GEOTECHNICAL REPORT

Stage Road over North Branch Swift River
Bridge Replacement
Bridge No. C-21-005
Cummington, MA
October 2024

Prepared for:

Town of Cummington

CUMMINGTON, MASS. WM. CULLEN BRYANT. INCORPORATED JUNE 23, 1779.

GILL ENGINEERING

Gill Engineering Associates, Inc.
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COMMONWEALTH OF MASSACHUSETTS
JOSEPH P
GILL
CIVIL
NO. 35455
REGISTERED
PROFESSIONAL ENGINEER

10/23/2024

Table of Contents

Appendix

1. INTRODUCTION

1.1. Scope of Report

The purpose of this report is to provide recommendations for the foundations for the replacement of Stage Road over the North Branch of the Swift River culvert, in the Town of Cummington, Massachusetts. The replacement is necessary due to the poor condition of the existing culvert, to restore the natural wildlife passageway and to provide adequate conveyance of stream flows in order to minimize damage from extreme water events. This report will evaluate the data from the subsurface exploration and provide the necessary parameters for designing proposed foundations. All parameters provided will be in accordance with AASHTO LRFD Bridge Design Specifications 9th Edition and the 2020 LRFD MassDOT Bridge Manual. The report will provide recommendations for the construction of the proposed foundations with guidance on minimizing potential construction issues.

1.2. Existing Structure and Site History

The culvert is located on Stage Road in Cummington, approximately 0.8 miles east of Nash Road and spans over the North Branch of the Swift River, a perennial stream with headwaters that originate approximately five miles upstream, as illustrated in Appendix 6.1 - Project Locus Map. The existing 12-foot diameter corrugated steel pipe culvert spans a length of 12-feet, original date of construction is approximately 1960. The out-to-out width of the structure is ± 70 feet with a ± 25 foot wide roadway with a varying slope. The existing culvert has deformations and severe section loss. The culvert deficiencies in conjunction with channel restrictions has caused the roadway to settle and water to flow beneath the culvert. The roadway is closed.

No plans were provided for the existing culvert. Dawood Engineering Inc. performed a survey of the site on August 9th, 2023 to verify the existing conditions.

1.3. Site Description

Stage Road is oriented west-to-east and provides 2 lanes of traffic. It is classified as a Rural Local road with an ADT of 388 as of 2017. The bridge location is bounded by light vegetation and trees.

At the project site, the North Branch of the Swift River channel consists of gravel and cobbles with some small boulders within the streambed. The stream site drainage area mostly consists of forested area and shrub swamps with low residential and no commercial development.

The site has an overhead utility along the eastbound shoulder of the roadway.

2. SUBSURFACE CONDITIONS

2.1. Local Geology

According to the Surficial Geologic Map of the Goshen Quadrangle, Massachusetts, the site is underlain by non-stratified till of sand, some silt, and little clay containing scattered pebble, cobble, and boulder clasts. Large boulders are common and there are areas of shallow bedrock. See Appendix 6.2 for a snapshot of the map.

2.2. Subsurface Exploration

The subsurface exploration consisted of four (4) soil borings (designated as B-1 through B-4). Soil boring No. B-1 was completed approximately 12 feet west of the existing culvert centerline in the westbound travel lane. Soil boring No. B-2 was completed approximately 22 feet west of the existing culvert centerline in the eastbound travel lane. Soil boring No. B-3 was completed approximately 16 feet east of the existing culvert centerline in the westbound travel lane. Soil boring No. B-4 was completed approximately 9 feet east of the existing culvert centerline in the eastbound travel lane. The borings were drilled using a 4 inch casing and a 1-3/8 inch split spoon sampler between June 9th 2020 and June 10th 2020 by New England Boring Contractors of Glastonbury, Connecticut and observed by Comprehensive Environmental Inc. CEI. See Appendix 6.3 for an as-drilled boring site plan and Appendix 6.4 for boring logs. The boring logs were provided to Gill Engineering by the Town of Cummington. GEA concurs with the information presented in the boring logs.

2.3. Subsurface Profile

2.3.1. South Boring B-1

The existing ground grade at B-1 is at 1131.0’. Below the top foot of asphalt, the first 7’ consists of medium dense sand which overlays a layer of dry medium dense sand which overlays a wet very dense layer of sand and gravel down to 27’ at which the boring augured through 3’ of rock to obtain the final sample at the practical refusal at 32’. No bedrock or ledge was encountered during the soil exploration. Ground water was measured at a depth of 20’.

