Dam is owned and operated by the Town of Liberty (Town) and is primarily used to maintain the water level in St. George Lake and Little Pond for recreational purposes and also serves as the headwaters of the St. George River.

Based on discussions with you, it is our understanding that the existing intersection lacks a sufficiently large turning radius, which has been problematic for commercial tractor trailers turning onto either Route 173 or 220. We understand that the "tight" turning radius results in the need for making multi-point turns, which is considered a safety concern. As a result, MaineDOT is currently planning to improve the intersection by widening portions of Routes 173 (to the south) and 220 (to the west) to more safely accommodate larger-sized vehicles. Widening of the roadways will result in filling a portion of Little Pond and will also require that the existing CMP/box culvert be extended. The vertical profile for the new roadway will roughly match the profile of the existing roadway.

We previously developed preliminary-level concepts and construction cost estimates for widening the roadways and extending the inlet/outlet infrastructure for the dam. The concepts that were evaluated for overall technical feasibility and cost consisted of the following: an earth embankment (Alternative No. 1), a Mechanically Stabilized Earth Wall (Alternative No. 2) and a Drilled-In King Pile System (Alternative No. 3). The concepts were presented at a team meeting on 7 January 2013 and documented in a Preliminary Geotechnical Design Report (PGDR) submitted to MaineDOT, dated 11 February 2013. Based on our discussions with you, it is our understanding that MaineDOT has decided to advance the earth embankment alternative into final design as it was technically feasible, easily permitted and would likely be the least expensive to design and construct.

ELEVATION DATUM AND PROJECT STATIONING

The project elevation datum and elevations referenced herein are in feet and reference the North American Vertical Datum of 1988 (NAVD 88).

Two baselines were developed by MaineDOT along existing (Route 173) and proposed (Route 220) roadway alignments as summarized below.

- Route 173: 20-series stationing (Sta. 20+00)
- Route 220: 50-series stationing (Sta. 50+00)

SUBSURFACE INVESTIGATION PROGRAMS

MaineDOT conducted preliminary (September 2011) and design phase (November 2011) subsurface investigation programs at the site. In addition, a geophysical survey was conducted at the site in August 2011. In total, eleven test borings were drilled along the existing and proposed roadway alignments in order to identify general subsurface soil, rock and groundwater conditions. "As-drilled" locations of the preliminary and design phase test borings are shown on Figure 2, Site and Subsurface Exploration Location Plan. Logs detailing subsurface conditions encountered in the test borings are provided in Appendix A. Each exploration program is discussed separately, in the following sections of this report.

Please note that the preliminary and design phase subsurface investigation programs were monitored in the field by MaineDOT. As a result, the details of each exploration program provided below have been interpreted by Haley & Aldrich based on information provided by MaineDOT.

Geophysical Survey

A geophysical survey was conducted at the site by Hager-Richter Geoscience, Inc. (Hager-Richter) of Salem, New Hampshire on 29 August 2011. The geophysical survey was conducted using multi-channel analysis of surface waves (MASW) and ground penetrating radar (GPR). MASW data was collected along two traverses located along Route 220 to determine the plan limits of the Dam. A report summarizing the results of the survey is provided for reference in Appendix B.

Preliminary Phase Investigation

A total of five test borings, designated HB-LIB-101 through HB-LIB-104, and one power auger probe were drilled along the existing Route 173 and 220 roadway alignments. "As-drilled" test boring locations and ground surface elevations were determined in the field by MaineDOT using GPS survey equipment.

Test borings were drilled by the MaineDOT drill crew using a truck-mounted CME 45C drill rig. Test borings were drilled to depths ranging from approximately 7 to 22 ft below ground surface (BGS) using 3.0-in. (NW-size) inside diameter (ID) steel casing, 2.5-in ID hollow stem augers (HSAs) or solid stem augers (SSAs). Soil samples were generally collected at standard 5-ft increments by driving a 1-3/8-in. ID split-spoon sampler with a 140-lb hammer dropped from a height of 30 in., using a calibrated automatic hammer.

The number of hammer blows required to advance the sampler through each 6-in. interval was recorded and is provided on the test boring logs. The uncorrected SPT N-value is defined as the total number of blows required to advance the sampler through the middle 12 in. of the 24-in. sampling interval (blows per foot, bpf). The energy-corrected SPT N-value (N_{60}) is equal to the uncorrected N-value multiplied by the hammer efficiency factor divided by 0.84 (i.e., 84 percent theoretical hammer efficiency).

Test borings HB-LIB-102 and HB-LIB-104 were terminated at depths of approximately 7 and 15 ft BGS, respectively, after encountering apparent obstructions.

Two test borings, HB-LIB-102A and HB-LIB-103, were drilled approximately 5 ft into bedrock using a 2.0-in. (NQ-size) ID diamond-tipped core barrel.

All test borings were backfilled with drill cutting upon completion with the exception of test borings HB-LIB-102A and HB-LIB-104, which were backfilled with cement/bentonite grout. Test borings drilled within paved areas were sealed at the ground surface with cold patch.

Design Phase Investigation

A total of five test borings, designated HB-LIB-201 through HB-LIB-205, were drilled near the edge of the proposed widened roadway and within the limits of Little Pond. "As-drilled" test boring locations and ground surface elevations were determined in the field by MaineDOT using GPS survey equipment.

Test borings were drilled by Maine Test Borings of Hermon, Maine using a skid-mounted CME 45C drill rig placed on a spud-barge. Test borings were drilled to depths ranging from approximately 7 to 24 ft BGS using 3.0-in. (NW-size) inside diameter (ID) steel casing or SSAs. Soil samples were generally collected at similar depth intervals and using the same means/methods as were used by MaineDOT for the preliminary phase investigation with the exception that the split-spoon sampler was advanced using a standard rope and cathead and safety hammer. Soil samples were not collected in test borings drilled with SSAs (HB-LIB-202 through HB-LIB-204).

Test borings HB-LIB-202 through HB-LIB-204 were drilled to refusal on probable bedrock. In addition, test borings HB-LIB-201 and HB-LIB-205 were advanced approximately 4.5 to 5 ft into bedrock using a 2.0-in. (NQ-size) ID diamond-tipped core barrel.

GENERALIZED SUBSURFACE CONDITIONS

Subsurface soil, bedrock and groundwater conditions encountered in subsurface explorations are described in the following sections of this report. Please recall that the subsurface explorations and conditions were monitored and documented in the field by MaineDOT. The summary provided below is based on the conditions documented by MaineDOT, as shown on the test boring logs, and provided to Haley & Aldrich.

Soil and Bedrock Conditions

A. Soil Overburden

Test borings drilled within the existing roadways (-100 series test borings) encountered 6 to 9 in. of bituminous concrete at the existing ground surface. Underlying the surficial bituminous concrete layer and in test borings where the entire soil overburden was penetrated (test borings HB-LIB-101, HB-LIB-102A, HB-LIB-103 and the power auger probe), the thickness ranged from approximate 8 to 33 ft. In general, the overburden soil consisted of SAND with varying amounts of silt and gravel and GRAVEL with varying amounts of silt and sand. Some portions of the overburden soil encountered within the existing roadways contained cobbles/boulders and layers of wood.

Outside the limits of the existing roadways (-200 series test borings) and within the limits of Little Pond, approximately 4 to 7 ft of very soft sandy SILT was encountered at mudline. These “lake bottom sediments” were likely deposited more recently as material transported by the lake water settled out of suspension. Please note that the thickness of the lake bottom sediments was estimated by comparing the bathymetry/topographic data and the surveyed ground surface at the test boring locations. As discussed with MaineDOT, it is our opinion that the difference in vertical distance between the bathymetry/topography and the surveyed ground surface represents the minimum thickness of the lake bottom sediments. An additional 3 ft was added to these differences to estimate the total sediment thickness based on the documented conditions encountered in in test boring HB-LIB-201. Approximately 4 to 17 ft of medium dense to dense SAND with varying amounts of silt and gravel was encountered beneath the lake bottom sediments and directly overlying bedrock.

B. Bedrock

As discussed previously, bedrock was encountered and sampled in test borings HB-LIB-102A, HB-LIB-103, HB-LIB-201 and HB-LIB-204 at depths ranging from approximately 12 to 34 ft BGS. In addition, refusal surfaces were encountered in test borings HB-LIB-101 and HB-LIB-202 through HB-LIB-204 at depths ranging from approximately 7 to 21 ft BGS. In general, the bedrock surface slopes down from north (Sta. 56+30) to south (approximately Sta. 55+25) before sloping up again to the south. The sampled bedrock generally consists of medium gray, fine-grained PHYLLITE. Primary joints were oriented at moderately steep to steep angles and joints were tight with some rust staining. A relatively thin layer of weathered bedrock, measuring between 3 in. and 1 ft (approximate), was encountered in test borings HB-LIB-201 through HB-LIB-204.

Rock quality designation (RQD) is a common parameter that is used to help assess the competency of sampled bedrock. RQD is defined as the sum of pieces of recovered bedrock greater than 4 in. in length divided by the total length of the core run. RQD values for bedrock encountered at the site ranged from 35 to 93 percent.

Groundwater Conditions

As discussed previously, the Dam is primarily used to maintain the water level in St. George Lake and Little Pond for recreational purposes and also serves as the headwaters of the St. George River. The lake levels are maintained/controlled using a manual screw stem sluice gate and an overflow spillway.

The outlet structures are operated based on the Maine Department of Environmental Protection (MDEP) water level order established in 1997. Based on our review of MDEP documents, it is our understanding that the normal summer and winter pool elevations are within approximately 6 in. (El. 507.4) and 2 ft (El. 505.9) of the spillway crest, respectively. It is also our understanding that passage of water from the lake to the river must be maintained at all times during construction.

LABORATORY TESTING PROGRAM

A geotechnical laboratory testing program was undertaken by MaineDOT on representative soil samples collected during the field investigations to assist in soil classification and determine engineering soil properties needed for design. In general, laboratory testing was performed on disturbed soil samples collected during SPT sampling. Laboratory testing was performed in accordance with applicable American Society for Testing Materials (ASTM) testing procedures. All laboratory soil testing was performed by the MaineDOT Materials Testing and Exploration Central Laboratory in Bangor, Maine in accordance with applicable American Society for Testing Material (ASTM) testing procedures.

The testing program consisted of six grain size analyses and six natural water content tests. A summary of laboratory test results on these samples is provided below.

- Soil Classification: ML, SM
- Natural Water Content: 10.9 to 35.4%

Results of individual laboratory tests are provided on the test boring logs included in Appendix A and on the individual laboratory test summary sheets provided for reference in Appendix C.

GEOTECHNICAL EVALUATIONS AND DESIGN RECOMMENDATIONS

Geotechnical design recommendations for the subject project, as discussed and provided herein are based, in part, on the subsurface conditions encountered in the explorations completed during the preliminary and design phase subsurface exploration programs. Variations in subsurface conditions are likely to exist between explorations and across the site. Our evaluations are based on the assumption that subsurface conditions are somewhat uniform in these areas and similar to those encountered in the test borings.

Results of our geotechnical evaluations and resulting design recommendations are provided in the following sections of this report.

Embankment Fill Areas

Based on our review of proposed grading information provided by MaineDOT, the widened portion of the roadway, outside the limits of the existing roadway (upstream side), will require filling to meet proposed grades. More specifically, fill heights up to approximately 15 ft (maximum) will be required.

The technical and economic feasibility as well as associated environmental and permitting impacts of three types of systems to facilitate construction of the proposed widened intersection were evaluated during preliminary design. Each system is summarized below.

- Alternative No. 1: A “self-compacting” stone (placed below lake level) and earthfill (placed above lake level) embankment
- Alternative No. 2: A “top-down” type of permanent, vertical-sided retaining wall system (e.g., soldier pile/lagging wall, steel sheeting, vinyl sheeting, king piles, etc.)
- Alternative No. 3: A “bottom-up” type of permanent, vertical-sided retaining wall system (e.g., modular block gravity wall, cast-in-place gravity wall, MSE wall, etc.)

