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REPORT ON

GEOTECHNICAL DATA REPORT
TWO-SPAN STONE ARCHES BRIDGE NO. 114
US ROUTE 7 OVER THE NESHOBE RIVER
BRANDON, VERMONT

by Haley & Aldrich, Inc.
Bedford, New Hampshire

for CLD Consulting Engineers, Inc.
Manchester, New Hampshire

File No. 41107-100
September 2015

HALEY & ALDRICH, INC.
3 Bedford Farms Drive
Bedford, NH 03110
603.625.5353

9 September 2015
File No. 41107-100

CLD Consulting Engineers, Inc.
540 North Commercial Street
Manchester, New Hampshire 03101

Attention: John Byatt, P.E.

Subject: Geotechnical Data Report
Two-Span Stone Arches Bridge No. 114
US Route 7 over the Neshobe River
Brandon, Vermont

Dear Mr. Byatt:

This data report summarizes the results of the subsurface explorations, laboratory testing, and geophysical testing for the two-span stone arches Bridge No. 114 which carries US Route 7 over the Neshobe River in Brandon, Vermont. This work was performed in accordance with our agreement dated 21 May 2015, as authorized by you.

We wish to thank you for the opportunity to work with you and your team during this phase of the project design. We look forward to our association with you as the design develops and the project advances into construction.

Please contact us if we can be of further assistance or if you wish to discuss the contents of this report.

Sincerely yours,
HALEY & ALDRICH, INC.

Meghan M. Hatton
Geotechnical Engineer

John G. DiGenova, P.E.
Vice President

Enclosures

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1. Introduction

1.1 SITE LOCATION AND SURFACE CONDITIONS

The existing Bridge No. 114 is located in the center of the Town of Brandon, Vermont and carries US Route 7 over the Neshobe River as shown on Figure 1 – Project Locus. US Route 7 at the bridge location is situated east/west and the Neshobe River is situated north/south. The area surrounding the bridge is in downtown Brandon and includes public and private businesses including the Brandon Town Hall, banks, cafes, and shops. Bedrock outcrops in the river are visible at the ground surface. A public park known as Green Park which includes a stone bench and gazebo is located to the southeast of the bridge.

1.2 EXISTING BRIDGE CONDITION

The existing bridge structure is a twin stone arch spanning the Neshobe River. The stone arches are approximately 42 ft long with a 6.5 ft long concrete extension consisting of concrete abutments, wingwall, and pier on its southern/downstream end. The concrete extension supports a 5 ft concrete sidewalk slab with concrete parapet. Each arch has a span of approximately 17.1 ft from springline to springline. The structure extends underneath US Route 7 before ending at the approximate location of the northern sidewalk. The bridge is skewed on a 15 degree angle.

In 2011, emergency repairs were performed on the east barrel of the arch structure following extensive flooding caused by Tropical Storm Irene. The repairs consisted of repointing and pressure grouting the arch stone, including mortar injections from above the arch to fill voids, as well as repairs to the downstream stone facing of arches. It is our understanding that only the first 7 to 10 ft of the east barrel was repaired.

There are concerns with the current condition of the arch structure of the bridge which include significant mortar loss, water infiltration and intrusion through the arch stones, and poor condition of the concrete extensions which has created water infiltration holes along the concrete curb. CLD is currently considering several improvement options for the arch structure to address these issues.

1.3 SCOPE OF WORK

We completed a geotechnical subsurface exploration program to address concerns with the stability of the roadway sub-slab bearing support (voids in the subgrade) and competencies of existing construction materials (soil and concrete testing).

Specifically our geotechnical engineering services included the following:

- A geophysical survey using ground penetration radar (GPR) techniques in the area of the roadway sub-slab to identify possible voids beneath the roadway/roadway sub-slab, presence or absence of the roadway sub-slab, and to identify existing utilities prior to undertaking the subsurface exploration program.

- A series of test probes in the area of the existing roadway sub-slab (eastern and western extents) to determine the concrete sub-slab areal limits and depth from the roadway sub-slab to the top of roadway. A core sample of the slab was collected to determine the thickness and condition of the slab. Soil sampling beneath the slab was performed to evaluate soil conditions.

- An additional series of test probes in the area of the existing roadway sub-slab (central area) based on findings and anomalies identified from the geophysical survey to aid in the evaluation of the areal limits and condition of the roadway sub-slab; identify the soil conditions beneath the roadway/roadway sub-slab; confirm or refute the presence of voids (identified in the geophysical survey); and collect soils for gradation testing.

- A test boring in the area of the southeast abutment to verify bearing conditions.

- A test boring in the area of the proposed retaining wall placement to evaluate soil/bedrock conditions.

- Collection of horizontal cores from the southeast abutment face for laboratory testing to aid in the evaluation of the existing abutment structure condition.

- Compressive strength and chloride ion laboratory testing on the collected concrete roadway slab cores.

- Gradation (sieves) laboratory testing on the soils collected beneath the roadway.

- Preparation of a geotechnical data report to include subsurface explorations and findings and results of laboratory testing

We note that two additional probes were initially planned to help define the geometry of the existing southeast abutment, but due to the presence of overhead utilities these probes were not performed.

2. Subsurface Explorations and Laboratory Testing

2.1 GEOPHYSICAL SURVEY

A geophysical survey using Ground Penetrating Radar (GPR) techniques was conducted at the site on 8 July 2015 by Hager-Richter Geosciences, Inc. of Salem, New Hampshire. The GPR survey was performed over a 6,000 sq. ft area which extended 20 ft northeast of the bridge to 60 ft southeast of the bridge. A representative of Haley & Aldrich was present to observe the GPR survey work. A lane closure and traffic control was provided by Green Mountain Flagging under contract to Hager-Richter. A traffic control plan was completed by CLD on 16 June 2015 and utilized for the lane closure.

The GPR survey identified 2 areas of possible disturbed soil and reinforced areas of the roadway. These areas identified from the GPR survey are shown on Figure 2.

Notably the GPR survey did not find “void space” conditions to a depth of about 4 ft beneath the existing roadway.

Results from the survey are included in the report titled “Ground Penetration Radar Survey, US Route 7 Bridge over Neshobe River, Brandon, Vermont” by Hager-Richter Geosciences, Inc. dated July 2015 which is presented in Appendix A of this report.

2.2 HORIZONTAL CORES

Briggs Engineering & Testing of Rockland, Massachusetts collected 4 horizontal cores at the southeast abutment face on 8 July 2015. A representative of Haley & Aldrich was present to observe the locations and collection of the horizontal cores. The cores were collected approximately 2 to 4 ft below the roadway slab elevation along the southeast abutment face. We note that 3 attempts were made approximately 2 ft below the roadway slab but encountered a possible cobble/boulder at a depth of 8 to 9 in. within the core. Due to existing cracking in the core samples, the samples were not suitable for compressive strength testing. A fourth attempt was made approximately 4 ft below the roadway slab where a sample approximately 8 in. long was collected and judged suitable for compressive strength testing.

2.3 TEST BORINGS

A drilling program including 5 test borings was completed during the period 4 to 6 August 2015. The test borings were completed by New England Boring Contractors, Inc. of Derry, New Hampshire. Similar to the geophysical survey work, a lane closure and traffic control was provided by Green Mountain Flagging under contract to New England Boring Contractors, Inc. The traffic control plan prepared by CLD was utilized for the lane closure.

A representative of Haley & Aldrich was present to document subsurface conditions. The test borings included 4 borings (HA-B1, HA-B1A, HA-B1B, and HA-B1C) at the area of the existing southeast abutment and 1 boring (HA-B2) at the area for the proposed future retaining wall. Locations of the test borings are presented on Figure 2.

Four attempts were made in the area of boring HA-B1 to advance the boring to natural materials but due to the presence of cobbles, boulders, granite blocks, or other obstructions the boring could not be advanced beyond 17.8 ft. It is uncertain if the boring encountered natural materials or not. The borings ranged in depth from 4.7 to 17.8 ft below existing grades.

2.4 TEST PROBES

A series of roadway probes was completed during the period of 3 to 5 August 2015. The test probes were completed by New England Boring Contractors, Inc. of Derry, New Hampshire. Similar to the geophysical survey work, a lane closure and traffic control was provided by Green Mountain Flagging under contract to New England Boring Contractors, Inc. The traffic control plan by CLD was utilized for the lane closure. A representative of Haley & Aldrich was present to document subsurface conditions. The roadway probes included 10 locations (HA-P1 through HA-P10 Alt. excluding HA-P8 and HA-P10) within the roadway area. Three probe locations (HA-P8, HA-P10, and HA-P11) were eliminated prior to the start of drilling after conversations with CLD. Locations of the roadway probes are presented on Figure 2. The roadway probes extended through the pavement asphalt, concrete roadway slab (if encountered) and were terminated in the underlying soils, with the exception of HA-P3 which was performed to identify the asphalt thickness only. The probes ranged in depth from 0.5 to 4 ft below existing grades.

2.5 LABORATORY TESTING

2.5.1 Geotechnical Laboratory Testing

Laboratory grain-size (ASTM D 422) analyses were performed on 8 soil sample recovered from the roadway probes beneath the roadway and/or roadway slab. The geotechnical laboratory testing was completed by GeoTesting Express, Inc. of Acton, Massachusetts. The results of the soil laboratory testing are presented in Appendix B.

2.5.2 Concrete Laboratory Testing

Laboratory concrete compressive strength testing was performed on 3 concrete cores collected. Chloride ion tests were performed on 4 concrete cores collected at core depths of 1 in. and 2.5 in. on each core. The concrete laboratory testing was performed by Briggs Engineering & Testing of Rockland, Massachusetts. The results of the concrete laboratory testing are presented in Appendix C.

3. Subsurface Conditions

The test borings and roadway probes encountered the following generalized soil strata at the site, in order from increasing depth below ground surface. Some strata may be missing at particular locations. We note that the roadway probes were extended just below the roadway/roadway-slab and terminated in fill soils 0.5 to 4 ft below ground surface, and other soil information below this depth for the area is based on the test borings which were extended to bedrock.

A table summarizing the thickness of asphalt, thickness of roadway slab (if encountered), and depth of exploration for the roadway probes is presented in Table I.

Asphalt: A thin layer of asphalt, ranging in thickness from 3.5 to 6 in., was encountered at each exploration location at the ground surface.

Roadway Slab: The concrete roadway slab was encountered below the asphalt at 7 of the exploration locations. The roadway slab was not observed at locations HA-P1, HA-P2, HA-B1, HA-B1A, HA-B1B, HA-B1C, and HA-B2. The roadway slab was cored at each location where encountered except HA-P3. At the locations where slab was cored it ranged from 6 to 7.5 in. thick. Three locations (HA-P4, HA-P9, and HA-P10 Alt.) encountered steel reinforcement at multiple depths along the cores. The steel reinforcement appeared to be about 0.4 in. diameter (close to a No. 3 size rebar).

Fill: The fill encountered beneath the asphalt and/or roadway slab from the probes was described as medium dense to dense well graded SAND (SW), poorly graded SAND (SP), poorly graded SAND with silt (SP-SM), well graded GRAVEL with silt (GW-GM), poorly graded GRAVEL with silt (GP-GM), poorly graded GRAVEL (GP), and/or silty SAND (SM) with varying amounts of gravel, sand, and silt. The fill was not fully penetrated at the roadway probe locations. The probes extended to depths ranging from 0.5 to 4 ft below the pavement surface.

The fill encountered beneath the asphalt at the boring locations was described as medium dense to dense poorly graded SAND (SP), silty SAND (SM), and/or poorly graded GRAVEL (GP) with varying amounts of sand, gravel, and silt. The fill was most likely fully penetrated at locations HA-B1B and HA-B2 where it was found to be 16.7 ft and 8 ft thick, respectively.

A large number of obstructions were observed in the fill at locations HA-B1, HA-B1A, HA-B1B, and HA-B1C. The obstructions were observed from 4 to 12.5 ft below the pavement surface and contained possible boulders, granite blocks, steel plates, etc. that the drilling equipment was not able to advance through. A loss of water return was also noted during the drilling through the fill at these locations. The fill in this area also contained possible brick, ceramic, glass, wood chips, and saw dust at location HA-B1B. A pocket of ORGANIC SOILS (OL/OH) was encountered from 14 to 17 ft below the pavement surface at location HA-B1B just above the probable top of bedrock. The fill was not fully penetrated at locations HA-B1, HA-B1A, and HA-B1C due to the presence of obstructions.