Based on the results of our preliminary evaluations, associated cost estimates and the assessment of environmental/permitting impacts, MaineDOT elected to advance Alternative No. 1 (earth embankment) into final design as it was technically feasible, will likely be the least expensive to design and construct, and could be permitted from an environmental standpoint. We evaluated the technical feasibility of constructing a stone/earthfill embankment. External stability modes of failure (i.e., global stability, settlement, bearing capacity) were evaluated and factors of safety for each were found to be acceptable. Specific design details for the earth embankment are provided below.

- Plain Riprap, meeting the requirements of MaineDOT Standard Specification 703.26, extending from mudline up to El. 510 (approximately 2.5 ft above the spillway maintained water level).

- Placement of a heavy separation fabric such as Mirafi 500X and meeting the requirements of MaineDOT Standard Specification 722.04, over the top of the plain riprap embankment fill

prior to additional fill placement. We recommend that the surface of the plain riprap fill be choked off with soil/rock (e.g., ¾-in. crushed stone) such that the surface is level prior to placement of the separation fabric in order to protect the fabric from being punctured or damaged during installation and subsequent fill placement.

- Placement of Gravel Borrow, meeting the requirements of MaineDOT Standard Specification 703.20, from El. 510 (top of plain riprap) up to the subgrade elevation (variable along the length of the alignment).

- Placement of subbase and base course materials and bituminous concrete surface course.

Embankment/Culvert Settlement

As discussed previously, approximately 4 to 7 ft of very soft sandy SILT lake bottom sediments were encountered in test borings drilled outside the limits and on the upstream side of the existing roadway. We anticipate that up to approximately 5 ft of this material could be displaced or consolidate during placement of embankment fill materials. As a result, we recommend that MaineDOT base the plain riprap quantity estimate on the assumption that approximately 5 ft of material displacement and/or consolidation will occur.

In addition, we recommend that the proposed culvert extension be supported on a minimum 5-ft thick Plain Riprap fill pad (fill pad), after the excavation and removal of the in-situ soil. We recommend that all "muck" soil be removed from within the zone of influence (ZOI) beneath the proposed culvert extension to a depth of at least 5 ft below the existing mudline level. For the purposes of this report, the ZOI is defined as the area below the culvert and below imaginary lines that extend 1 ft laterally beyond the culvert outer bottom edges and down on a one horizontal to one vertical (1H:1V) slope for a minimum vertical distance of 5 ft, as shown in Figures 3 and 4. If during excavation the thickness of the lake bottom sediments is found to be less than 5 ft, the full 5-ft over-excavation depth would not be required. If the sediments are found to be thicker than 5 ft, over-excavation should continue until the sediments are completely removed from within the ZOI of the culvert.

CONSTRUCTION CONSIDERATIONS

Excavation

Excavation will be required for general site grading and for general construction of various interchange improvements, including the replacement of the corrugated metal culvert. We anticipate that excavation of the in-situ soils can be accomplished using normal earth-excavating equipment. We anticipate that excavations may be made using sloped-open cut techniques. We recommended that the Contractor be responsible for the design, stability and safety of all excavations in accordance with local, state and federal regulations.

LIMITATIONS OF RECOMMENDATIONS

This report is prepared for the exclusive use of MaineDOT relative to the subject project. There are no intended beneficiaries other than MaineDOT. Haley & Aldrich shall owe no duty whatsoever to any other person or entity on account of the Agreement or the report. Use of this report by any person or entity other than MaineDOT for any purpose whatsoever is expressly forbidden unless such other person or entity obtains written authorization from MaineDOT and from Haley & Aldrich indicating that the Report is adequate for such other use. Use of this report by such other person or entity without the written authorization of MaineDOT and Haley & Aldrich shall be at such other person's or entities sole risk, and shall be without legal exposure or liability to Haley & Aldrich.

The analyses and recommendations are based, in part, upon the data obtained from the referenced subsurface explorations. The nature and extent of variations between explorations may not become evident until construction. If variations then appear, it may be necessary to reevaluate the recommendations of this report.

We appreciate the opportunity to provide geotechnical consulting services on this project. Please do not hesitate to call if you have any questions or comments.

Sincerely yours,
HALEY & ALDRICH, INC.

Bryan C. Steinert, P.E.
Senior Geotechnical Engineer

Wayne A. Chadbourne, P.E.
Lead Geotechnical Engineer/Vice President

STATE OF MAINE
WAYNE A. CHADBOURNE
No. 10620
LICENSED
PROFESSIONAL ENGINEER

Enclosures:

Figure 1 -	Project Locus
Figure 2 -	Site and Subsurface Exploration Location Plan
Figure 3 -	Cross Section through End of Box Culvert Extension
Figure 4 -	Profile along Centerline of Box Culvert Extension
Appendix A -	Test Boring Logs
Appendix B -	Hager-Richter Geoscience, Inc. Report entitled, "Geophysical Survey Lake St. George Dam, Liberty, Maine," dated 29 August 2011
Appendix C -	Laboratory Test Results

REFERENCES

1. Report entitled, "Preliminary Geotechnical Design Report, Routes 173/220 Intersection Improvements, MaineDOT WIN 17888.00, Liberty, Maine," prepared by Haley & Aldrich, Inc. for the Maine Department of Transportation, dated 11 February 2013.

2. Memorandum entitled, "Preliminary Concept for Hydraulic Structures at the Route 173/220 Intersection," prepared by Kleinschmidt Associates for Haley & Aldrich, Inc., dated 12 February 2013.

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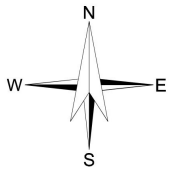
SITE COORDINATES:44°23'43"N 69°18'41"W



U.S.G.S. QUADRANGLE: LIBERTY, ME

HALEY & ALDRICH

WIDENING OF ROUTE 220 AND ROUTE 173 INTERSECTION
PIN 017888.00
LIBERTY, MAINE

PROJECT LOCUS

SCALE: 1:24,000
SEPTEMBER 2011

FIGURE 1

38170-000 1.PDF

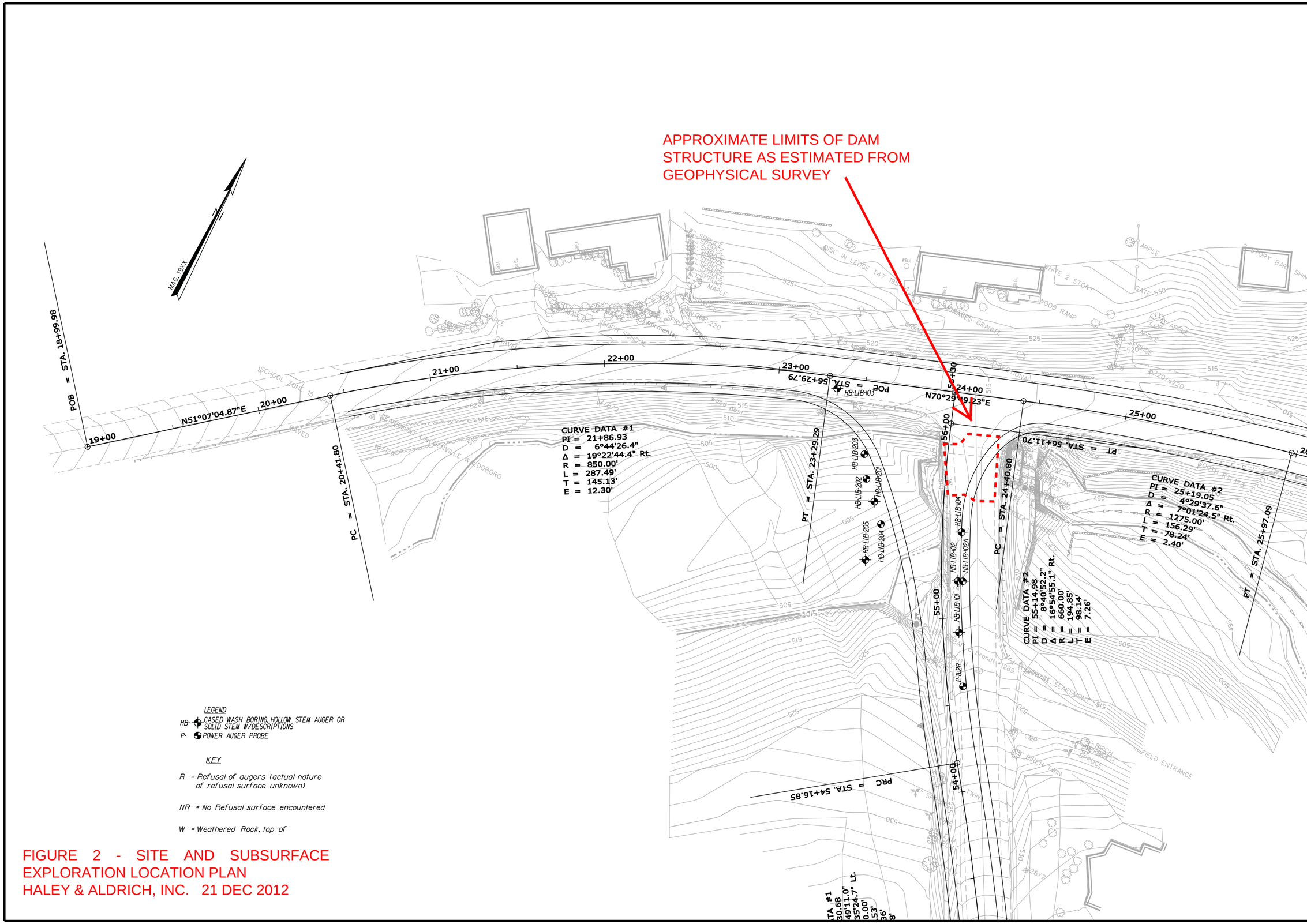


FIGURE 2 - SITE AND SUBSURFACE EXPLORATION LOCATION PLAN
HALEY & ALDRICH, INC. 21 DEC 2012

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

STP-1788(800)X

PIN 17888.00

HIGHWAY PLANS

	BY	DATE
PROJ. MANAGER		
DESIGN-DETAILED	K.BRESKIN	OCT 2011
CHECKED-REVIEWED		
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

LIBERTY
INTERSECTION ROUTES 173/220

GEOPLANS

SHEET NUMBER

1

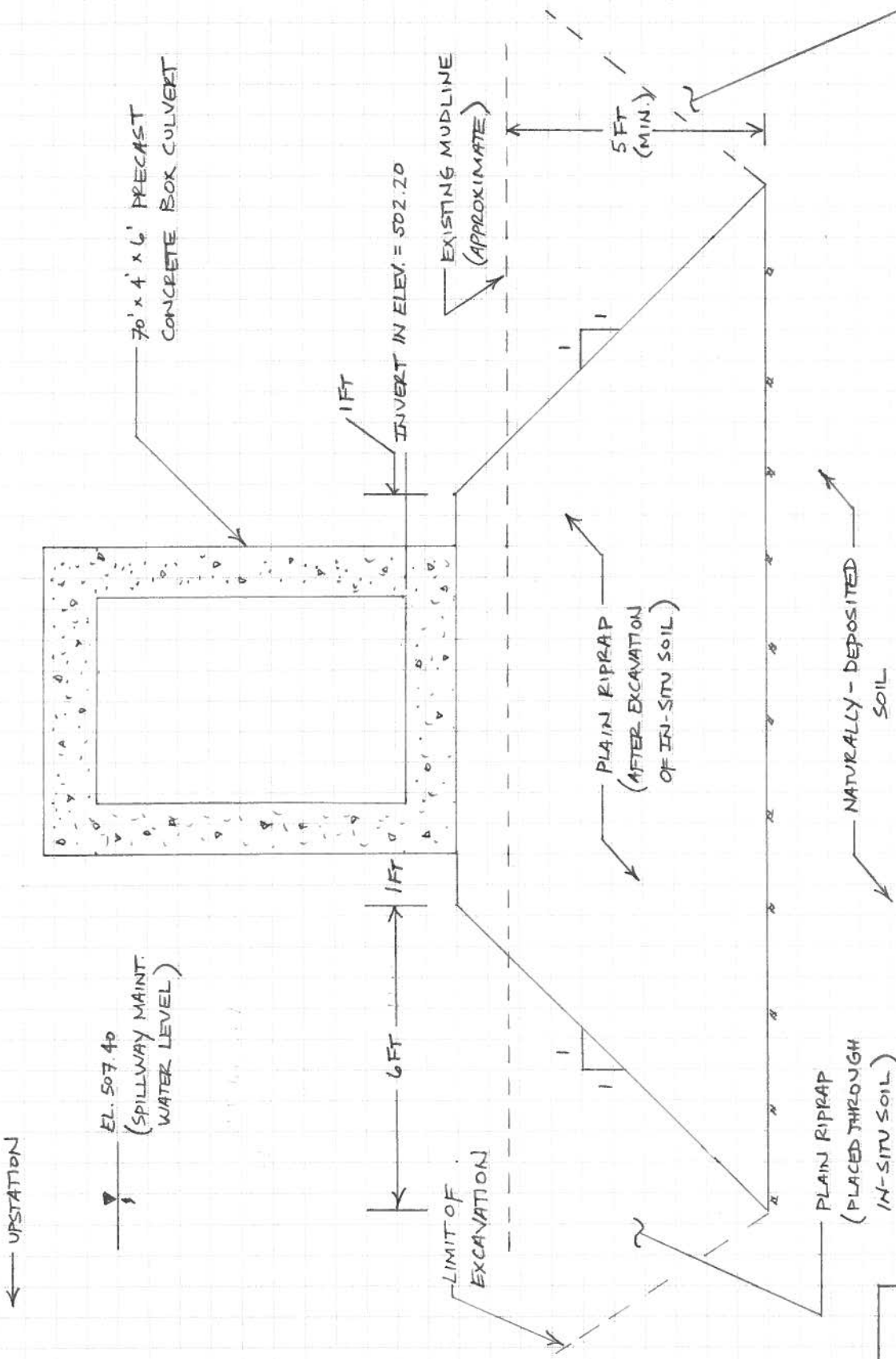
OF 3

Filename: ...\geotech\msta\001_Geoplan1.dgn Division: GEOTECH Username: kitty.breskin Date:12/14/2011

HALEY & ALDRICH

Calculations

Client	MAINEDOT	File No.	38170-020
Project	LIBERTY	Sheet	1 of 1
Subject	CROSS SECTION THROUGH END OF BOX CULVERT EXTENSION	Date	8/21/2013
		Computed By	BCS
		Checked By	MSC



SCALE: N.T.S.

NOTES:

1. IF, DURING EXCAVATION, THE THICKNESS OF LAKE BOTTOM SEDIMENTS IS FOUND TO BE LESS THAN 5 FT, THE FULL 5-FT OVER-EXCAVATION DEPTH MAY NOT BE NEEDED. IF LAKE BOTTOM SEDIMENTS ARE FOUND TO BE THICKER THAN 5 FT, OVER-EXCAVATION WILL CONTINUE UNTIL THE SEDIMENTS ARE COMPLETELY REMOVED.

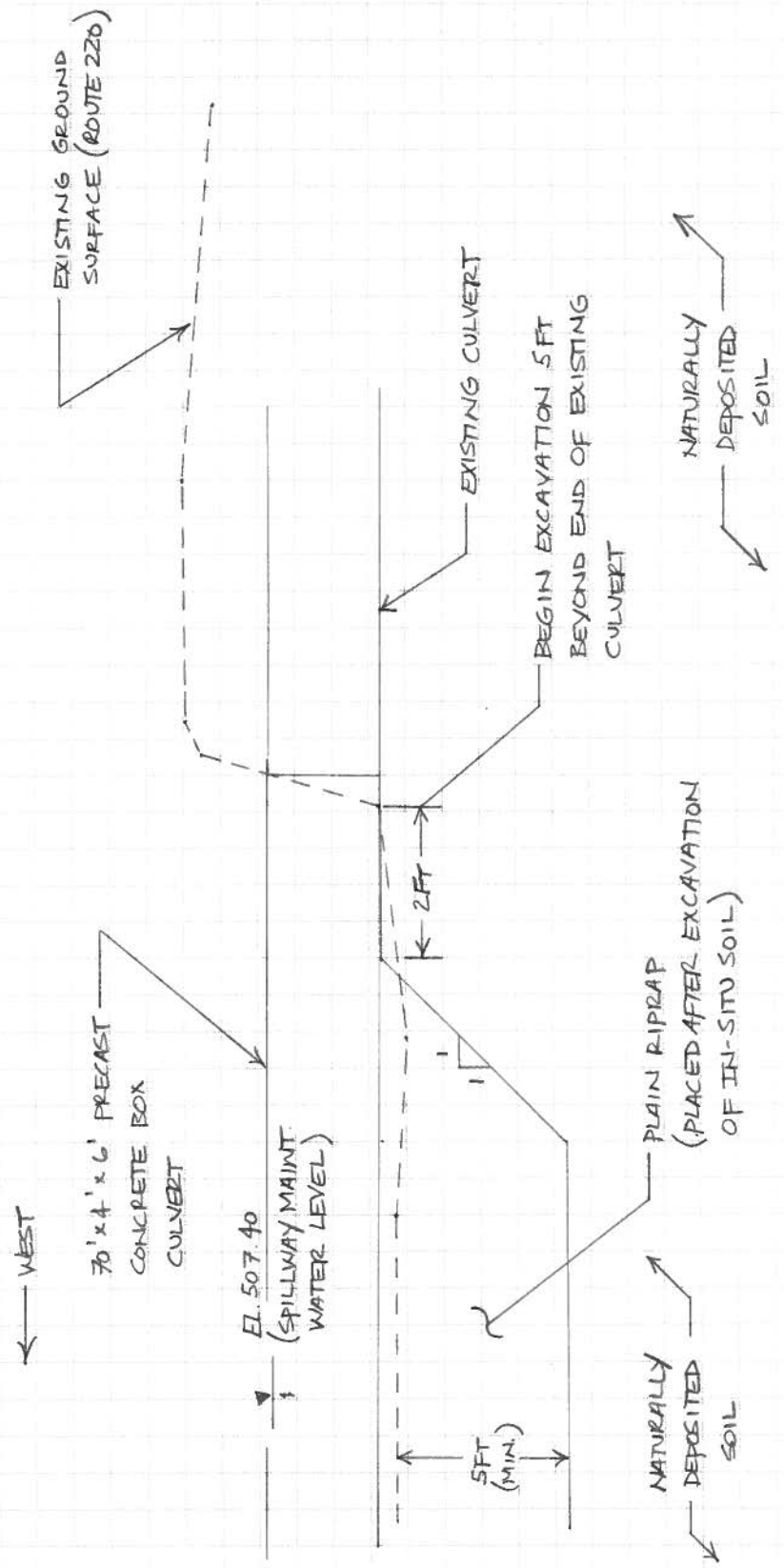
FIGURE 3

HALEY & ALDRICH

Calculations

Client	MAINEDOT	File No.	28170-020
Project	LIBERTY	Sheet	1 of 1
Subject	PROFILE ALONG CENTERLINE OF BOX CULVERT EXTENSION	Date	8/21/2013
		Computed By	BCS
		Checked By	WAC

SCALE: N.T.S.



NOTE: 1. PROPOSED WIDENED ROADWAY NOT SHOWN FOR CLARITY.

2. IF, DURING EXCAVATION, THE THICKNESS OF LAKE BOTTOM SEDIMENTS IS FOUND TO BE LESS THAN 5 FT, THE FULL 5-FT OVER-EXCAVATION DEPTH MAY NOT BE NEEDED. IF LAKE BOTTOM SEDIMENTS ARE FOUND TO BE THICKER THAN 5 FT, OVER-EXCAVATION WILL CONTINUE UNTIL THE SEDIMENTS ARE COMPLETELY REMOVED.

FIGURE 4

APPENDIX A

Test Boring Logs

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-101
PIN: 17888.00

Driller:	MaineDOT	**Elevation (ft.)**	516.8	**Auger ID/OD:**	N/A
Operator:	Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/28/11-9/28/11	**Drilling Method:**	Hollow Stem Auger	**Core Barrel:**	N/A
Boring Location:	54+91.5, 9.1 ft Rt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							HSA	516.13		8" HMA. 0.67	
	1D	24/6	1.00 - 3.00	7/9/5/4	14	20				Brown, damp, medium dense, sandy GRAVEL, some silt.	
5	2D	24/17	5.00 - 7.00	3/3/3/4	6	8				Brown, moist, loose, silty SAND.	
10	3D	24/20	10.00 - 12.00	4/9/26/12	35	49				Brown, moist, medium dense, silty SAND, some stones.	
15	4D	24/24	15.00 - 17.00	11/13/15/18	28	39				Brown, saturated, medium dense, silty SAND, little stones, layers of wood.	
20	5D	8.4/7	20.00 - 20.70	21/50(2")	---			496.10		Brown, saturated, medium dense, SAND, some silt. 20.70	
										Bottom of Exploration at 20.70 feet below ground surface. SPOON REFUSAL	
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-102
PIN: 17888.00

Driller:	MaineDOT	**Elevation (ft.)**	514.9	**Auger ID/OD:**	5" Dia.
Operator:	Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	9/28/11-9/28/11	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	55+21.3, 9.3 ft Rt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	514.40		6" HMA. 0.50	
5	MD	24/0	5.00 - 7.00	Not Recorded	---					Brown, moist, silty SAND, breaking rock grindings. Sample from auger flight. Roller Coned ahead to 6.5 ft bgs.	
								508.40		6.50 **Bottom of Exploration at 6.50 feet below ground surface.** ABANDONED HOLE, moved to HB-LIB-102A	
10											
15											
20											
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: HB-LIB-102

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-102A
PIN: 17888.00

Driller:	MaineDOT	**Elevation (ft.)**	515.0	**Auger ID/OD:**	5" Dia Solid Stem
Operator:	Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/28/11-9/29/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	55+21.2, 12.1 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	±9.0 ft bgs
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			See HB-LIB-102 for descriptions.	
5	MD	0/0	5.00 - 5.00	Not Recorded						Roller Coned through Cobble from 5.0-7.0 ft bgs.	
							2				
10	2D	24/12	10.00 - 12.00	1/1/1/2	2	3	10			Brown, saturated, very loose, GRAVEL, some silt. 7-8" of wood in spoon tip.	
							13				
							25				
							29				
							40				
15	3D	24/24	15.00 - 17.00	6/6/6/10	12	17	38			Brown, saturated, medium dense, GRAVEL, some silt, layers of wood.	
							81				
							61				
							62				
20	4D	24/12	20.00 - 22.00	10/18/20/24	38	53	15			GRAVEL, saturated, dense, some silt, rock fragments.	
							17				
							26				
							57				
							40			4" Cobble at 24.3 ft bgs.	
25	5D	15/9	25.00 - 26.25	9/27/30(3")	---		30			Brown, saturated, very dense, GRAVEL, some silt, rock fragments, wood.	