Forest Mat: A possible old forest mat or topsoil layer was encountered at a depth of 5 ft (El. 409.5) below the ground surface at boring location HA-B2. The layer was 3.5 ft thick and consisted of very loose to loose dark brown ORGANIC SOILS (OL/OH) and silty SAND (SM) and was directly above the bedrock.

Bedrock: Probable bedrock was encountered at 2 test borings (HA-B1B and HA-B2) at depths of 17 and 8.5 ft below ground surface (El. 397.7 and 406 respectively). The roller bit was advanced 0.8 to 1.5 ft into the probable bedrock to confirm the bedrock presence.

Based on published information for Brandon, Vermont from the United States Geological Survey (USGS), the bedrock is most likely quartzite from the Danby and Potsdam Formation or dolomite from the Gorge Formation.

Groundwater was not observed at the roadway probes or boring locations. The Neshobe River level just below the bridge is at about El. 402.6 (normal river level).

4. Closure

This report has been prepared for specific application to the two-span stone arches bridge no. 114 over the Neshobe River in Brandon, Vermont, as understood by Haley & Aldrich at this time. In the event that changes in the design or location of the project are planned, the conclusions and recommendations contained in the report should not be considered valid unless they are reviewed and modified or verified in writing by Haley & Aldrich, Inc. Our recommendations are based in part upon data obtained from the referenced subsurface exploration program. The nature and extent of variation between explorations may not become evident until construction. If significant variations then appear, it may be necessary to re-evaluate the recommendations of this report.

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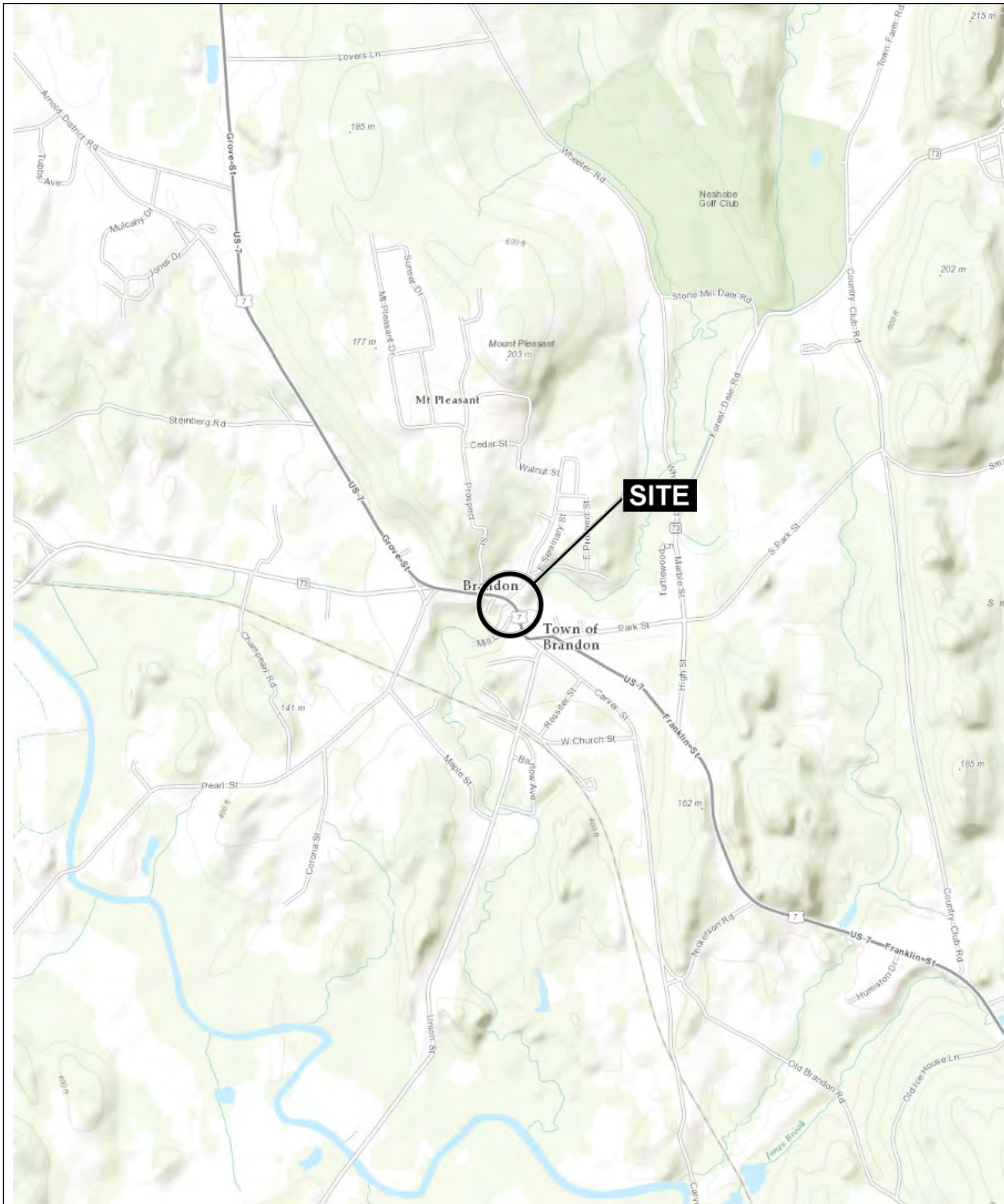
TABLE I
SUMMARY OF ROADWAY PROBE EXPLORATIONS
Two-Span Stone Arches Bridge No. 114
US Route 7 over the Neshobe River
Brandon, Vermont
File No. 41107-100

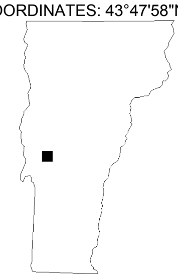
Roadway Probe Exploration No.	Approximate Thickness of Asphalt (in.)	Approximate Thickness of Concrete Slab (in.)	Depth of Probe (ft)	Notes
HA-P1	4.5	NE	0.7	
HA-P2	4	NE	0.8	
HA-P3	5.5	see note 2	0.5	
HA-P4	5	6	4.0	reinforcement observed in concrete slab core
HA-P5	4	6	3.3	
HA-P6	5	6	2.3	
HA-P7	4	6	2.8	
HA-P9	3.5	7.5	1.2	reinforcement observed in concrete slab core
HA-P10 Alt.	4	7	1.0	reinforcement observed in one of the concrete slab cores

NOTES:
1. Roadway probe exploration locations HA-P8, HA-P10, and HA-P11 were eliminated after discussions on site with CLD.
2. HA-P3 was included in the program to observe the asphalt thickness (the roadway slab was observed beneath the asphalt but no core sample or soil samples were obtained).
3. NE designates no concrete slab was encountered beneath the asphalt.
4. A second concrete core was obtained at a location directly adjacent to HA-P10 Alt. to be submitted for compressive strength laboratory testing.



MAP SOURCE: ESRI

SITE COORDINATES: 43°47'58"N, 73°5'20"W



HALEY ALDRICH

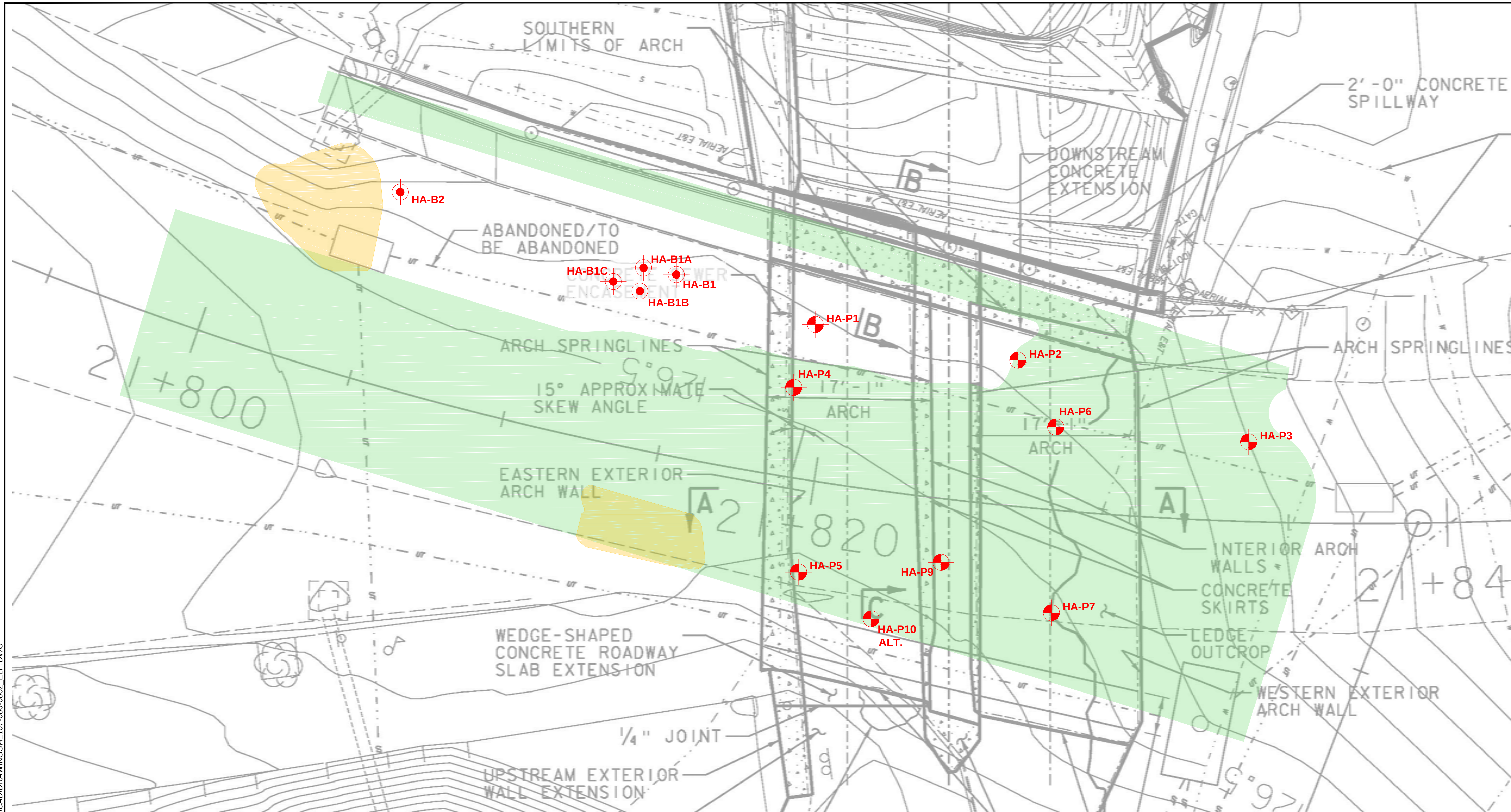
TWO-SPAN STONE ARCHES BRIDGE NO. 114
US ROUTE 7 OVER THE NESHOBE RIVER
BRANDON, VERMONT

PROJECT LOCUS

APPROXIMATE SCALE: 1 IN = 2000 FT
SEPTEMBER 2015

FIGURE 1

41107-100_1_LOCUS.PDF



LEGEND

HA-B1 — DESIGNATION AND APPROXIMATE LOCATION OF TEST BORING COMPLETED BY NEW ENGLAND BORING CONTRACTORS, INC, DURING THE PEROD 4 TO 6 AUGUST 2015

HA-P4 — DESIGNATION AND APPROXIMATE LOCATION OF TEST PROBE COMPLETED BY NEW ENGLAND BORING CONTRACTORS, INC. DURING THE PERIOD 3 TO 5 AUGUST 2015

APPROXIMATE LOCATION OF POSSIBLE DISTURBED SOILS IDENTIFIED IN GEOPHYSICAL REPORT BY HAGER-RICHTER DATED JULY 2015

APPROXIMATE LOCATION OF REINFORCED AREA IDENTIFIED IN GEOPHYSICAL REPORT BY HAGER-RICHTER DATED JULY 2015

NOTES

1. BASE PLAN WITH EXISTING GROUND SURFACE CONTOURS PROVIDED BY CLD CONSULTING ENGINEERS, INC. IN ELECTRONIC FORMAT ON 18 AUGUST 2015.
2. EXPLORATION LOCATIONS WERE LAID OUT IN THE FIELD BY A REPRESENTATIVE OF HALEY & ALDRICH BY PACING OR TAPING FROM EXISTING SITE FEATURES.
3. EXPLORATIONS WERE MONITORED IN THE FIELD BY A REPRESENTATIVE OF HALEY & ALDRICH.
4. ELEVATIONS ARE IN METERS AND REFERENCED THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

0 10 20
SCALE IN FEET

HALEY ALDRICH

TWO-SPAN STONE ARCHES BRIDGE NO. 114
US ROUTE 7 OVER THE NESHOBE RIVER
BRANDON, VERMONT

EXPLORATION LOCATION PLAN

SCALE: AS SHOWN
SEPTEMBER 2015

FIGURE 2

APPENDIX A

Geophysical Report by Hager-Richter

HAGER-RICHTER
GEOSCIENCE, INC.