Remarks:

Filled in Boring with grout.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: HB-LIB-102A

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-102A
PIN: 17888.00

Driller:	MaineDOT	**Elevation (ft.)**	515.0	**Auger ID/OD:**	5" Dia Solid Stem
Operator:	Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/28/11-9/29/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	55+21.2, 12.1 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	±9.0 ft bgs
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample attempt
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MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
							6				
							10				
							46				
30											
	6D	24/24	30.00 - 32.00	14/31/30/32	61	85	113			Saturated, very dense, strata: 0.7 ft GRAVEL, trace silt. (6D/A) 0.8 ft sandy SILT. (6D/B) 0.5 ft WOOD. (6D/C)	
							68				
	R1	60/ 60	33.50 - 38.50	RQD = 93%			NQ-2	481.50		Casing refusal at 33.3 ft bgs, Roller Coned ahead to 33.5 ft bgs. 33.50	
35										Top of Bedrock aty Elev. 481.5 ft. R1:Bedrock: Medium grey, fine grained, PHYLLITE, steep to moderately steep, tight joints with some rust staining. R1:Core Times (min:sec) 33.5-34.5 ft (2:53) 34.5-35.5 ft (2:03) 35.5-36.5 ft (2:04) 36.5-37.5 ft (2:20) 37.5-38.5 ft (3:25)	
								476.50		38.50 **Bottom of Exploration at 38.50 feet below ground surface.**	
40											
45											
50											

Remarks:

Filled in Boring with grout.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-103
PIN: 17888.00

Driller:	MaineDOT	**Elevation (ft.)**	517.2	**Auger ID/OD:**	5" Dia Solid Stem
Operator:	Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/29/11-9/29/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NQ-2"
Boring Location:	23+34, 6.7 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	516.45		9" HMA. 0.75	
	1D	24/19	1.00 - 3.00	13/11/10/10	21	29				Brown, moist, medium dense, gravelly SAND, trace silt.	G#244132 A-1-b, SM WC=6.0%
										Gravelly SAND, some silt at 2.6 ft bgs. Roller Coned through rock at 3.0-4.0, 5.0-6.0 and 7.5-8.5 ft bgs.	
5							20				
							51				
							39				
							44				
							36				
10	2D	24/9	10.50 - 12.50	4/6/9/10	15	21	31			Wet to saturated, medium dense strata: 1" grey, medium uniform SAND, trace silt; 3" peastone and gravel; 2" silty SAND; 2" stones	
							55				
							96				
							120				
15	3D	21.6/11	15.00 - 16.80	36/45	---						G#244133 A-1-b, GM WC=10.3%
	R1	58.8/ 58.8	16.80 - 21.70	RQD = 70%			NQ-2	500.40		16.80 Top of Bedrock at Elev. 500.4 ft. R1:Bedrock: Medium grey, fine grained PHYLLITE, steep to moderately steep, tight joints, some rust staining. R1:Core Times (min:sec) 16.8-17.8 ft (3:40) 17.8-18.8 ft (2:20) 18.8-19.8 ft (2:20) 19.8-20.8 ft (1:55) 20.8-21.7 ft (2:45) RQD maybe reduced as result of coring through 3" casing.	
20								495.50		21.70 **Bottom of Exploration at 21.70 feet below ground surface.**	
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: HB-LIB-103

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-104
PIN: 17888.00

Driller:	MaineDOT	**Elevation (ft.)**	513.8	**Auger ID/OD:**	5" Dia Solid Stem
Operator:	Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/30/11-9/30/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	55+49.7, 11.0 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	±9.0 ft bgs
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	513.30		6" HMA. 0.50	
	1D	24/17	1.00 - 3.00	5/8/6/5	14	20				Brown, moist, medium dense, SAND, trace silt, sandy SILT in bottom 3".	
5	2D	24/18	5.00 - 7.00	1/2/2/1	4	6				Brown, damp, loose, silty SAND.	
										Cobbles at 7.8 ft bgs.	
10	3D	24/14	10.00 - 12.00	9/4/3/14	7	10	34			Brown, saturated, medium dense, SAND, trace silt upper 3". Brown, saturated, loose, silty SAND lower 12".	
							450			6" Rock.	
							125			Roller Cone through rocks to 14.5 ft bgs.	
15								499.30		14.50 **Bottom of Exploration at 14.50 feet below ground surface.** ABANDONED BORING	
20											
25											

Remarks:

Filled in Boring with grout.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: HB-LIB-104

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-201
PIN: 17888.00

Driller:	Maine Test Borings	**Elevation (ft.)**	498.6	**Auger ID/OD:**	N/A
Operator:	Enos/Barlow	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	11/16/11-11/16/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NX
Boring Location:	55+64.5, 39.7 ft Lt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	MD	0/0	0.00 - 0.00	WOR/WOR/WOR/ WOR	---		WOR		Very loose SILT.	
							WOR			
							WOR			
							40	495.60	3.00	
							40			
5	1D	24/5	5.25 - 7.25	27/22/8/8	30	0	46		Grey, wet, medium dense, SAND, some silt, little gravel.	G#262004 A-2-4, SM WC=14.5%
							40		Stone at 6.0 ft bgs.	
							40			
							77		Brown wash water at 8.0 ft bgs.	
							183			
10							139			
	2D	9/4	11.00 - 11.75	46/50(3")	---				Reddish wash water at 10.5 ft bgs. Brown, wet, dense SAND, some gravel, some silt.	G#262005 A-1-b, SM WC=12.2%
								486.85	11.75	
	R1	53/44	12.25 - 16.67	RQD = 77%			NX	486.35	Roller Cone ahead into Weathered Rock to 12.25 ft bgs.	
									12.25	
									Top of Intact Bedrock at Elev. 486.35 ft. R1:Bedrock: Medium grey, fine grained PHYLLITE, steep to moderately steep, tight joints, some rust stains. R1:Core Times (min:sec) 12.25-13.25 ft (5:20) 13.25-14.25 ft (5:00) 14.25-15.25 ft (4:00) 15.25-16.25 ft (4:10) 16.25-16.67 ft (2:50) 83% Recovery	
15								481.93		
									16.67	
									Bottom of Exploration at 16.67 feet below ground surface.	
20										
25										

Remarks:

Deck to Ground 9.08 ft.
Deck to top of water 1.67 ft.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Boring No.: HB-LIB-201

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-202
PIN: 17888.00

Driller:	Maine Test Borings	**Elevation (ft.)**	498.02	**Auger ID/OD:**	5" Dia.
Operator:	Enos/Barlow	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	11/16/11-11/16/11	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	55+76.4, 45.0 ft Lt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MU = Unsuccessful Thin Wall Tube Sample attempt
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MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Soil.	
5											
								491.35		6.67	
								490.72		Augered into Rock. 7.30	
										Bottom of Exploration at 7.30 feet below ground surface.	
10											
15											
20											
25											

Remarks:

Deck to Ground 9.67 ft.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-203
PIN: 17888.00

Driller:	Maine Test Borings	**Elevation (ft.)**	501.3	**Auger ID/OD:**	5" Dia.
Operator:	Enos/Barlow	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	11/17/11-11/17/11	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	55+89.5, 47.4 ft Lt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Soil.	
5										Cobble from 3.8-4.4 ft bgs.	
								494.80		6.50	
								494.55		Augered into Rock.	
										6.75	
										Bottom of Exploration at 6.75 feet below ground surface.	
10											
15											
20											
25											

Remarks:

Deck to Ground 6.67 ft.

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* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-204
PIN: 17888.00

Driller:	Maine Test Borings	**Elevation (ft.)**	499.5	**Auger ID/OD:**	5" Dia.
Operator:	Enos/Barlow	**Datum:**	NAVD88	**Sampler:**	N/A
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	N/A
Date Start/Finish:	11/17/11-11/17/11	**Drilling Method:**	Solid Stem Auger	**Core Barrel:**	N/A
Boring Location:	55+52.5, 35.2 ft Lt.	**Casing ID/OD:**	N/A	**Water Level*:**	None Observed
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			Soil.	
5											
10											
								488.50		11.00	
										Augered into Rock.	
								487.50		12.00	
										Bottom of Exploration at 12.00 feet below ground surface.	
15											
20											
25											

Remarks:

Deck to Ground 8.5 ft.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Intersection Routes 173/220
Location: Liberty, Maine

Boring No.: HB-LIB-205
PIN: 17888.00

Driller:	Maine Test Borings	**Elevation (ft.)**	502.8	**Auger ID/OD:**	N/A
Operator:	Enos/Barlow	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	K. Breskin	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	11/17/11-11/17/11	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	NX
Boring Location:	55+33, 43.6 ft Lt.	**Casing ID/OD:**	HW & NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:		**Hammer Type:**	Automatic ☐ Hydraulic ☐ Rope & Cathead ☒		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR = weight of rods
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0	1D	24/12	0.00 - 2.00	WOR/WOH/3/7	3	0	WOH		Grey, wet, very loose, sandy SILT, trace gravel.	G#262006 A-4, ML WC=35.4%
							7			
							25	500.80	2.00	
							26			
							31			
5	2D	24/14	5.00 - 7.00	5/9/10/14	19	0	WASH AHEAD		Grey-brown, wet, medium dense, sandy SILT, some gravel.	G#262007 A-4, SM WC=10.9%
10	3D	24/12	10.00 - 12.00	10/13/10/12	23	0	23		Grey-brown, wet, medium dense, SAND, some silt, some gravel, stones similar to bedrock. Changed to NW Casing at 10.0 ft bgs.	G#262008 A-2-4, SM WC=11.1%
							25			
							34			
							39			
							28		Reddish water from 14.0-14.5 ft bgs.	
15	4D		15.17 - 16.59	22/27/52(5")	---		18 WA		Washed ahead to 19.25 ft bgs. Gray-brown, wet, dense Sandy SILT, little gravel, weathered rock in tip of spoon.	G#262009 A-4, SM WC=11.6%
	R1	60/48	19.25 - 24.25	RQD = 35%			NX	483.55	19.25	
20									Top of Bedrock at Elev. 483.55 ft. R1:Bedrock: Same as HB-LIB-201, R1, except poor quality. Maybe granite in bottom of core, white wash water. R1:Core Times (min:sec) 19.25-20.25 ft (2:55) 20.25-21.25 ft (2:40) 21.25-22.25 ft (2:25) 22.25-23.25 ft (2:50) 23.25-24.25 ft (3:50)	
								478.55	24.25	
25									**Bottom of Exploration at 24.25 feet below ground surface.**	

Remarks:

Deck to Ground 5.25 ft.

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: HB-LIB-205

State of Maine - Department of Transportation

Power Auger Probe Summary Sheet

Town(s): Liberty

Work Number: 17888.00

Station (Feet)	Offset (Feet)	Weathered Rock (Feet)	Refusal (Feet)	No Refusal (Feet)	Water Depth (Ft.)	Comments / Date 9/30/2011
55+49	10.0 Rt.		8.2			Roller Coned to 9.0 ft.

MaineDOT Drill Crew
Logged By: B. Wilder
Drill Rig: CME 45C

5" Solid Stem Auger

APPENDIX B

Hager-Richter Geoscience, Inc. Report entitled,
"Geophysical Survey Lake St. George Dam, Liberty, Maine,"
Dated 29 August 2011

HAGER-RICHTER
GEOSCIENCE, INC.

GEOPHYSICAL SURVEY
LAKE ST. GEORGE DAM
LIBERTY, MAINE

PIN 017888.00
MaineDOT Contract
No. 20110613000000006486

Prepared for:

Maine Department of Transportation
Highway Program
16 State House Station
Augusta, Maine 04333-0016

Prepared by:

Hager-Richter Geoscience, Inc.
8 Industrial Way - D10
Salem, New Hampshire 03079

File 11J32
August, 2011

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HAGER-RICHTER
GEOSCIENCE, INC.

CONSULTANTS IN GEOLOGY AND GEOPHYSICS
8 INDUSTRIAL WAY - D10
SALEM, NEW HAMPSHIRE 03079-5820
TELEPHONE (603) 893-9944
FAX (603) 893-8313

August 29, 2011
File 11J32

Kitty Breskin, P.E.
Geotechnical Design Engineer
Maine Department of Transportation
Highway Program
16 State House Station
Augusta, Maine 04333-0016

Phn: 207-592-7605
Email Kitty.Breskin@maine.gov

RE: **MaineDOT Contract No. 20110613000000006486**
Geophysical Survey
Lake St. George Dam
Liberty, Maine
PIN 017888.00

Dear Ms. Breskin:

In this letter, we report the results of a geophysical survey conducted by Hager-Richter Geoscience, Inc. (Hager-Richter) at the Lake St. George Dam located in Liberty, Maine for the Maine Department of Transportation (MaineDOT) in July, 2011. The work is being conducted under MaineDOT Contract No. 20110613000000006486 and PIN 017888.00. The scope of the project and areas of interest were specified by MaineDOT.

INTRODUCTION

MaineDOT is undertaking a geotechnical investigation for the design of a road widening project for State Route 220. A portion of the highway just south of the intersection with State Route 173 is carried by the Lake St. George Dam. According to information provided by MaineDOT, the dam was built circa 1820, is approximately 18 feet high at its crest, and is approximately 80 feet long. The exposed portions of the upstream and down stream sides of the dam are faced with dry packed stone. The internal structure of the dam is not known. A sluice is present on the downstream side of the structure. MaineDOT was interested in conducting a geophysical survey to provide information on construction details of the dam. The general location of the Site is shown in Figure 1, and Figure 2 is a Site Plan.

The area of interest (AOI) at the Site consists of the paved portion of Route 220 over the dam structure. The AOI is approximately 120 feet long and 25 feet wide. The shoulders of the roadway dip away from the centerline and have been repaired multiple times.

MaineDOT Contract No. 20110613000000006486
Geophysical Survey
Lake St. George Dam
Liberty, Maine
PIN 017888.00 - HR File 11J32 - August, 2011

The geophysical survey consisted of a multi channel analysis of surface waves (MASW) survey and a ground penetrating radar (GPR) survey to attempt to identify structures within the dam.

OBJECTIVES

The objective of the geophysical survey was to detect possible structural elements within the dam.

THE SURVEY

Jeffery Reid, P.G., and Erik Rickert of Hager-Richter conducted the field operations on July 12, 2011. The project was coordinated with Ms. Kitty Breskin, P.E. Ms. Breskin was present for the fieldwork and specified the area of interest for the work.

The geophysical survey was conducted using multi-channel analysis of surface waves (MASW) and ground penetrating radar (GPR). MASW data were acquired along two traverses located in the east and west travel lanes of the roadway over the dam, respectively. The locations of the MASW survey lines are shown in Figure 2. GPR data were acquired on the roadway along a series orthogonal traverses spaced 2 feet apart oriented parallel and perpendicular to the to the long axis of the dam.

EQUIPMENT AND PROCEDURES

MASW. The multichannel analysis of surface waves (MASW) method is a seismic method that determines a shear-wave velocity (Vs) profile (i.e., Vs versus depth and horizontal distance) by analyzing a particular type of seismic wave on a multichannel record. The MASW method uses Rayleigh waves which are elastic waves that travel in the subsurface near the earth's surface. The amplitude of such waves decreases with depth and the phase velocity of the waves is a function of frequency. The method uses multichannel recording and processing concepts widely used in reflection surveying by the oil and gas industry.

MASW requires multichannel records with at least 12 traces to produce reliable results. We use 48 channels (two 24-channel Geometrics Geode digital seismographs), coupled to 48 geophones to acquire 24-trace records. The data acquired for geophones numbered 1 - 24 are processed as discussed below to determine the shear wave velocity as a function of depth for discrete layers, and the velocity of each layer $V_s(x,n)$ is assigned to the midpoint of the line between Stations 1 and 24, i.e. x = 27.5 ft if the geophone spacing is 2.5 feet. The data acquired for geophones numbered 2 through 25 yield the vertical velocity profile at the midpoint of the line between stations 2 and 25, i.e. x = 30 ft if the geophone spacing is 2.5 feet. By processing the

data for geophones m through m+24 and assigning the vertical profiles to the midpoints, the velocity of each layer is generated as a function of horizontal distance. The end point for the velocity determined with a 24-geophone spread using data acquired with 24 geophones is located at x = 90 ft from the start of the line if a 2.5-foot geophone spacing is used. Figure 3 shows the data acquisition scheme and the way in which processing produces 24 vertical velocity profiles for a 48 geophone spread. As shown in Figure 3, a series of the first and last geophones do not yield velocities as function of depth at each of those geophone locations. For this project, we used 48 4.5-Hz geophones spaced 2.5 feet apart.

The surface waves used in MASW, considered noise in refraction and reflection surveys, are *enhanced* during data acquisition and processing for the MASW method. The seismic data are analyzed using *SurfSeis 3.0,* a commercially licensed software package developed by the Kansas Geological Survey. Briefly, SurfSeis provides a dispersion curve from which the interpreter selects the fundamental mode in detail, and the software then inverts the dispersion curve in terms of a model of shear wave velocity (Vs) as a function depth at the midpoint of the geophone spread (see Figure 3). Results can be presented as 2-D graphical plots using contouring software such as *Surfer* or in tabular form showing shear wave velocity as a function of depth at a given station. The data for many stations acquired along a survey line can be presented as a contour plot of the shear wave velocity as a function of depth and distance along the line.

As discussed above, data are acquired for 24 channels at a time and the resulting 1-D shear wave distribution as a function of depth is assigned the horizontal position at the center of the 24-channel spread. The 1-D distributions are then combined to provide shear wave velocity distribution across the survey line and are presented as 2-D color plots. The variations in color correspond to apparent variations in subsurface shear wave velocity. Low shear wave velocities correlate with softer soils and higher shear wave velocities correlate with harder, more dense soil or bedrock.

GPR. The GPR survey was conducted using a Sensors & Software Smart Cart Noggin Plus digital subsurface imaging radar system. The system includes a survey wheel that triggers the recording of the data at fixed intervals, thereby increasing the accuracy of the locations of features detected along the survey lines. The system was used with a 250 MHz antenna and a 100 ns[1] window.

GPR uses a high-frequency electromagnetic pulse (referred to herein as “radar signal”) transmitted from a radar antenna to probe the subsurface. The transmitted radar signals are

[1] ns, abbreviation for nanosecond, 1/1,000,000,000 second. Light and the GPR signal require about 1 ns to travel 1 ft in air. The GPR signal requires about 3.5 ns to travel 1 ft in unsaturated sandy soil.

reflected from subsurface interfaces of materials with contrasting electrical properties. Travel times of the radar signal can be converted to approximate depth below the surface by correlation with targets of know depths. We monitor the acquisition of GPR data in the field and record the GPR data digitally for subsequent processing. Interpretation of the records is based on the nature and intensity of the reflected signals and on the resulting patterns.

Data from the GPR survey were processed using EkkoMapper 4.0, commercially licensed GPR processing software from Sensors and Software. We reviewed profile images and created plan view time slice maps of the GPR data.

LIMITATIONS OF THE METHODS

HAGER-RICHTER GEOSCIENCE, INC. MAKES NO GUARANTEE THAT ALL SUBSURFACE FEATURES OF INTEREST WERE DETECTED IN THIS SURVEY. HAGER-RICHTER GEOSCIENCE, INC. IS NOT RESPONSIBLE FOR DETECTING FEATURES OF INTEREST THAT CANNOT BE DETECTED DUE TO THE LIMITATIONS OF THE METHODS OR BECAUSE OF SITE CONDITIONS.

MASW. The MASW method, although theoretically sound, may not be applicable at all sites for the determination of shear wave velocity because of site limitations. Such limitations include adequate space, attenuation of the soils (especially for frequencies in the range 5 Hz to about 15 Hz), and the presence of structures with high velocity materials that extend to appreciable depth (such as thick concrete or asphalt slabs or basement walls of several below-grade stories).

For sites where a high velocity layer overlies a significantly lower velocity layer, Lamb Waves may be generated rather than Raleigh Waves. Because of the dispersive and multi-modal nature, the Lamb waves can be easily misidentified as Rayleigh-type surface waves during a MASW survey. The inversion algorithms used to interpret MASW data cannot be utilized to determine shear wave velocity structure when Lamb Waves dominate the data.

The depth of investigation for an MASW survey depends on the frequency spectrum of the seismic signal, and low frequency (long wavelength) signals are required to obtain data at large depths—the lower the frequency, the greater the depth of investigation. As with all physical measurements, there is experimental error in the velocities that are determined using the MASW method. The uncertainty in velocity of shear waves is estimated to be approximately 10-15%.

GPR. GPR detects and maps interfaces of contrasting electrical properties, and an air-filled void has electrical properties very different from soil and rock. The GPR method is useful for detecting voids and determining their footprint, but in general, GPR data cannot be used to determine the thickness of voids.

There are other limitations of the GPR technique: (1) surface conditions, (2) electrical conductivity and thickness of the subsurface layers, (3) electrical properties of the target(s), and (4) spacing of the traverses. Of these restrictions, only the last is controllable by us in most cases.

The condition of the survey surface can affect the quality of the GPR data and the depth of penetration of the GPR signal. For exterior sites, a surface covered with obstacles such as automobiles, dumpsters, thick leaf debris, materials piles, etc. limit the survey access. Similarly, for interior sites, a surface covered with obstacles such as desks, benches, laboratory equipment, etc. also limit access. Some floor coverings may limit the coupling of the GPR antenna with the subsurface.

The electrical conductivity of the subsurface determines the attenuation of the GPR signals, and thereby limits the maximum depth of exploration. The GPR signal does not penetrate clay-rich soils or soils contaminated with road salt. In some cases, the GPR signal may not penetrate below concrete pavement, and some asphalts are electrically conducting.

A strong contrast in the electrical conductivities of the ground and the target (for examples, UST, pipe, void, dry well, drum, contaminant plume) is required to obtain a reflection of the GPR signal. If the contrast is too small, then the reflection may be too weak to recognize, and the target can be missed.

Spacing of the traverses is limited by access at many sites, but where flexibility of traverse spacing is possible, the spacing is adjusted on the basis of the size of the target.

RESULTS

The geophysical survey consisted of a combination of MASW and GPR. MASW and GPR data were acquired on the roadway over the dam. The locations of the MASW lines are shown in Figure 2 and the locations of the GPR traverses are shown in Figure 5. The results of the MASW survey are shown in Figure 4 and the results of the GPR survey are shown in Figure 5.

MASW. MASW data were acquired along two survey lines identified as Lines 1 and 2, with lengths of 117.5 feet. The locations of the MASW seismic lines are shown in Figure 2.

From a practical perspective, the MASW method determines the spatial variation of shear wave velocity (Vs), and interfaces or anomalies are interpreted by relative changes in Vs. In general, higher shear wave velocities indicate more dense materials while lower shear wave velocities indicate softer soils. The results of the MASW survey are shown in profile form in Figure 4.

The values of Vs for the Site range from 400 to more than 1600 fps. The following table outlines the typical ranges of shear wave velocities expected for soil and bedrock:

Material	**Shear Wave Velocity (feet per second)**
Loose Fill and Soil	300-600
Medium Dense Fill and Soil	600-800
Dense Fill and Soil	800-1200
Dense Till	1200-1800
Weathered Bedrock (Igneous and Metamorphic)	1500-3500
Bedrock (Igneous and Metamorphic)	3500 +

An examination of the profiles shown in Figure 4 shows three velocity ranges. Shallow soils at the Site exhibit velocities in the range of 500-800 fps, shown as blue on Figure 4, and are indicative of less dense soils. Deeper soils consist of more dense soils overlying very dense soil or till, shown as green and yellow and orange colors, respectively, on Figure 4. Velocities typical of bedrock were not detected. The northernmost 20-30 feet of both Lines 1 and 2 exhibit higher velocity soils in the upper five feet. The MASW data do not indicate the presence of very loose soil or voids in the areas surveyed.