GROUND PENETRATING RADAR SURVEY
US ROUTE 7 BRIDGE OVER NESHOBE RIVER
BRANDON, VERMONT

H&A File No 41107-970

Prepared for:

Haley & Aldrich, Inc.
3 Bedford Farms Drive
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Prepared by:

Hager-Richter Geoscience, Inc.
8 Industrial Way - D10
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File 15SG11
July, 2015

HAGER-RICHTER
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July 23, 2015
File 15SG11

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RE: Ground Penetrating Radar Survey
US Route 7 Bridge over Neshobe River
Brandon, Vermont
H&A File No 41107-970

Dear Ms. Hatton:

In this letter we report the results of a ground penetrating radar (GPR) survey conducted by Hager-Richter Geoscience, Inc. (Hager-Richter) at the above referenced Site as part of a geotechnical investigation of the bridge by Haley & Aldrich, Inc. (H&A) in July, 2015. The scope of the project and area of interest were specified by H&A.

INTRODUCTION

The Site is an active bridge on US Route 7 over the Neshobe River in Brandon, Vermont. The general location of the Site is shown in Figure 1. The bridge is a twin bore stone-arch bridge. According to information provided by H&A, the bridge has been adversely impacted by flooding, and settlement has occurred along the approaches for the bridge. H&A was interested in determining whether voids are present below the approaches and bridge deck.

H&A specified an area of interest (AOI) measuring about 50 feet wide by 120 feet long that extends from about 20 feet northwest of the bridge to about 60 feet southeast of the bridge. Figure 2 is a Site Plan showing the area of interest for the geophysical survey. The bridge surface in the AOI was asphalt paved. A few subtle surface depressions were visible in the pavement surface at the time of the survey and were water filled due to recent rainfall. The geophysical survey was conducted during daytime hours and included lane closures to minimize impacts to traffic.

OBJECTIVE

The objective of the geophysical survey was to detect possible voids below the roadway in the accessible portions of the specified area of interest at the site.

THE SURVEY

Michael Howley, P.G., and Michael Lavery of Hager-Richter conducted the field work on July 8, 2015. The project was coordinated with Meghan M. Hatton, P.E., of H&A. Ms. Hatton was present for the duration of the field work and specified the area of interest. Traffic control services were provided by Green Mountain Flagging, LLC.

The GPR survey was conducted across the accessible portions of the specified AOI. GPR data were acquired along parallel traverses spaced 1 foot apart oriented parallel to the travel lanes, and along parallel traverses spaced 10 feet apart oriented perpendicular to the travel lanes, as access permitted. Such tightly spaced GPR traverses are sufficient to detect voids with minimum dimensions of 1-2 feet in lateral size.

The GPR signature for voids is site specific and non-unique. Other structures or subsurface conditions may produce GPR reflections that are similar to the GPR reflections caused by voids. Whether voids are actually present can only be determined by ground truth such as through borings and/or test excavations.

EQUIPMENT AND PROCEDURES

The GPR survey was conducted using our GSSI UtilityScan DF subsurface imaging radar system. The system includes a survey wheels that trigger the recording of the data at fixed intervals, thereby increasing the accuracy of the locations of features detected along the survey lines. The GPR data were acquired simultaneously using 300 MHz and 800 MHz transmit/receive antennas.

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 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 known 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 RADAN 7, commercially licensed GPR processing software from GSSI. The GPR data were examined in both profile format and as horizontal depth slices.

LIMITATIONS OF THE METHOD

HAGER-RICHTER GEOSCIENCE, INC. MAKES NO GUARANTEE THAT ALL VOIDS, AREAS OF SOFT MATERIALS, OR OTHER TARGETS OF INTEREST WERE DETECTED IN THIS SURVEY. HAGER-RICHTER GEOSCIENCE, INC. IS NOT RESPONSIBLE FOR DETECTING TARGETS THAT CANNOT BE DETECTED DUE TO SITE CONDITIONS OR DUE TO THE LIMITATIONS OF THE GPR METHOD.

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 GPR survey was conducted along traverses spaced one foot apart along the long axis of the bridge and at 10-foot intervals along the short axis of the bridge. Figure 3 shows the locations of the GPR traverses and our interpretation of the data. Prior experience has demonstrated that GPR reflections from voids are site-specific and non-unique. Where possible, the GPR signal response at the locations of known voids is used to characterize reflection patterns at a particular site. At the subject site, however, known voids or surface depressions were not available.

GPR signal penetration for the different frequency antennae was very similar. The GPR data acquired with the 800 MHz antenna were used for interpretation due to higher resolution of the GPR records. Apparent GPR signal penetration at the Site was fair, with reflections received for approximately 20-30 ns of the 45 ns time window. Although GPR measures the time between sending and receiving EM energy, most applications of the GPR method require the depth of the reflecting objects, not the time. Thus, the velocities of propagation of EM energy in subsurface materials are required to convert time, the parameter measured, to depth, the parameter desired. Three methods are commonly used to determine velocity of the GPR signal in situ in the absence of coring: (1) fitting a hyperbola to reflections due to small objects, (2) the common mid-point method of interpretation, and (3) direct transmission through the subsurface. GPR software such as RADAN 7 has the capabilities to perform hyperbola matching, that allows determination of the velocity in situ. Using the estimated velocity for the propagation of the GPR signal yields to an average GPR signal penetration of approximately 3-4 feet.

GPR reflections typical of disturbed soils are evident in the records for two locations in the specified area of interest. Both areas are located in the approach on the southeast side of the bridge and are located in the vicinity of catch basins. Whether the disturbed soils are due to the catch basins or related storm drain lines cannot be determined on the basis of the GPR data. Figure 4 is an example of a GPR record that crosses the northern area of disturbed soils. According to information provided by H&A, the southern area of disturbed soils might be located in an area where a void was repaired in the past.

The GPR records exhibit reflections typical of reinforcement steel in the central portion of the bridge and much of the northwestern approach to the bridge. The area where reinforcing steel is inferred to be present is shown as a stippled area on Figure 3. GPR reflections typical of reinforcement are shown in the example GPR record in Figure 4. The rows of reinforcing are spaced approximately 2.5 feet apart and are oriented both parallel and perpendicular to the long axis of the bridge. GPR reflections typical of reinforcing steel are not present in the data for the areas not stippled in Figure 3.

CONCLUSIONS

Based on the geophysical survey performed by Hager-Richter for H&A at the US Route 7 Bridge over Neshobe River in Brandon, Vermont in July, 2015, we conclude:

- Two areas of disturbed soils were detected in the vicinity of catch basins in the southeast approach to the bridge.

- Reinforcement steel is present through much of the bridge deck and northwestern approach to the bridge and is spaced at approximately 2.5-foot intervals.

LIMITATIONS

This letter report was prepared for the exclusive use of Haley & Aldrich, Inc. (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.

HAGER-RICHTER
GEOSCIENCE, INC.

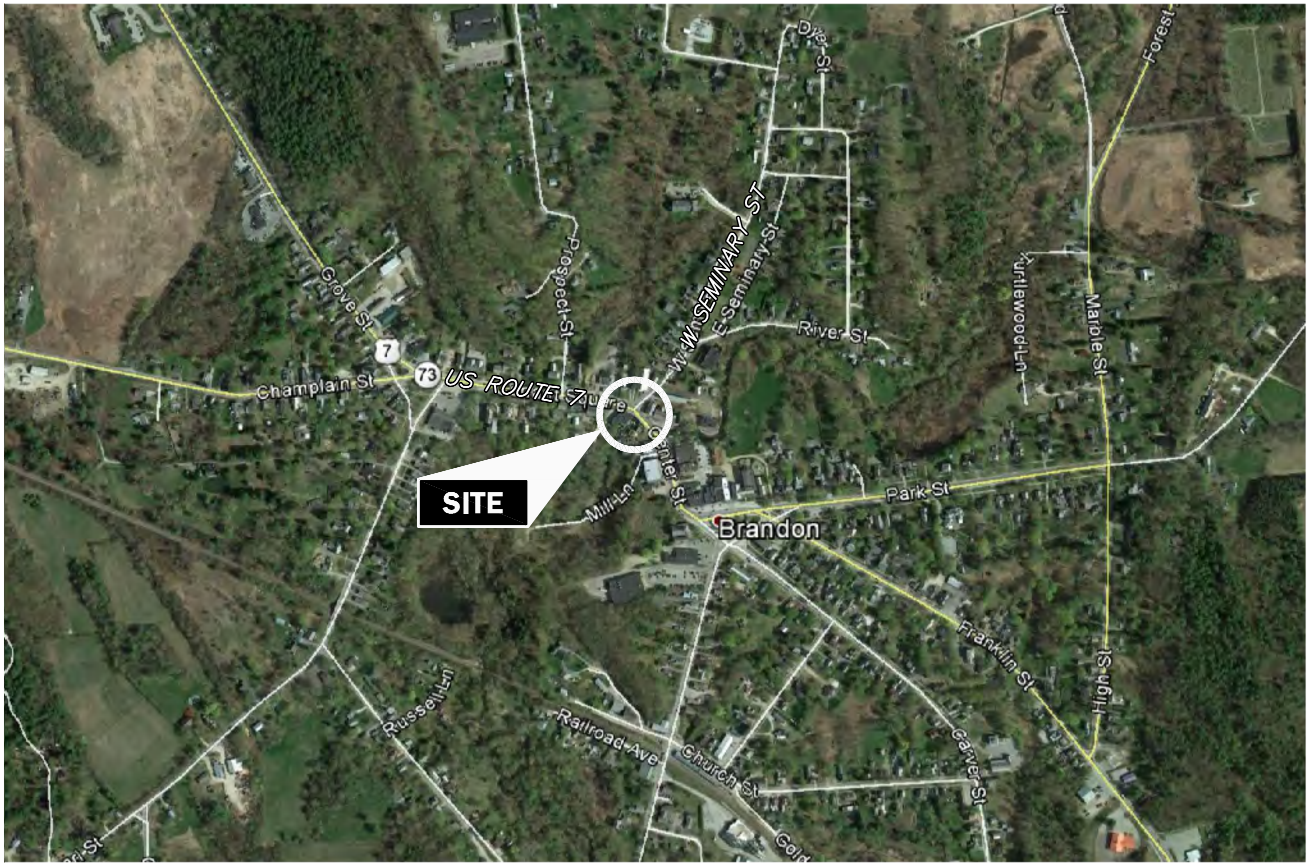
If you have any questions or comments on this letter report, please contact us at your convenience. It has been a pleasure to work with H&A on this project. We look forward to working with you again in the future.

Sincerely yours,
HAGER-RICHTER GEOSCIENCE, INC.