GPR. The GPR survey was conducted using a 250 MHz antenna and an 100 ns time window. Figure 5 shows the locations of the GPR traverses and the interpretation of the data. Figures 6 and 7 show examples of GPR records over the dam 7.5 feet west of the roadway centerline, and 5 feet east of the roadway centerline, respectively with the corresponding MASW superimposed over the GPR data.

Apparent GPR signal penetration on the road surface was good to very good, with reflections recorded for 60-100 ns. Based on velocity matching calibrations made for the site and on handbook time-to-depth conversions for the GPR signal in average to sandy soils, the GPR signal penetration in most areas of the roadway are estimated to have been approximately 15-20

feet across most of the roadway.

The GPR records for the southern portion of the dam structure show reflections typical of relatively homogenous fill. The layered nature of the soils suggest that the fill may have been placed in lifts and compacted. An abrupt change in the character of the GPR reflections occurs midway through the records and extends through the northern portion of the dam structure. The location of the change is shown on Figure 5 and identified on Figures 6 and 7. The GPR reflections become more chaotic below a significant reflector at a depth of about five feet below the pavement. This significant reflector may originate from a structural element in the dam such as a layer of rock covering the drainage structures. The chaotic nature of the reflectors below the structure indicate that the fill is less homogenous and may be composed of larger stones and rubble fill rather than the homogenous fill noted to the south. Additionally, the width of the west abutment wall thickens in this area and the inferred limit of the wall is shown on Figure 5. GPR data were not acquired over the eastern abutment due to significant brush off the eastern side of the roadway.

Figures 6 and 7 show examples of GPR records over the dam 7.5 feet west of the roadway centerline, and 5 feet east of the roadway centerline, respectively with the corresponding MASW superimposed over the GPR data. The sharp change lateral in the nature of the reflectors is quite obvious in the data set at about 55 feet from the north end of the GPR traverses. GPR reflections typical of the sluiceway are present in the records at about 20 feet from the north end of the lines and its location is shown on Figure 5. There is excellent correlation between the MASW and GPR data. The shear wave velocities increase in the areas of strong GPR reflections indicating changes in the internal structure of the dam.

CONCLUSIONS

Based on the geophysical survey conducted by Hager-Richter Geoscience, Inc. on the Lake St George Dam located in Liberty, Maine for the Maine Department of Transportation in July, 2011, we conclude the following:

- The southern portion of the dam structure under the roadway appears to be constructed of homogeneous fill

- The northern portion of the dam structure under the roadway appears to be constructed of coarser material and may be covered by a dense layer, possibly a stone structural element.

- The width of the west abutment wall appears to thicken in the northern portion of the dam

MaineDOT Contract No. 20110613000000006486
Geophysical Survey
Lake St. George Dam
Liberty, Maine
PIN 017888.00 - HR File 11J32 - August, 2011

LIMITATIONS

This letter report was prepared for the exclusive use of the Maine Department of Transportation (Client). No other party shall be entitled to rely on this Report or any information, documents, records, data, interpretations, advice or opinions given to Client by Hager-Richter Geoscience, Inc. (H-R) in the performance of its work. The Report relates solely to the specific project for which H-R has been retained and shall not be used or relied upon by Client or any third party for any variation or extension of this project, any other project or any other purpose without the express written permission of H-R. Any unpermitted use by Client or any third party shall be at Client's or such third party's own risk and without any liability to H-R.

H-R has used reasonable care, skill, competence and judgment in the performance of' its services for this project consistent with professional standards for those providing similar services at the same time, in the same locale, and under like circumstances. Unless otherwise stated, the work performed by H-R should be understood to be exploratory and interpretational in character and any results, findings or recommendations contained in this Report or resulting from the work proposed may include decisions which are judgmental in nature and not necessarily based solely on pure science or engineering. It should be noted that our conclusions might be modified if subsurface conditions were better delineated with additional subsurface exploration including, but not limited to, test pits, soil borings with collection of soil and water samples, and laboratory testing.

Except as expressly provided in this limitations section, H-R makes no other representation or warranty of any kind whatsoever, oral or written, expressed or implied; and all implied warranties of merchantability and fitness for a particular purpose, are hereby disclaimed.

If you have any questions or comments on this letter report, please contact us at your convenience. It has been a pleasure to work with the Maine Department of Transportation on this project. We look forward to working with you again in the future.

Sincerely yours,
HAGER-RICHTER GEOSCIENCE, INC.

Jeffery Reid, P.G.
Senior Geophysicist

Dorothy Richter, P.G.
President

Attachments: Figures 1-7

N

APPROXIMATE SCALE (feet)

0 1000 2000

LOCATION

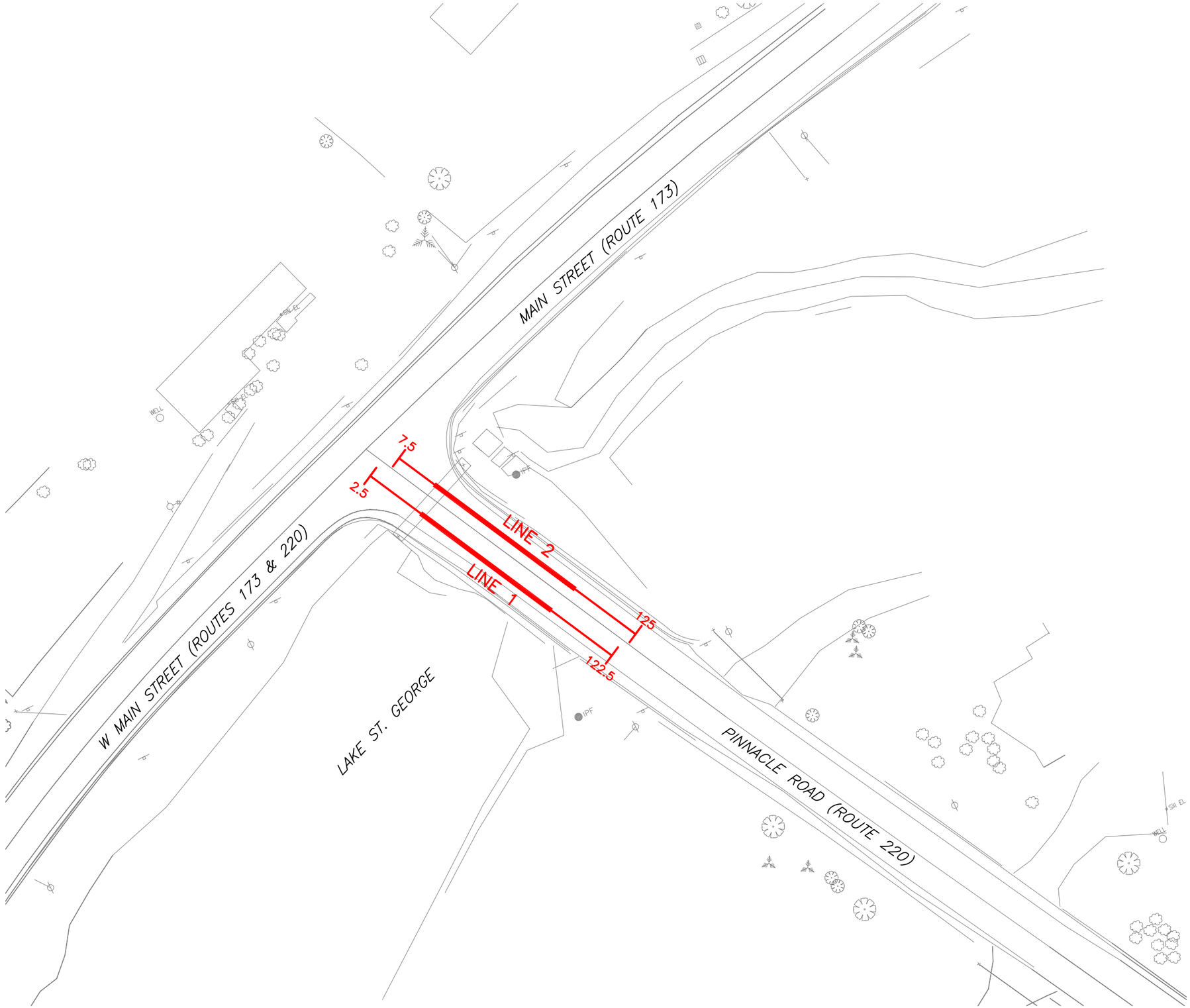
NOTE:

Modified from Google Earth aerial photograph.

Figure 1
General Site Location
Lake St. George Dam
Liberty, Maine
PIN 017888.00

File 11J32	August, 2011

HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire



LEGEND

MASW SURVEY LINE WITH INDICATION OF THE EFFECTIVE DATA COVERAGE IN BOLD

SCALE (feet)

0 40 80

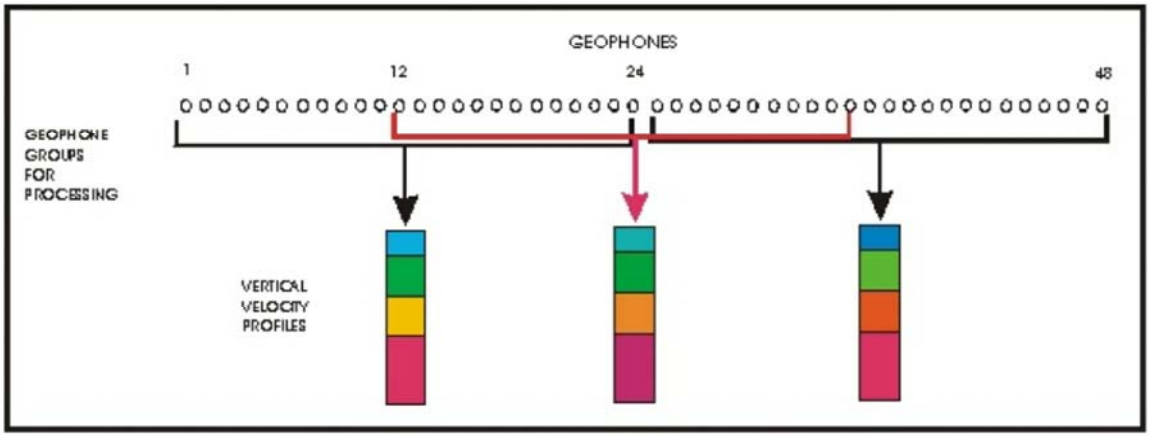
NOTE:

Modified from site plan provided by Maine Department of Transportation.

Figure 2
Site Plan
Lake St. George Dam
Liberty, Maine
PIN 017888.00

File 11J32	August, 2011

HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire



Forty-eight geophones are connected to a seismograph. The seismic wave generator by a source located left of, and in line with, the geophones, is detected by geophone number 1 through 24 and recorded by the seismograph. The seismic wave recorded as a function of distance at geophones 1-24 is subsequently processed to provide the velocity of shear waves as a function of depth, and the vertical velocity profile is assigned to the location midway between geophones 1-24.