Jeffrey Reid, P.G.
Vice President/Senior Geophysicist

Dorothy Richter, P.G.
President

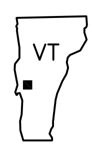
Attachments: Figures 1-4



N

APPROXIMATE SCALE (feet)

0 1000 2000



LOCATION

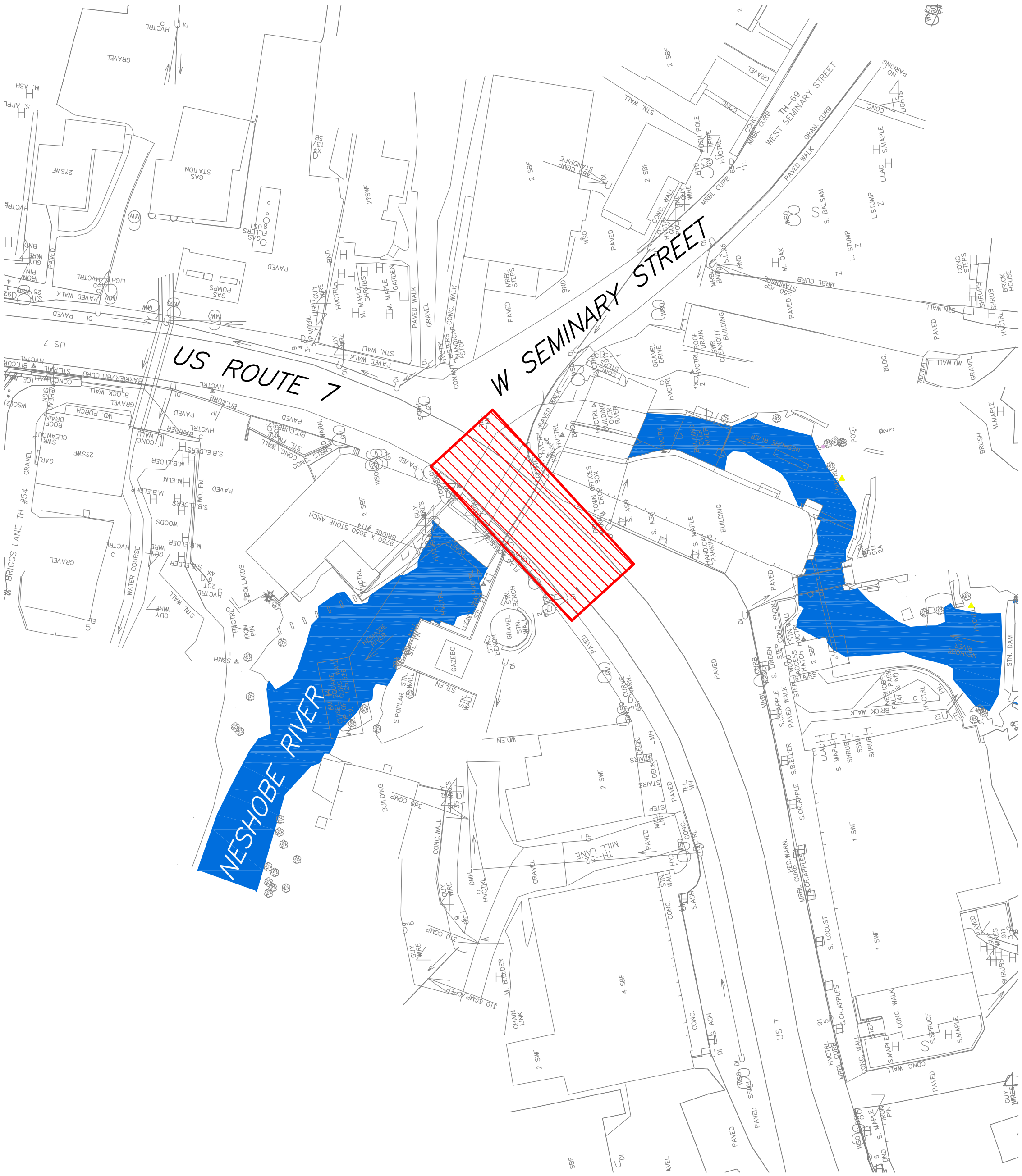
NOTE:

Modified from Google Earth Pro aerial photograph.

Figure 1
General Site Location
US Route 7 Bridge Over Neshobe River
Brandon, Vermont

File 15SG11	July, 2015

HAGER-RICHTER GEOSCIENCE, INC.
Salem, New Hampshire



LEGEND

APPROXIMATE LIMITS OF GPR SURVEY AREA

SCALE (feet)

0 100 200

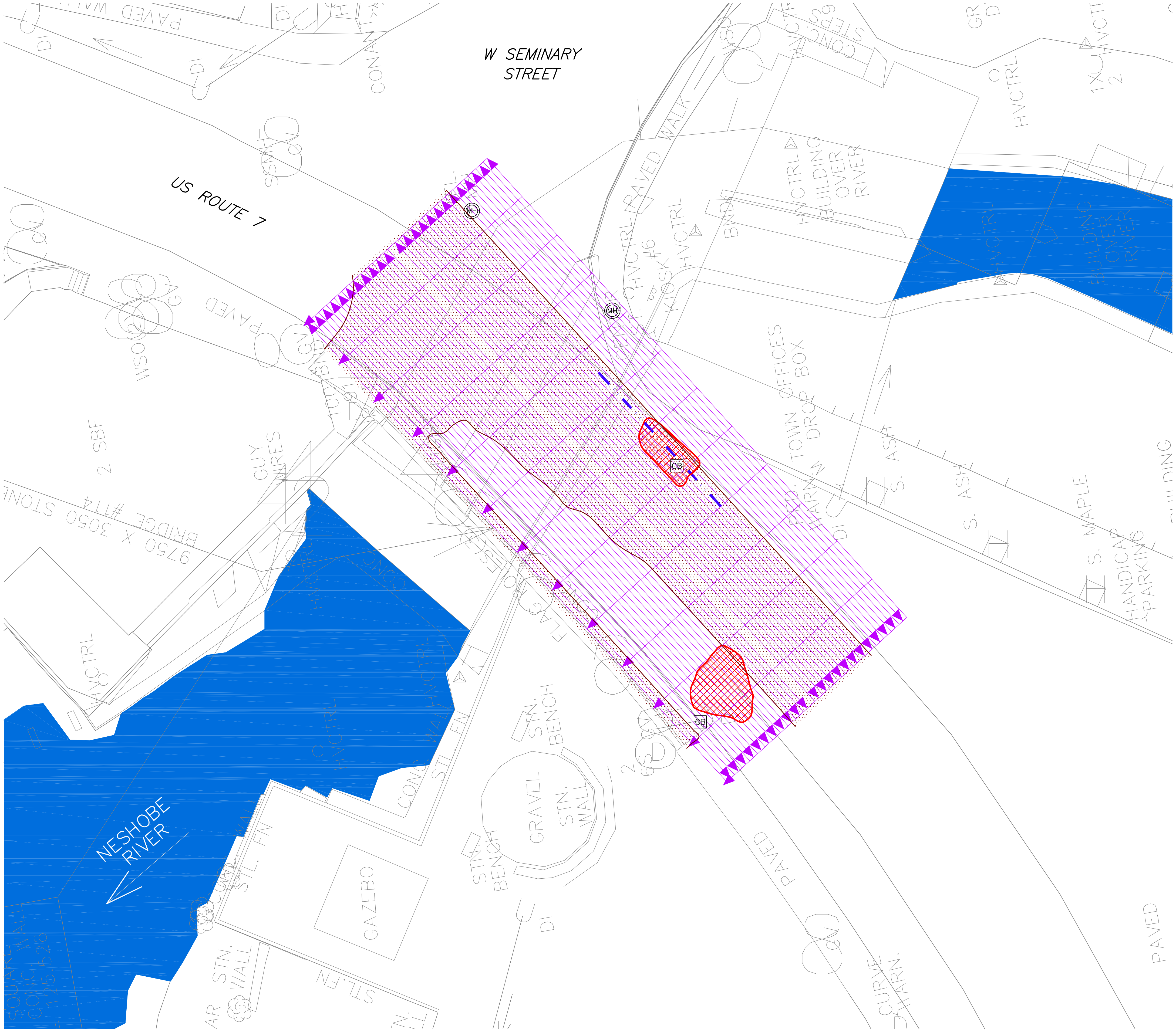
NOTE:

Modified from site plan provided by Haley & Aldrich, Inc. identified as zb008top-6.dgn.

Figure 2
Site Plan
US Route 7 Bridge Over Neshobe River
Brandon, Vermont

File 15SG11	July, 2015

HAGER-RICHTER GEOSCIENCE, INC.
Salem, New Hampshire



N

LEGEND

- GPR TRAVERSE
- PORTION OF GPR TRAVERSE SHOWN IN FIGURE 4
- AREA OF POSSIBLE DISTURBED SOILS
- REINFORCED AREA
- MANHOLE
- CATCH BASIN

SCALE (feet)

0 20 40

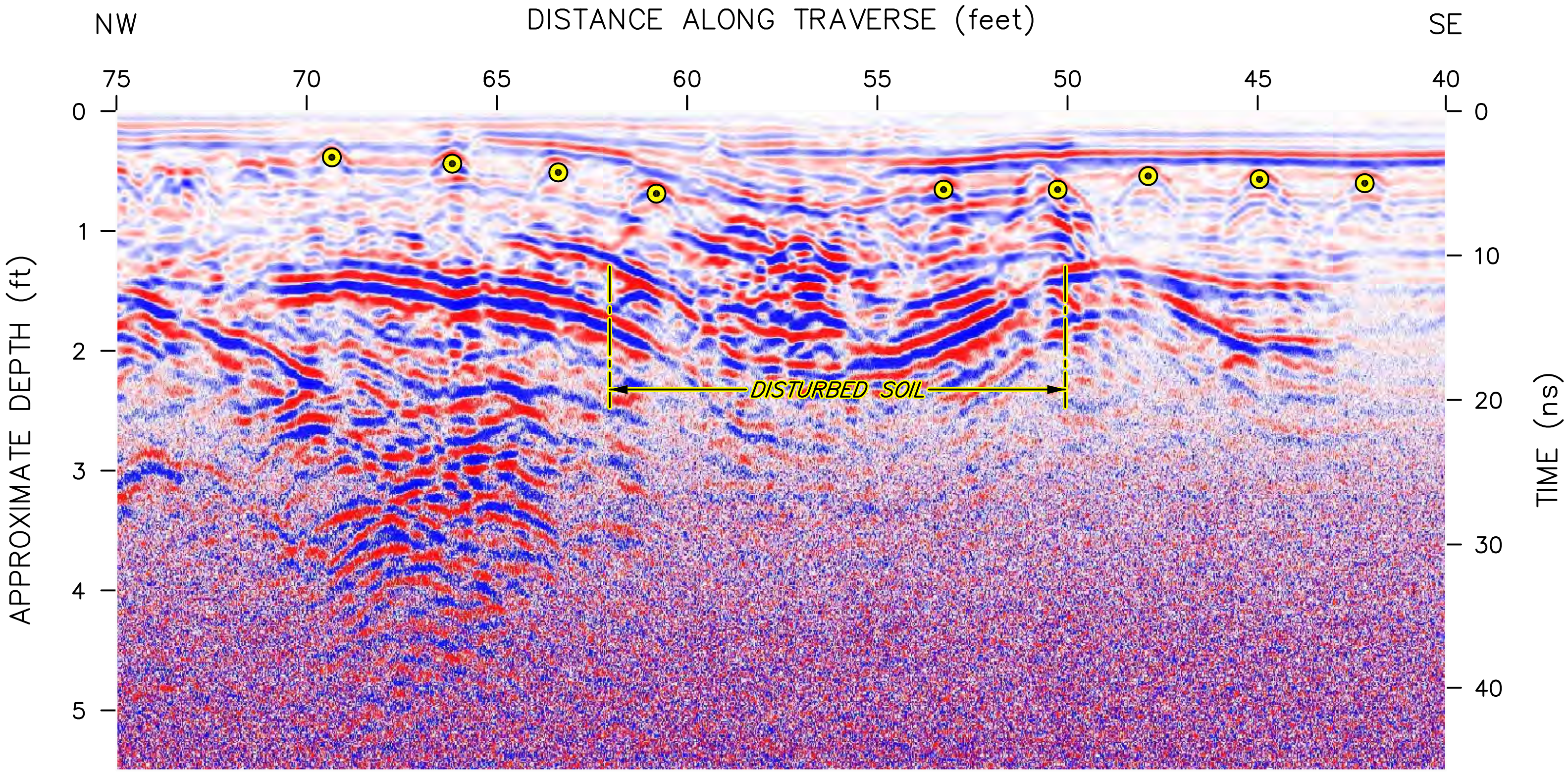
NOTE:

Modified from site plan provided by Haley & Aldrich, Inc. identified as zb008top-6.dgn.

Figure 3
GPR Survey
US Route 7 Bridge Over Neshobe River
Brandon, Vermont

File 15SG11	July, 2015

HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire



LEGEND

⊙ REINFORCING STEEL

HORIZONTAL SCALE (feet)

0 5 10

NOTES:

1. GPR data were acquired using a GSSI UtilityScan DF digital dual-frequency system using both 300MHz & 800 MHz antennas with 90 ns & 45 ns time windows, respectively. 800 MHz data shown above.
2. Location of GPR record shown in Figure 3.

Figure 4 Example GPR Record US Route 7 Bridge Over Neshobe River Brandon, Vermont	
File 15SG11	July, 2015
HAGER–RICHTER GEOSCIENCE, INC. Salem, New Hampshire	

APPENDIX B

Geotechnical Laboratory Test Results

GeoTesting
EXPRESS

Technologies to manage risk for infrastructure

Boston
Atlanta
Chicago
Los Angeles
New York
www.geotesting.com

Transmittal

TO:

Meghan Hatton
Haley & Aldrich, Inc.
3 Bedford Farms Drive
Bedford, NH 03110

DATE: 8/27/2015	GTX NO: 303588
RE: Bridge No. 114, US Route 7 over the Neshobe River	

COPIES	DATE	DESCRIPTION
	8/27/2015	**August 2015 Laboratory Test Report**

REMARKS:

SIGNED: ______________________

Joe Tomei, Laboratory Manager

CC:

APPROVED BY: ______________________

Mark Dobday, P.G., Laboratory Manager

GeoTesting
EXPRESS
Technologies to manage risk for infrastructure

Boston
Atlanta
Chicago
Los Angeles
New York
www.geotesting.com

August 27, 2015

Meghan Hatton
Haley & Aldrich, Inc.
3 Bedford Farms Drive
Bedford, NH 03110

RE: Bridge No. 114, US Route 7 over the Neshobe River, Brandon, VT (GTX-303588)

Dear Meghan:

Enclosed are the test results you requested for the above referenced project. GeoTesting Express, Inc. (GTX) received eight samples from you on 8/13/2015. These samples were labeled as follows:

Boring	Sample	Depth
HA-P1	S1	0.4-0.7 ft
HA-P2	S1	0.3-0.8 ft
HA-P4	S1 and S2	1.0-4.0 ft
HA-P5	S1	0.8-2.8 ft
HA-P6	S1	1.3-2.3 ft
HA-P7	S1	0.8-2.8 ft
HA-P9	S1	0.9-1.2 ft
HA-P10 Alt.	S1	0.9-1.0 ft

GTX performed the following test on each of these samples:

ASTM D422 - Grain Size Analysis - Sieve Only

A copy of your test request is attached.

The results presented in this report apply only to the items tested. This report shall not be reproduced except in full, without written approval from GeoTesting Express. The remainder of these samples will be retained for a period of sixty (60) days and will then be discarded unless otherwise notified by you. Please call me if you have any questions or require additional information. Thank you for allowing GeoTesting Express the opportunity of providing you with testing services. We look forward to working with you again in the future.

Respectfully yours,

Joe Tomei
Laboratory Manager

GeoTesting
EXPRESS

Technologies to manage risk for infrastructure

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Los Angeles
New York
www.geotesting.com

Geotechnical Test Report **8/27/2015**

GTX-303588

Bridge No. 114, US Route 7 over the Neshobe River

Brandon, VT

Client Project No.: 41107-100

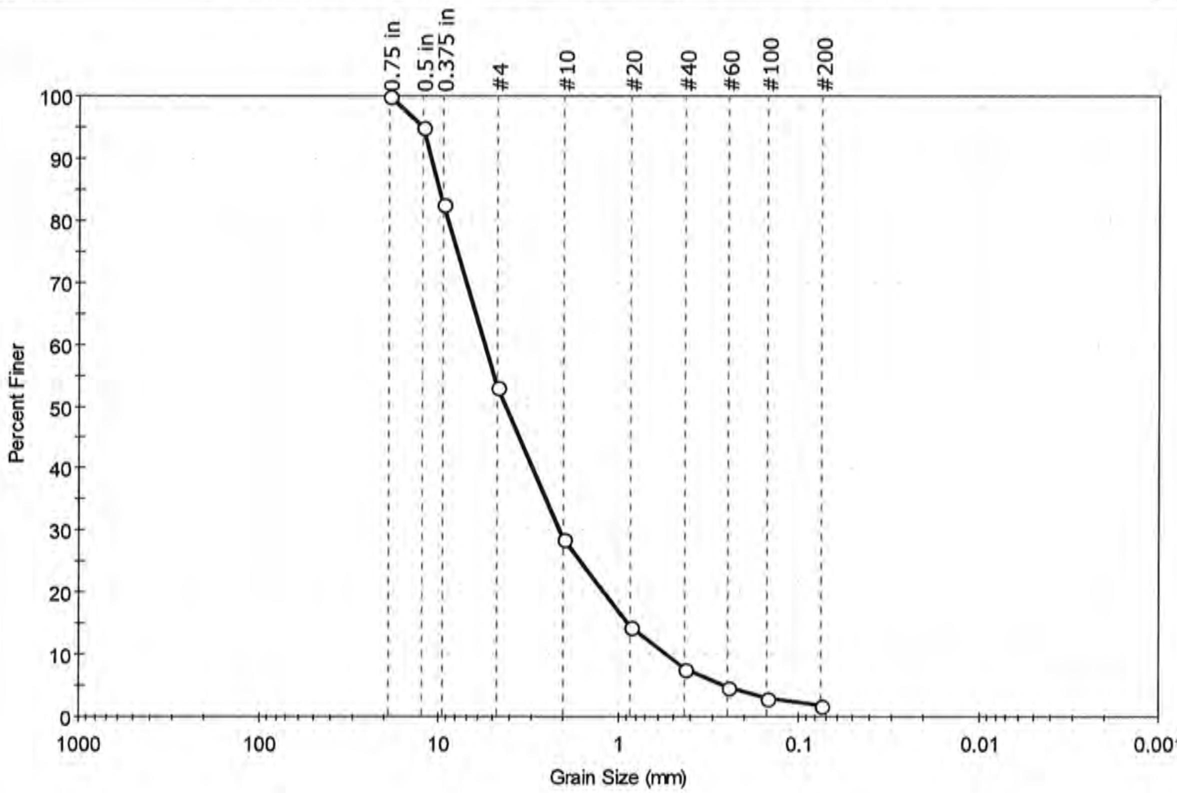
Prepared for:

Haley & Aldrich, Inc.

GeoTesting EXPRESS

Client:	Haley & Aldrich, Inc.				
Project:	Bridge No. 114, US Route 7 over the Neshobe River				
Location:	Brandon, VT			Project No:	GTX-303588
Boring ID:	HA-P1	Sample Type:	bag	Tested By:	jbr
Sample ID:	S1	Test Date:	08/20/15	Checked By:	emm
Depth :	0.4-0.7 ft	Test Id:	343813		
Test Comment:	---				
Visual Description:	Moist, dark gray sand with gravel				
Sample Comment:	--				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	47.0	51.2	1.8

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	95		
0.375 in	9.50	83		
#4	4.75	53		
#10	2.00	29		
#20	0.85	14		
#40	0.42	8		
#60	0.25	5		
#100	0.15	3		
#200	0.075	1.8		

Coefficients

D_{85} = 10.0381 mm D_{30} = 2.1022 mm

D_{60} = 5.6030 mm D_{15} = 0.8815 mm

D_{50} = 4.2771 mm D_{10} = 0.5366 mm

C_u = 10.442 C_c = 1.470

Classification

ASTM Well-graded sand with gravel (SW)

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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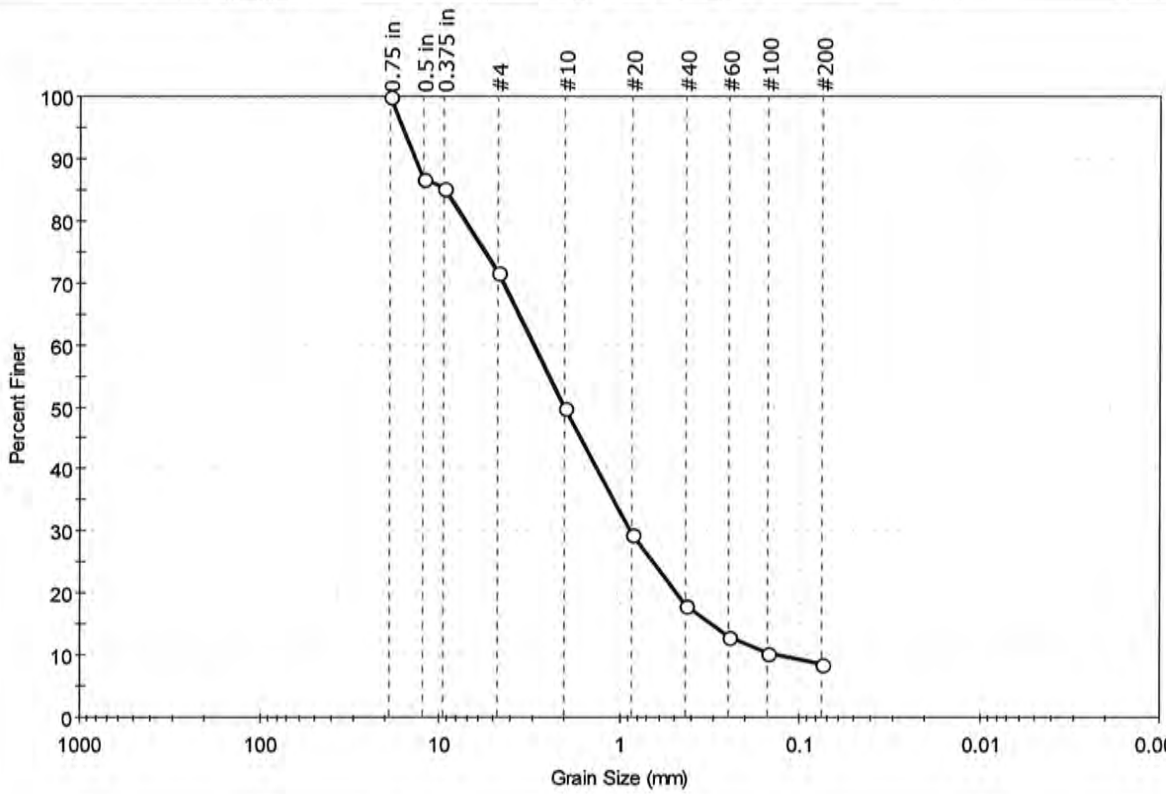
Client:	Haley & Aldrich, Inc.				
Project:	Bridge No. 114, US Route 7 over the Neshobe River				
Location:	Brandon, VT			Project No:	GTX-303588
Boring ID:	HA-P2	Sample Type:	bag	Tested By:	jbr
Sample ID:	S1	Test Date:	08/20/15	Checked By:	emm
Depth :	0.3-0.8 ft	Test Id:	343810		

Test Comment: ---

Visual Description: Moist, black sand with silt and gravel

Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	28.4	63.1	8.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	87		
0.375 in	9.50	85		
#4	4.75	72		
#10	2.00	50		
#20	0.85	29		
#40	0.42	18		
#60	0.25	13		
#100	0.15	10		
#200	0.075	8.5		

Coefficients

D_{85} =9.3231 mm	D_{30} =0.8710 mm
D_{60} =2.9998 mm	D_{15} =0.3094 mm
D_{50} =2.0197 mm	D_{10} =0.1321 mm
C_u =22.709	C_c =1.914