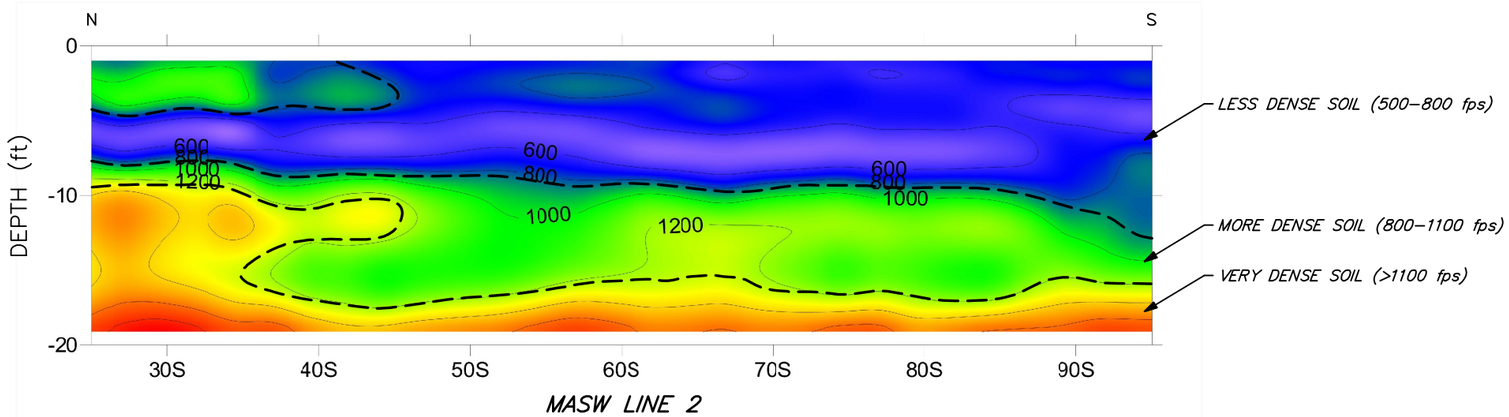
The data acquisition continues using geophones 2-25 with source located the same distance from geophone 2 as it was from geophone 1 for acquisition using geophones 1-24. This procedure continues using 24 geophones until the data for geophones 25-48 have been acquired. The figure shows the resulting vertical profiles for three sets of 24 geophones: 1-24 located midway between geophones 11 and 12, 12-35 located midway between geophones 23 and 24, 25-48 located midway between geophones 36 and 37.

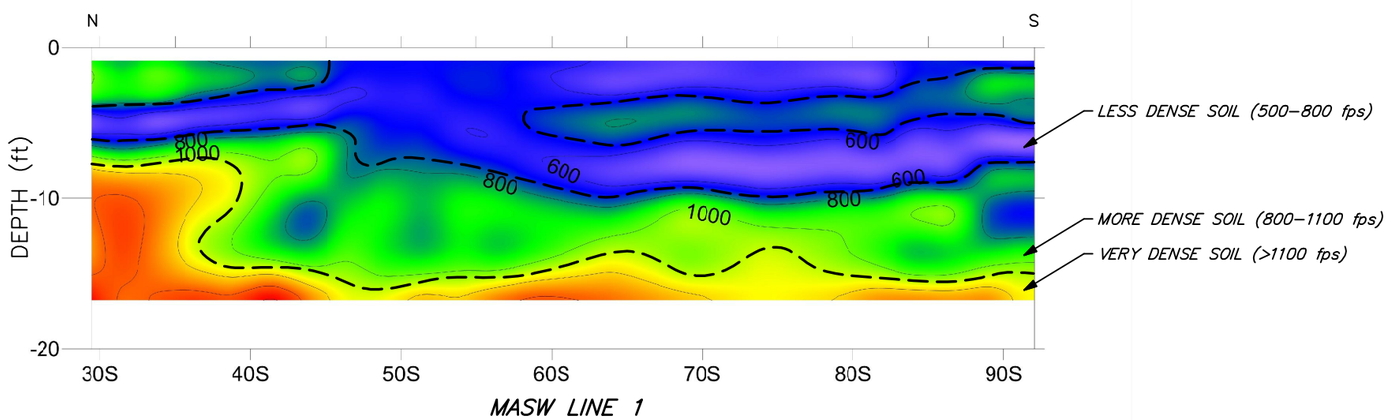
These procedures produce vertical velocity profiles at 24 locations. The data can be presented in tables and as a cross section in which the values are contoured. On order to extend the coverage of the MASW line pre DDC we also processed the data for geophones 1 through 12 for the first 6 records. Due to the array configuration, the MASW results could not be extender further.

Figure 3
MASW Method
Lake St. George Dam
Liberty, Maine
PIN 017888.00

File 11J32	August, 2011

HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire





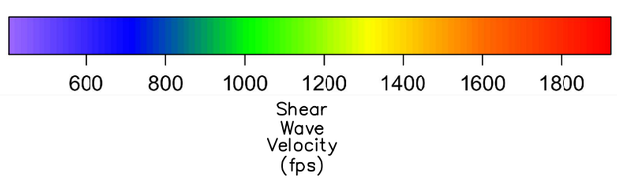


Figure 4
MASW Survey
Lake St. George Dam
Liberty, Maine
PIN 017888.00

File 11J32	August, 2011

HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire

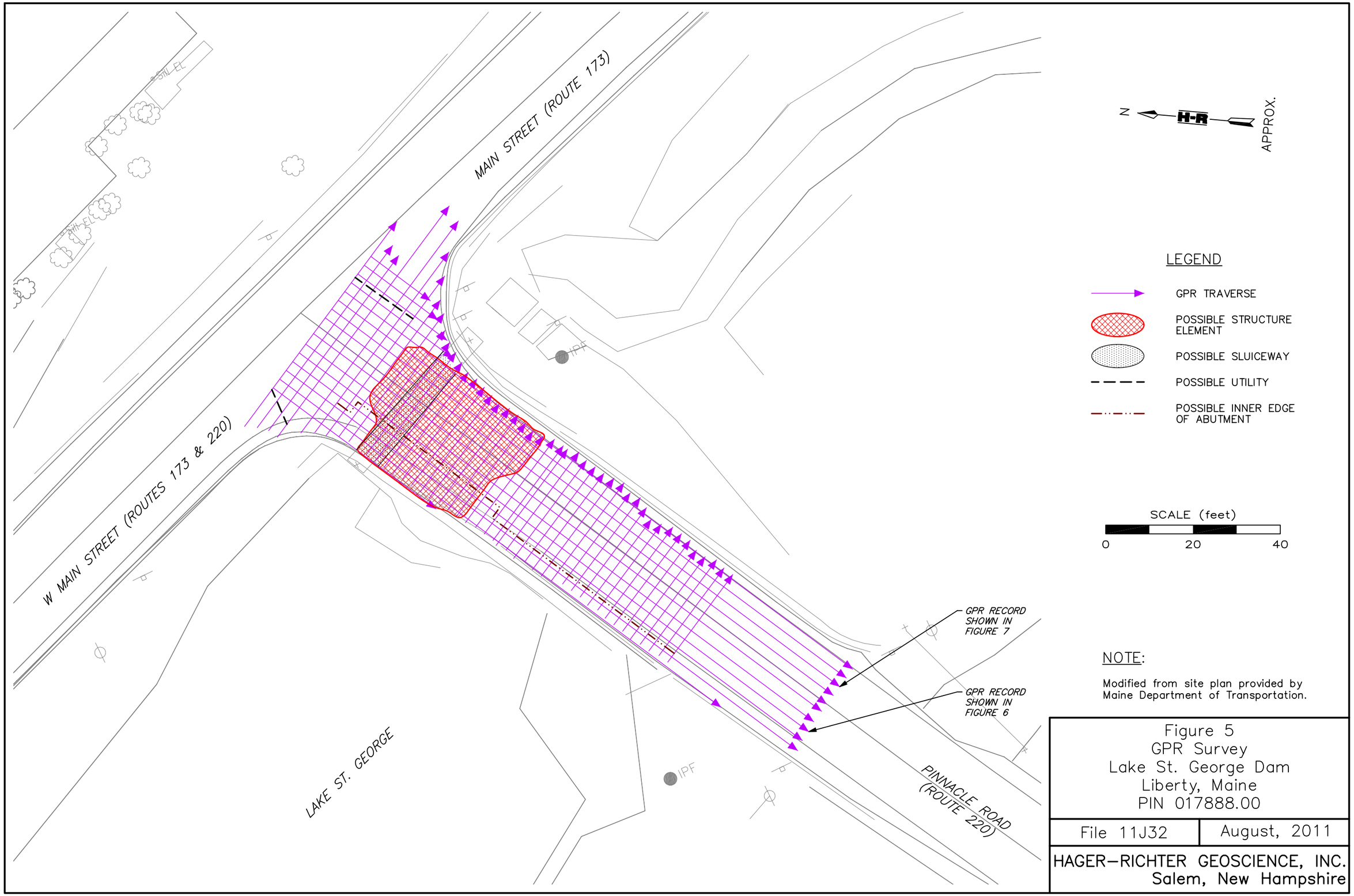
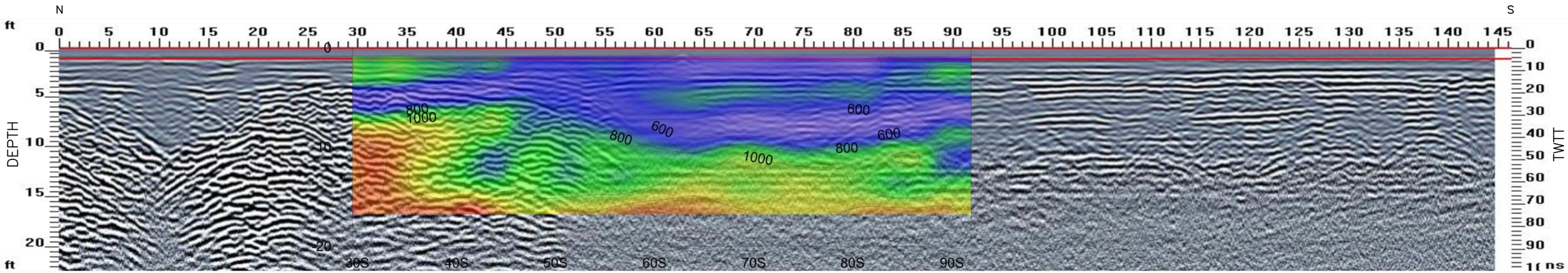
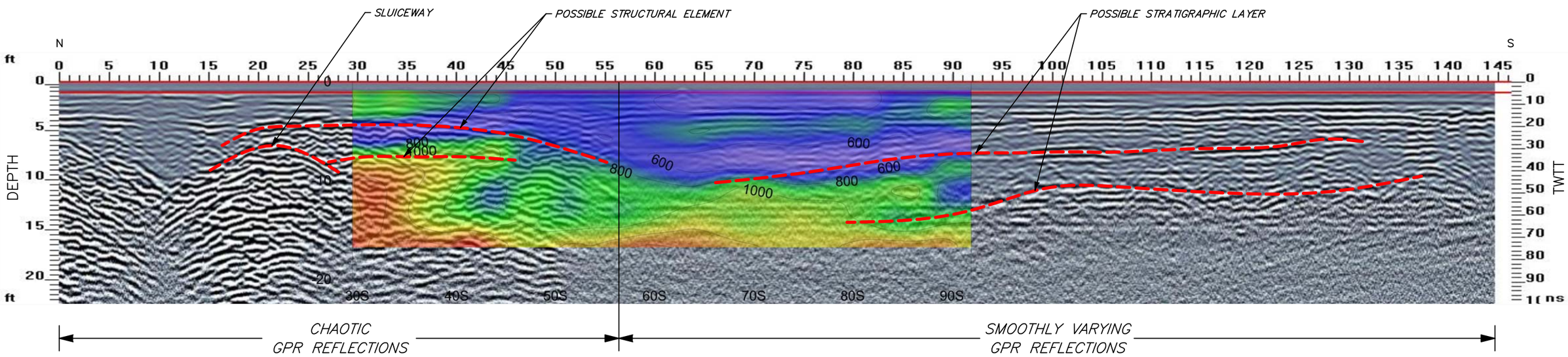


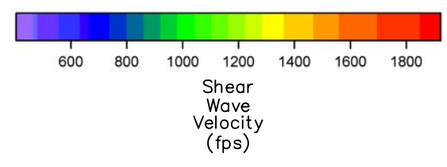
Figure 5
GPR Survey
Lake St. George Dam
Liberty, Maine
PIN 017888.00