Classification

ASTM N/A

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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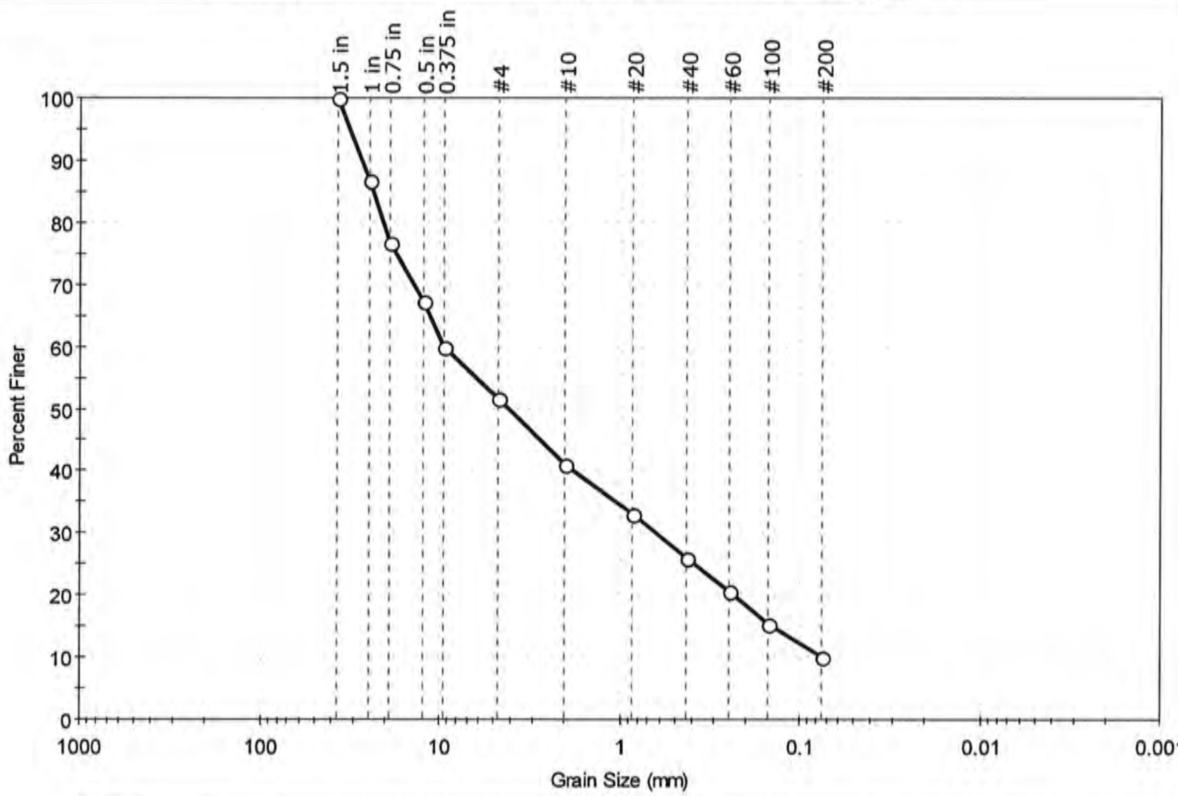
GeoTesting EXPRESS

Client:	Haley & Aldrich, Inc.				
Project:	Bridge No. 114, US Route 7 over the Neshobe River				
Location:	Brandon, VT			Project No:	GTX-303588
Boring ID:	HA-P4	Sample Type:	bag	Tested By:	jbr
Sample ID:	S1 and S2	Test Date:	08/20/15	Checked By:	emm
Depth :	1.0-4.0 ft	Test Id:	343807		
Test Comment:	---				
Visual Description:	Moist, dark yellowish brown gravel with silt and sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	48.5	41.5	10.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	87		
0.75 in	19.00	77		
0.5 in	12.50	67		
0.375 in	9.50	60		
#4	4.75	51		
#10	2.00	41		
#20	0.85	33		
#40	0.42	26		
#60	0.25	21		
#100	0.15	15		
#200	0.075	10		

Coefficients

D_{85} =23.7908 mm D_{30} =0.6299 mm
D_{60} =9.5194 mm D_{15} =0.1435 mm
D_{50} =4.2029 mm D_{10} =N/A
C_u =N/A C_c =N/A

Classification

ASTM N/A

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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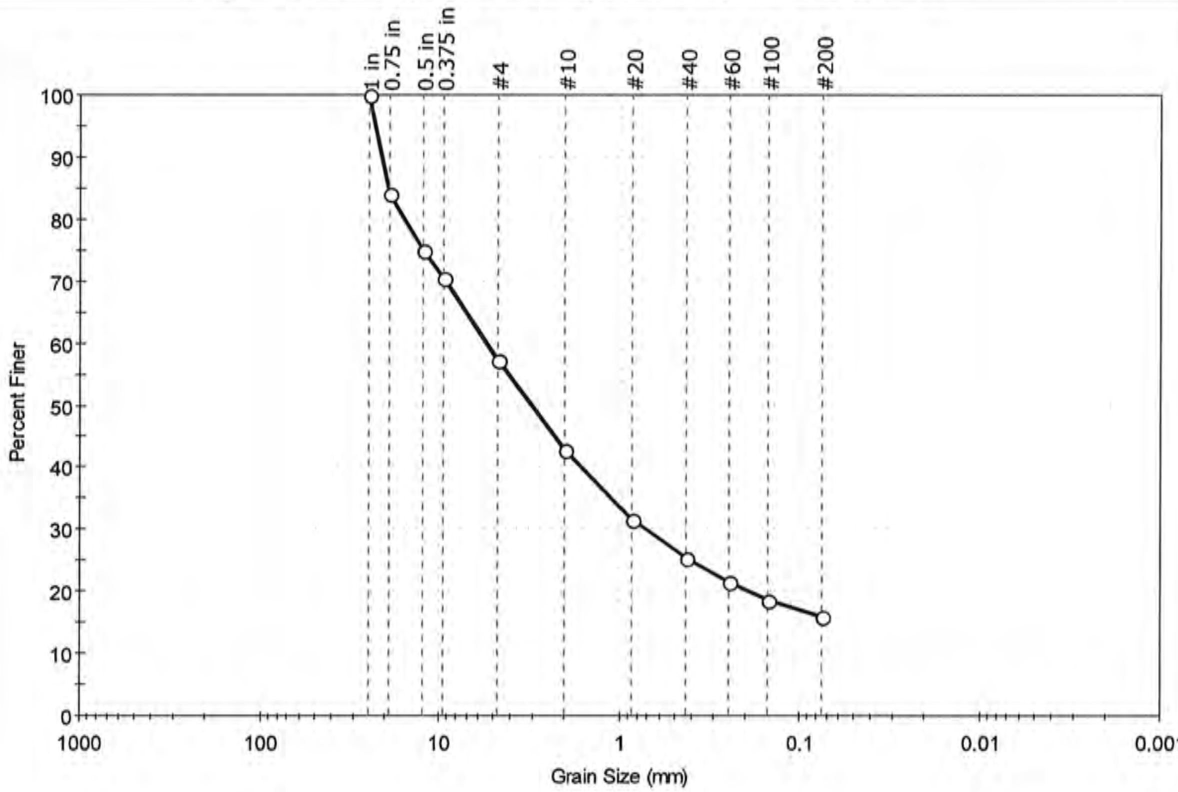
GeoTesting EXPRESS

Client:	Haley & Aldrich, Inc.		
Project:	Bridge No. 114, US Route 7 over the Neshobe River		
Location:	Brandon, VT	Project No:	GTX-303588
Boring ID: HA-P5	Sample Type: bag	Tested By:	jbr
Sample ID: S1	Test Date: 08/20/15	Checked By:	emm
Depth : 0.8-2.8 ft	Test Id: 343811		
Test Comment:	---		
Visual Description:	Moist, grayish brown silty gravel with sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	42.8	41.3	15.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	84		
0.5 in	12.50	75		
0.375 in	9.50	71		
#4	4.75	57		
#10	2.00	43		
#20	0.85	32		
#40	0.42	25		
#60	0.25	22		
#100	0.15	19		
#200	0.075	16		

Coefficients

D_{85} =19.3058 mm	D_{30} =0.7111 mm
D_{60} =5.4960 mm	D_{15} =N/A
D_{50} =3.0822 mm	D_{10} =N/A
C_u =N/A	C_c =N/A

Classification

ASTM N/A

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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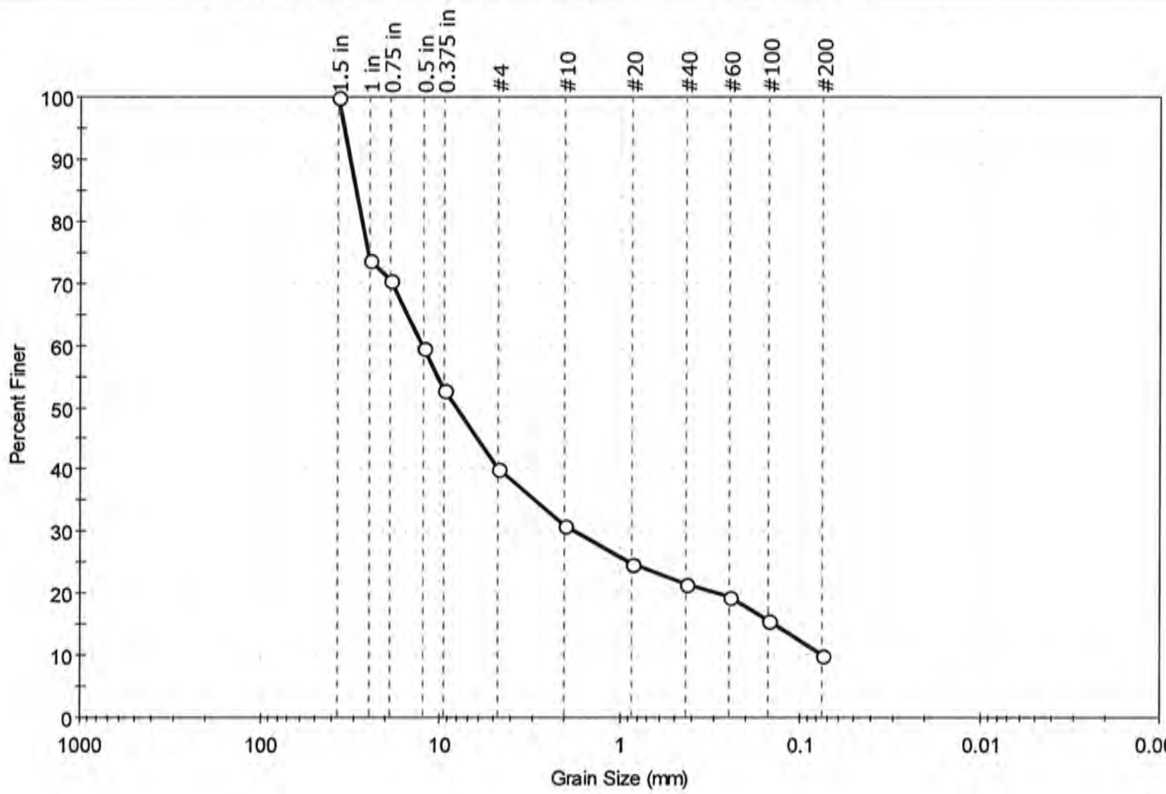
Client:	Haley & Aldrich, Inc.		
Project:	Bridge No. 114, US Route 7 over the Neshobe River		
Location:	Brandon, VT	Project No:	GTX-303588
Boring ID: HA-P6	Sample Type: bag	Tested By:	jbr
Sample ID: S1	Test Date: 08/20/15	Checked By:	emm
Depth : 1.3-2.3 ft	Test Id: 343812		
Test Comment:	---		
Visual Description:	Moist, pale yellow gravel with silt and sand		
Sample Comment:	---		

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	59.9	30.0	10.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1.5 in	37.50	100		
1 in	25.00	74		
0.75 in	19.00	71		
0.5 in	12.50	60		
0.375 in	9.50	53		
#4	4.75	40		
#10	2.00	31		
#20	0.85	25		
#40	0.42	22		
#60	0.25	20		
#100	0.15	15		
#200	0.075	10		

Coefficients

D_{85} = 29.7690 mm D_{30} = 1.7713 mm
D_{60} = 12.6785 mm D_{15} = 0.1409 mm
D_{50} = 8.1391 mm D_{10} = N/A
C_u = N/A C_c = N/A

Classification

ASTM N/A

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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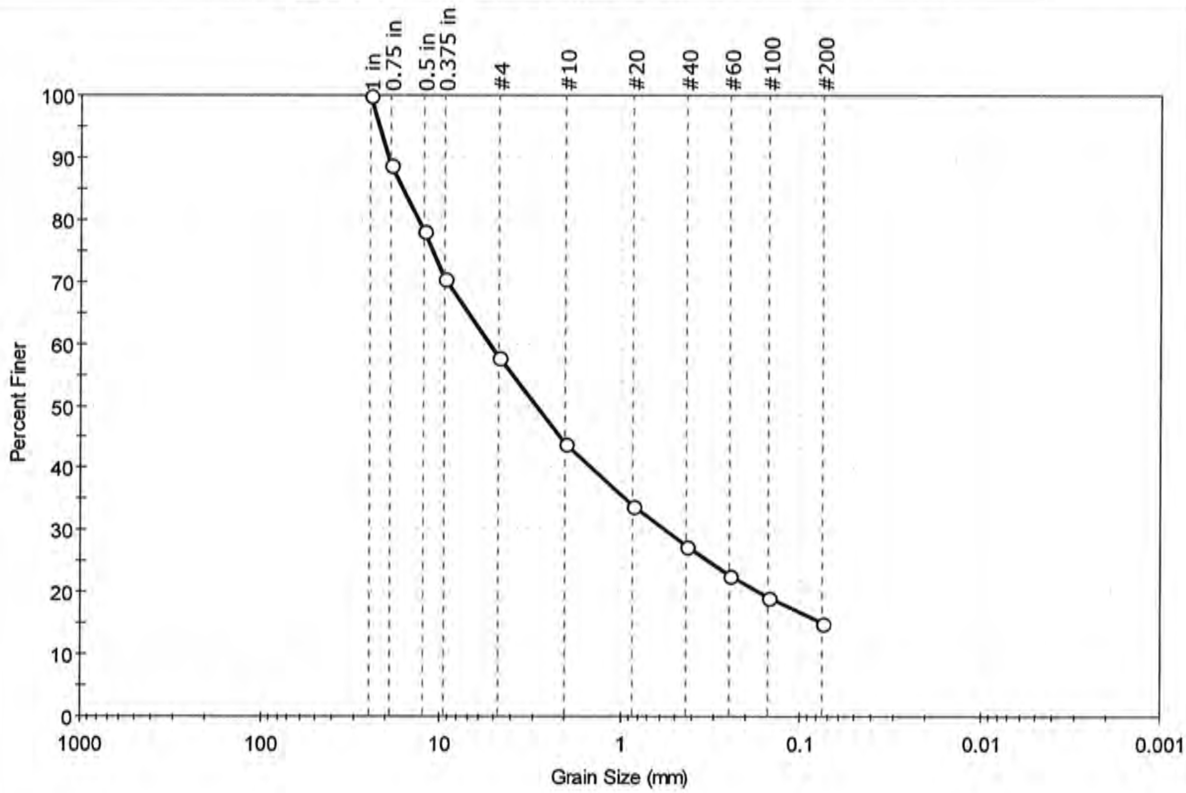
GeoTesting EXPRESS

Client:	Haley & Aldrich, Inc.				
Project:	Bridge No. 114, US Route 7 over the Neshobe River				
Location:	Brandon, VT			Project No:	GTX-303588
Boring ID:	HA-P7	Sample Type:	bag	Tested By:	jbr
Sample ID:	S1	Test Date:	08/20/15	Checked By:	emm
Depth :	0.8-2.8 ft	Test Id:	343808		

Test Comment: ---
Visual Description: Moist, very dark brown silty sand with gravel
Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	42.2	42.7	15.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	89		
0.5 in	12.50	78		
0.375 in	9.50	70		
#4	4.75	58		
#10	2.00	44		
#20	0.85	34		
#40	0.42	27		
#60	0.25	23		
#100	0.15	19		
#200	0.075	15		

Coefficients

D_{85} = 16.3091 mm	D_{30} = 0.5578 mm
D_{60} = 5.3710 mm	D_{15} = N/A
D_{50} = 2.9324 mm	D_{10} = N/A
C_u = N/A	C_c = N/A

Classification

ASTM N/A

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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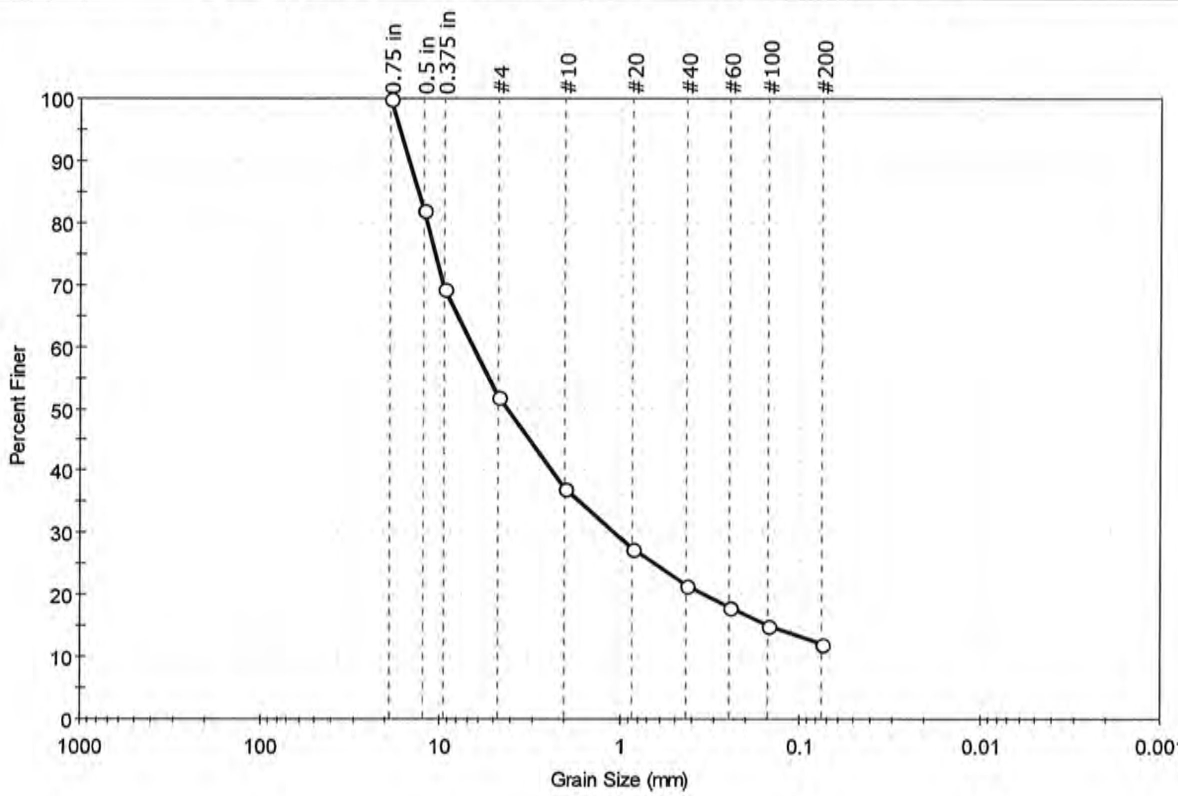
GeoTesting EXPRESS

Client:	Haley & Aldrich, Inc.				
Project:	Bridge No. 114, US Route 7 over the Neshobe River				
Location:	Brandon, VT			Project No:	GTX-303588
Boring ID:	HA-P9	Sample Type:	bag	Tested By:	jbr
Sample ID:	S1	Test Date:	08/20/15	Checked By:	emm
Depth :	0.9-1.2 ft	Test Id:	343814		
Test Comment:	---				
Visual Description:	Moist, very dark brown silty gravel with sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	48.1	39.7	12.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	82		
0.375 in	9.50	69		
#4	4.75	52		
#10	2.00	37		
#20	0.85	27		
#40	0.42	22		
#60	0.25	18		
#100	0.15	15		
#200	0.075	12		

Coefficients

D_{85} =13.3782 mm
D_{30} =1.0675 mm
D_{60} =6.5389 mm
D_{15} =0.1452 mm
D_{50} =4.2468 mm
D_{10} =N/A
C_u =N/A
C_c =N/A

Classification

ASTM N/A

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

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

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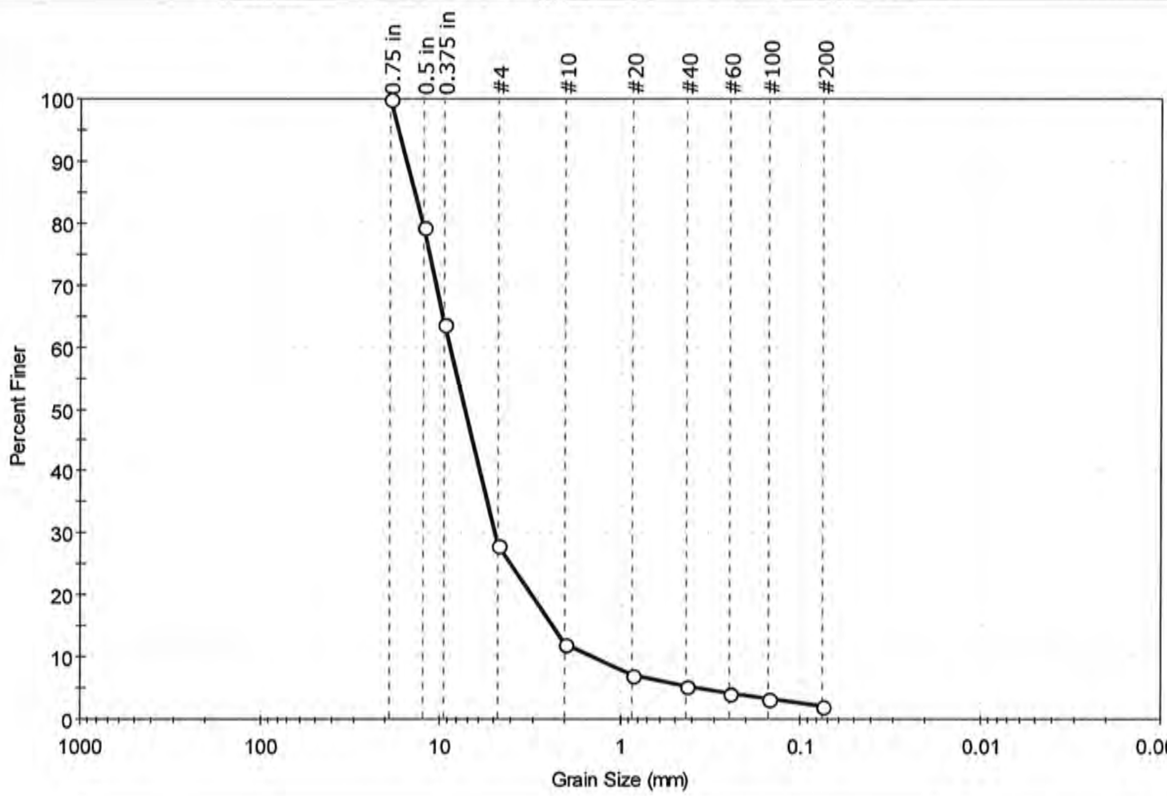
Client:	Haley & Aldrich, Inc.				
Project:	Bridge No. 114, US Route 7 over the Neshobe River				
Location:	Brandon, VT			Project No:	GTX-303588
Boring ID:	HA-P10 Alt.	Sample Type:	bag	Tested By:	jbr
Sample ID:	S1	Test Date:	08/20/15	Checked By:	emm
Depth :	0.9-1.0 ft	Test Id:	343809		