File 11J32	August, 2011

HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire







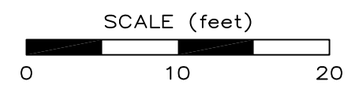
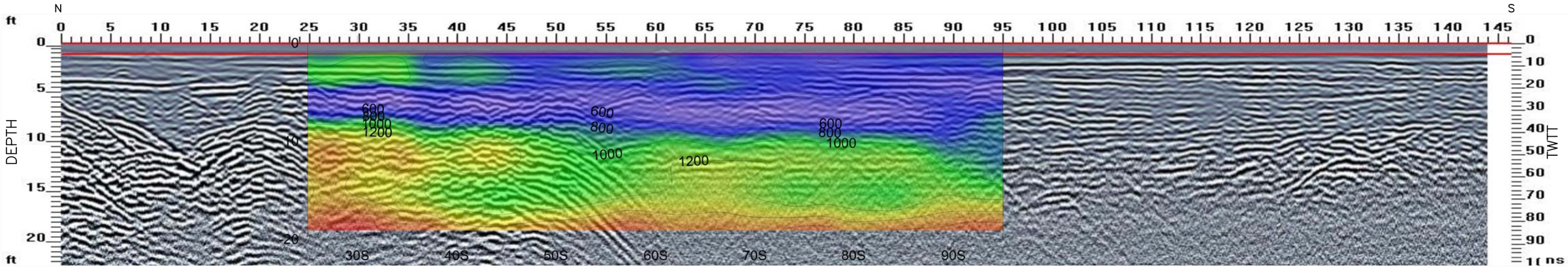
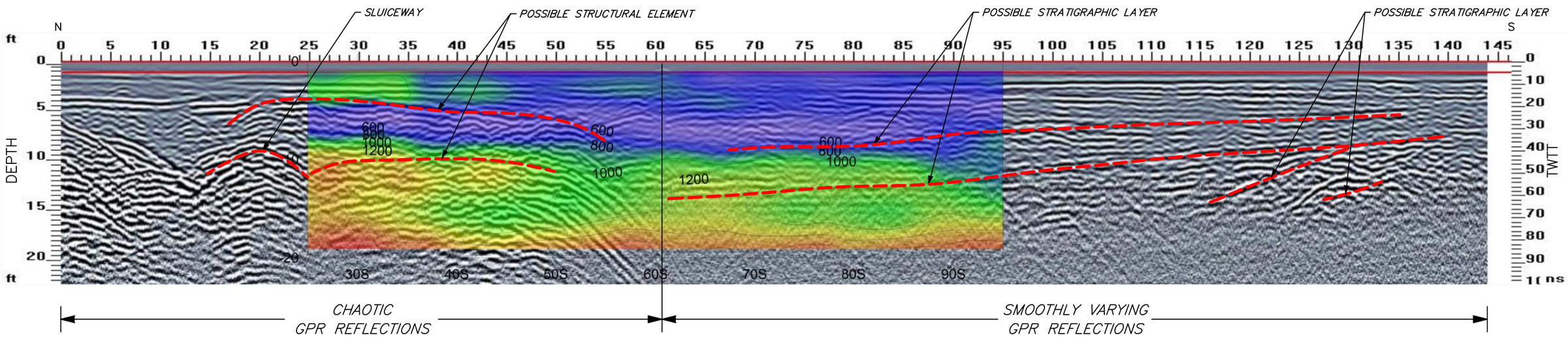


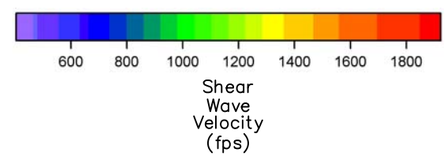
Figure 6
Example GPR Record – Line 1
Lake St. George Dam
Liberty, Maine
PIN 017888.00

File 11J32	August, 2011

HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire







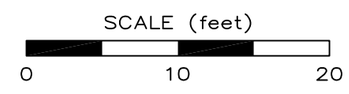


Figure 7
Example GPR Record – Line 2
Lake St. George Dam
Liberty, Maine
PIN 017888.00

File 11J32	August, 2011

HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire

APPENDIX C

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Liberty Work Number: 17888.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification		
									Unified	AASHTO	Frost
HB-LIB-201, 1D			5.25-7.25	262004	1	14.5			SM	A-2-4	II
HB-LIB-201, 2D			11.0-11.75	262005	1	12.2			SM	A-1-b	II
HB-LIB-205, 1D			0.0-2.0	262006	1	35.4			ML	A-4	IV
HB-LIB-205, 2D			5.0-7.0	262007	1	10.9			SM	A-4	III
HB-LIB-205, 3D			10.0-12.0	262008	1	11.1			SM	A-2-4	II
HB-LIB-205, 4D			15.17-16.59	262009	1	11.6			SM	A-4	III

Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT and Corps of Engineers Classification Systems.

GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98

PI = Plasticity Index as determined by AASHTO 90-96 and/or ASTM D4318-98

Maine DOT, Materials Testing & Exploration, 219 Hogan Road, Bangor, Maine 04401

GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
262004	**HB-LIB-201/1D**	**GEOTECHNICAL (DISTURBED)**	**11/17/2011**	**11/28/2011**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: Offset, ft: Dbfg, ft: **5.25-7.25**

WIN **017888.00** Town: **Liberty** Sampler: **BRESKIN, KALIA L**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	**100.0**
½ in. [12.5 mm]	**95.7**
⅜ in. [9.5 mm]	**94.0**
¼ in. [6.3 mm]	**88.9**
No. 4 [4.75 mm]	**86.1**
No. 10 [2.00 mm]	**75.9**
No. 20 [0.850 mm]	**62.7**
No. 40 [0.425 mm]	**53.7**
No. 60 [0.250 mm]	**47.5**
No. 100 [0.150 mm]	**40.8**
No. 200 [0.075 mm]	**31.7**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

14.5

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **12/1/2011**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
262005	**HB-LIB-201/2D**	**GEOTECHNICAL (DISTURBED)**	**11/17/2011**	**11/28/2011**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: Offset, ft: Dbfg, ft: **11.0-11.75**

WIN **017888.00** Town: **Liberty** Sampler: **BRESKIN, KALIA L**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	**100.0**
½ in. [12.5 mm]	**97.0**
⅜ in. [9.5 mm]	**82.0**
¼ in. [6.3 mm]	**75.2**
No. 4 [4.75 mm]	**71.9**
No. 10 [2.00 mm]	**59.0**
No. 20 [0.850 mm]	**46.9**
No. 40 [0.425 mm]	**39.3**
No. 60 [0.250 mm]	**35.0**
No. 100 [0.150 mm]	**30.1**
No. 200 [0.075 mm]	**21.6**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

12.2

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
262006	**HB-LIB-205/1D**	**GEOTECHNICAL (DISTURBED)**	**11/17/2011**	**11/28/2011**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: Offset, ft: Dbfg, ft: **0.0-2.0**

WIN **017888.00** Town: **Liberty** Sampler: **BRESKIN, KALIA L**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	
¾ in. [19.0 mm]	**100.0**
½ in. [12.5 mm]	**99.6**
⅜ in. [9.5 mm]	**99.6**
¼ in. [6.3 mm]	**98.2**
No. 4 [4.75 mm]	**96.7**
No. 10 [2.00 mm]	**90.9**
No. 20 [0.850 mm]	**83.6**
No. 40 [0.425 mm]	**77.9**
No. 60 [0.250 mm]	**73.2**
No. 100 [0.150 mm]	**67.0**
No. 200 [0.075 mm]	**58.0**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %	

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

35.4

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **12/2/2011**

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
262007	**HB-LIB-205/2D**	**GEOTECHNICAL (DISTURBED)**	**11/17/2011**	**11/28/2011**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: Offset, ft: Dbfg, ft: **5.0-7.0**

WIN **017888.00** Town: **Liberty** Sampler: **BRESKIN, KALIA L**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	**100.0**
¾ in. [19.0 mm]	**88.1**
½ in. [12.5 mm]	**87.0**
⅜ in. [9.5 mm]	**84.8**
¼ in. [6.3 mm]	**80.9**
No. 4 [4.75 mm]	**79.2**
No. 10 [2.00 mm]	**74.1**
No. 20 [0.850 mm]	**68.7**
No. 40 [0.425 mm]	**63.0**
No. 60 [0.250 mm]	**57.7**
No. 100 [0.150 mm]	**51.1**
No. 200 [0.075 mm]	**41.0**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

10.9

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
262008	**HB-LIB-205/3D**	**GEOTECHNICAL (DISTURBED)**	**11/17/2011**	**11/28/2011**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: Offset, ft: Dbfg, ft: **10.0-12.0**

WIN **017888.00** Town: **Liberty** Sampler: **BRESKIN, KALIA L**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	
1 in. [25.0 mm]	**100.0**
¾ in. [19.0 mm]	**94.3**
½ in. [12.5 mm]	**87.0**
⅜ in. [9.5 mm]	**82.3**
¼ in. [6.3 mm]	**77.3**
No. 4 [4.75 mm]	**74.4**
No. 10 [2.00 mm]	**67.0**
No. 20 [0.850 mm]	**59.4**
No. 40 [0.425 mm]	**52.7**
No. 60 [0.250 mm]	**47.0**
No. 100 [0.150 mm]	**40.3**
No. 200 [0.075 mm]	**32.6**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

11.1

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

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GEOTECHNICAL TEST REPORT
Central Laboratory

SAMPLE INFORMATION

Reference No.	Boring No./Sample No.	Sample Description	Sampled	Received
262009	**HB-LIB-205/4D**	**GEOTECHNICAL (DISTURBED)**	**11/17/2011**	**11/28/2011**

Sample Type: **GEOTECHNICAL** Location: **OTHER** Station: Offset, ft: Dbfg, ft: **15.17-16.59**

WIN **017888.00** Town: **Liberty** Sampler: **BRESKIN, KALIA L**

TEST RESULTS

Sieve Analysis (T 27, T 11)

Wash Method

Procedure A

SIEVE SIZE U.S. [SI]	% Passing
3 in. [75.0 mm]	**100.0**
1 in. [25.0 mm]	**93.3**
¾ in. [19.0 mm]	**93.3**
½ in. [12.5 mm]	**91.4**
⅜ in. [9.5 mm]	**89.7**
¼ in. [6.3 mm]	**84.7**
No. 4 [4.75 mm]	**82.9**
No. 10 [2.00 mm]	**75.9**
No. 20 [0.850 mm]	**69.1**
No. 40 [0.425 mm]	**63.3**
No. 60 [0.250 mm]	**58.2**
No. 100 [0.150 mm]	**51.5**
No. 200 [0.075 mm]	**41.9**

Direct Shear (T 236)

Shear Angle, °			
Initial Water Content, %			
Normal Stress, psi			
Wet Density, lbs/ft³			
Dry Density, lbs/ft³			
Specimen Thickness, in			

Consolidation (T 216)

Trimmings, Water Content, %

	Initial	Final		Void Ratio	% Strain
Water Content, %			Pmin		
Dry Density, lbs/ft³			Pp		
Void Ratio			Pmax		
Saturation, %			Cc/C'c		

Miscellaneous Tests

Liquid Limit @ 25 blows (T 89), %
Plastic Limit (T 90), %
Plasticity Index (T 90), %
Specific Gravity, Corrected to 20°C (T 100)

Loss on Ignition (T 267)

Loss, %	H2O, %

Water Content (T 265), %

11.6

Vane Shear Test on Shelby Tubes (Maine DOT)

Depth taken in tube, ft	3 In.		6 In.		Water Content, %	Description of Material Sampled at the Various Tube Depths
	U. Shear tons/ft²	Remold tons/ft²	U. Shear tons/ft²	Remold tons/ft²		

Comments:

AUTHORIZATION AND DISTRIBUTION

Reported by: **FOGG, BRIAN** Date Reported: **12/1/2011**

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