Test Comment: ---

Visual Description: Moist, dark grayish brown gravel with sand

Sample Comment: ---

Particle Size Analysis - ASTM D422



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	72.0	25.9	2.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	79		
0.375 in	9.50	64		
#4	4.75	28		
#10	2.00	12		
#20	0.85	7		
#40	0.42	5		
#60	0.25	4		
#100	0.15	3		
#200	0.075	2.1		

Coefficients

D_{85} = 14.0115 mm | D_{30} = 4.9357 mm

D_{60} = 8.8426 mm | D_{15} = 2.3473 mm

D_{50} = 7.2807 mm | D_{10} = 1.4014 mm

C_u = 6.310 | C_c = 1.966

Classification

ASTM Well-graded gravel with sand (GW)

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

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

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GeoTesting
EXPRESS

SOIL CHAIN OF CUSTODY & TEST REQUEST

GeoTesting Express, Inc.
125 Nagog Park
Acton, MA 01720
800 434 1062 Toll Free
978 635 0266 Fax

2358 Perimeter Park Drive, Suite 320
Atlanta, GA 30341
770 645 6575 Tel
770 645 6570 Fax

www.geotesting.com

CLIENT	
Company: Haley & Aldrich	
Address: 3 Bedford Farms Drive	
City, State, Zip: Bedford, NH 03110	
Contact: Meghan Hatton	Phone: 603 391 3326
E-mail: mhatton@haleyaldrich.com	Cell: 857 383 8603

INVOICE (complete if different from Client)	
Company:	
Address:	
City, State, Zip:	
Contact:	Phone:
E-mail:	Cell:

PROJECT		
Project Name: Bridge No. 114, US Route 7 over the Neshobe River	Client Project #: 41107-100	Purchase Order#:
Project Location: Brandon, VT	GTX Sales Order #:	Requested Turnaround:
On-site Contact:	E-mail:	Phone:

Boring ID	Sample ID	Depth	Atterberg Limits (ASTM D 4318)	USCS – Classification (ASTM D 2487)	Grain Size: ASTM D 422 ☒ Sieve Only ☒ Sieve & Hydrometer ☐	Density: ASTM D 2937 ☐ ASTM D 7263 ☐	Moisture Content (ASTM D 2216)	Organic Content (ASTM D 2974)	pH (ASTM D 4972)	Specific Gravity (ASTM D 854)	Electrical Resistivity (ASTM G 57)	Proctor Compaction: Standard – ASTM D 698 ☐ Modified – ASTM D 1557 ☐	California Bearing Ratio* (ASTM D 1883)	Direct Shear* (ASTM D 3080)	Triaxial Shear*: UU – ASTM D 2850 ☐ CU – ASTM D 4767 ☐ CD – ASTM D7181 ☐	Incremental Consolidation* (ASTM D 2435)	Permeability/ Hydraulic Conductivity*: Fixed Wall – ASTM D 2434 ☐ Flexible Wall – ASTM D 5084 ☐	Unconfined Compression (ASTM D 2166)	Other:	Other:
HA-P4	S1 and S2	1.0-4.0 ft			x															
HA-P7	S1	0.8-2.8 ft			x															
HA-P10 Alt.	S1	0.9-1.0 ft			x															
HA-P2	S1	0.3-0.8 ft			x															
HA-P5	S1	0.8-2.8 ft			x															
HA-P6	S1	1.3-2.3 ft			x															
HA-P1	S1	0.4-0.7 ft			x															
HA-P9	S1	0.9-1.2 ft			x															

*Specify Test Conditions (Undisturbed or Remolded, Density and moisture, Test Normal Loads, Test Confining Stresses, etc.):

AUTHORIZE BY SIGNING AND DATING:

SIGNATURE: Meghan Hatton PRINT NAME: Meghan Hatton DATE: [illegible]/12/2015

For GTX Use Only
Incoming Sample Inspection Performed ☐
Adverse conditions:

Relinquished By:	DATE: TIME:	Received By:	DATE: TIME:
Relinquished By:	DATE: TIME:	Received By:	DATE: TIME:

GeoTesting EXPRESS

WARRANTY and LIABILITY

GeoTesting Express (GTX) warrants that all tests it performs are run in general accordance with the specified test procedures and accepted industry practice. GTX will correct or repeat any test that does not comply with this warranty. GTX has no specific knowledge as to conditioning, origin, sampling procedure or intended use of the material.

GTX may report engineering parameters that require us to interpret the test data. Such parameters are determined using accepted engineering procedures. However, GTX does not warrant that these parameters accurately reflect the true engineering properties of the *in situ* material. Responsibility for interpretation and use of the test data and these parameters for engineering and/or construction purposes rests solely with the user and not with GTX or any of its employees.

GTX's liability will be limited to correcting or repeating a test which fails our warranty. GTX's liability for damages to the Purchaser of testing services for any cause whatsoever shall be limited to the amount GTX received for the testing services. GTX will not be liable for any damages, or for any lost benefits or other consequential damages resulting from the use of these test results, even if GTX has been advised of the possibility of such damages. GTX will not be responsible for any liability of the Purchaser to any third party.

Commonly Used Symbols

A	pore pressure parameter for $\Delta\sigma_1 - \Delta\sigma_3$
B	pore pressure parameter for $\Delta\sigma_3$
CIU	isotropically consolidated undrained triaxial shear test
CR	compression ratio for one dimensional consolidation
C_c	coefficient of curvature, $(D_{30})^2 / (D_{10} \times D_{60})$
C_u	coefficient of uniformity, D_{60}/D_{10}
C_c	compression index for one dimensional consolidation
C_α	coefficient of secondary compression
c_v	coefficient of consolidation
c	cohesion intercept for total stresses
c'	cohesion intercept for effective stresses
D	diameter of specimen
D_{10}	diameter at which 10% of soil is finer
D_{15}	diameter at which 15% of soil is finer
D_{30}	diameter at which 30% of soil is finer
D_{50}	diameter at which 50% of soil is finer
D_{60}	diameter at which 60% of soil is finer
D_{85}	diameter at which 85% of soil is finer
d_{50}	displacement for 50% consolidation
d_{90}	displacement for 90% consolidation
d_{100}	displacement for 100% consolidation
E	Young's modulus
e	void ratio
e_c	void ratio after consolidation
e_o	initial void ratio
G	shear modulus
G_s	specific gravity of soil particles
H	height of specimen
PI	plasticity index
i	gradient
K_o	lateral stress ratio for one dimensional strain
k	permeability
LI	Liquidity Index
m_v	coefficient of volume change
n	porosity
PI	plasticity index
P_c	preconsolidation pressure
p	$(\sigma_1 + \sigma_3) / 2$, $(\sigma_v + \sigma_h) / 2$
p'	$(\sigma'_1 + \sigma'_3) / 2$, $(\sigma'_v + \sigma'_h) / 2$
p'_c	p' at consolidation
Q	quantity of flow
q	$(\sigma_1 - \sigma_3) / 2$
q_f	q at failure
q_o, q_i	initial q
q_c	q at consolidation
S	degree of saturation
SL	shrinkage limit
s_u	undrained shear strength
T	time factor for consolidation
T	temperature
t	time
U, UC	unconfined compression test
UU, Q	unconsolidated undrained triaxial test
u_a	pore gas pressure
u_e	excess pore water pressure
u, u_w	pore water pressure
V	total volume
V_g	volume of gas
V_s	volume of solids
V_v	volume of voids
V_w	volume of water
V_o	initial volume
v	velocity
W	total weight
W_s	weight of solids
W_w	weight of water
w	water content
w_c	water content at consolidation
w_f	final water content
w_l	liquid limit
w_n	natural water content
w_p	plastic limit
w_s	shrinkage limit
w_o, w_i	initial water content
α	slope of q_f versus p_f
α'	slope of q_f versus p_f'
γ_t	total unit weight
γ_d	dry unit weight
γ_s	unit weight of solids
γ_w	unit weight of water
ε	strain
ε_{vol}	volume strain
ε_h, ε_v	horizontal strain, vertical strain
μ	Poisson's ratio, also viscosity
σ	normal stress
σ'	effective normal stress
σ_c, σ'_c	consolidation stress in isotropic stress system
σ_h, σ'_h	horizontal normal stress
σ_v, σ'_v	vertical normal stress
σ_1	major principal stress
σ_2	intermediate principal stress
σ_3	minor principal stress
τ	shear stress
φ	friction angle based on total stresses
φ'	friction angle based on effective stresses
φ'_r	residual friction angle
φ_{ult}	φ for ultimate strength

APPENDIX C

Concrete Laboratory Test Results

Briggs Engineering & Testing
A Division of PK Associates, Inc.

August 25, 2015

Haley & Aldrich, Inc.
3 Bedford Farms Drive
Bedford, NH 03110
Attn.: Meghan Hatton, Geotechnical Engr.

RE: Test Results – Concrete Investigation – Brandon, VT Bridge #114

Dear Ms. Hatton,

We have completed the analysis of the concrete samples for the above referenced project site. A total of three (3) compressive strength tests and ten (10) chloride ion tests were performed.

The powder samples extracted from the cores were tested for chloride content in accordance with ASTM C1218 and the compressive strength test were performed in accordance with ASTM C 39.

The samples that were tested for chloride content had a wide range of results. The results ranged from 17.0 lbs/cu.yd. to 1.8 lbs./cu.yd. for the samples extracted at a depth of 1". The individual results by location are attached. Chloride ion content greater than 1.7 lbs. per cubic yard of concrete may be considered to initiate corrosion of steel embedded in concrete. However, other factors such as pH, moisture and resistivity of the concrete are also known to influence the corrosion of embedded steel.

Corrosion of embedded steel may be caused by low pH values as well as by high concentrations of chloride ions, at the level of the steel. There is, as well, a synergistic effect of low pH and chloride ion presence.

Please do not hesitate to contact me if you have any questions or are in need of additional information.

Very truly yours,
Briggs Engineering & Testing
A Division of PK Associates, Inc.

Paul M. Skorohod
President

www.briggsengineering.com

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56 Roland Street - Suite 102-I
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Briggs Engineering & Testing
A Division of PK Associates, Inc.

August 21, 2015

Briggs # 28330

Haley & Aldrich, Inc.
3 Bedford Farms Drive
Bedford, NH 03110
Attn: Meghan Hatton

EVALUATION OF CORES
Brandon VT Bridge

DATE TESTED — August 21, 2015

SPECIMEN — Three core samples obtained from onsite.

METHOD OF ANALYSIS — Obtaining and Testing Drilled Cores and Sawed Beams of Concrete ASTM C 42.

Core #	Diameter(in)	Length (in)	L/D Ratio	Factor	Comp. Str. (psi)
7/8/15	4.00	5.75	1.4	0.95	3760
HA-P6	2.00	4.10	2.1	1.00	6360
HA-P10 Alt. A	2.00	4.10	2.1	1.00	6880

REMARKS — ASTM C42 states that the diameter of core specimens for determination of compressive strength shall be at least 3.70" or at least two times the nominal maximum size of the coarse aggregate, whichever is larger. The 2.00" diameter cores contained coarse aggregate as larger as 2". The larger aggregate may have contributed to the significantly higher compressive strength results obtained for the cores versus the 4.00" one.

If you have any questions or if I can be of further service please contact me at your convenience.

Very truly yours,
BRIGGS ENGINEERING & TESTING
A Division of PK Associates, Inc.

Sean Skorohod
Director of Testing Services

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Table 2
Results of Total Chloride Ion Analysis of Concrete
ASTM C1218

Route 7, Bridge 114, Brandon, VT

Lab Sample #	Field Identification	CHLORIDE CONTENT OF CONCRETE @ DEPTH INDICATED			
		percemt by mass		lbs./cu.yd.	
		1"	2.5"	1"	2.5"
M-26293	HA-P4	0.2094	0.2026	8.2	7.9
M-26294	HA-P5	0.2168	0.2147	8.5	8.4
M-26295	HA-P7	0.4349	0.4064	17.0	15.9
M-26296	HA-P10	0.0896	0.0829	3.5	3.2
M-26297	CORE 2	0.0469	0.0611	1.8	2.4

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