2.3.2. North Boring B-2

The existing ground grade at B-2 is at 1130.5’. Below the top foot of asphalt, the first 12’ consists of medium dense sand which overlays a layer of dry loose to medium dense sand to 17’ which overlays a wet very dense layer of sand and gravel down to 32’ at which the final sample at the practical refusal was taken at 31’. No bedrock or ledge was encountered during the soil exploration. Ground water was measured at a depth of 17 feet.

2.3.3.North Boring B-3

The existing ground grade at B-3 is at 1132.5’. Below the top foot of asphalt, the first 12’ consists of dry loose to medium dense sand which overlays a layer of dry medium dense sand and silt down to 17 feet which overlays a wet very dense layer of sand down to 22’ which overlays a layer of wet very dense till and weathered rock with sand to a depth of 27’ at which the auger encountered conglomerate clasts of rounded and subangular cobbles to a depth of 40’. Ground water was measured at a depth of 22’.

2.3.4.North Boring B-4

The existing ground grade at B-4 is at 1132.0’. Below the top foot of asphalt, the first 7 feet consists of medium dense sand which overlays a layer of dry loose to medium dense sand which overlays a dry very dense layer of sand down to 17’ which overlays a layer of wet very dense sand and gravel to a depth of 27’at which the boring augured through 3’ of boulder or rock to obtain the final sample at the practical refusal at 32’. No bedrock or ledge was encountered during the soil exploration. Ground water was measured at a depth of 21’.

2.3.5. Soil Parameters

See Table 1 for recommended soil parameters for design. See Appendix 6.5 for calculations.

Layer	Unit Weight γ (lb/ft^3)	Friction Angle Φ
Upper (0’ to 20’)	120	35
Lower (>20’)	120	38

1. Friction angle based upon SPT N160 Correlation and AASHTO Table 10.4.6.2.4-1
2. Gravel borrow per MassDOT M1.03.0

Table 1: Recommended Soil Parameters

2.4. Seismic Design Category Evaluation

Seismic design parameters were determined using the 2011 AASHTO Guide Specifications for LRFD Seismic Bridge Design, and the 2020 MassDOT Bridge Manual. Calculations are presented in Appendix 6.5 – Preliminary Design Calculations. The following are recommended seismic parameters for design:

Site Class (AASHTO Table 3.10.3.1-1): D (Medium dense soil with 15<N<50 blows/ft)

Seismic Design Category (SDC): A

Mapped Ground and Spectral Response (AASHTO LRFD Bridge Design):
7% Probability of Exceedance in 75 Years (1,000 year event)

- Peak Horizontal Ground Acceleration (PGA): 0.06
- Horizontal Response Spectral Acceleration, 0.2 Sec (S_S): 0.14
- Horizontal Response Spectral Acceleration, 1.0 Sec (S_1): 0.04

Site Factors (AASHTO LRFD Bridge Design, Table 3.10.3.2-1, 3.10.3.2-2, & 3.10.3.2-3):

- Zero-Period (F_{pga}): 1.6
- Short Period (F_a): 1.6
- Long Period (F_v): 2.4

Design Spectral Response Parameters for Site Class D:

- A_S: 0.10 G
- S_{DS}: 0.224 G
- S_{D1}: 0.10 G

Seismic Zone (AASHTO LRFD Bridge Design, Table 3.10.6-1)

- Seismic Zone: 1

2.5. Liquefaction Potential

Based on the location of the bridge site being in low seismic zone, seismically induced settlement should not be significant; therefore, there is a low potential for liquefaction in the event of seismic activity. The soils present are generally non-plastic loose to medium dense sand with traces of gravel and well-graded. The encountered groundwater table was estimated based on observations during subsurface exploration, groundwater is estimated at 20 feet below the roadway surface. Additionally, the site has a low probability of having an event that would trigger liquefaction (M<6.0).

3. RECOMMENDED FOUNDATION SYSTEM

3.1. Shallow Foundation

The stiff soil will provide adequate bearing resistance to support a spread footing foundation. Since the scale of the project is small, precast wingwalls and abutments could be transported to the site and lowered into place with a crane. Factored bearing resistance and settlement will vary depending on the footing width.

The bottom of spread footing will need to be low enough to accommodate frost protection and be outside the limits of predicted scour. A spread footing foundation for a wingwall should be designed to the parameters in Table 1 and section 2-4 of this report. Embankment slopes may be constructed at 1.5:1 with added stone rip-rap per MassDOT LRFD Bridge Manual Standard 2.4.1.

3.2. GRS-IBS Foundation

The proposed project is a good candidate for a GRS-IBS abutments. To construct the GRS-IBS abutments, structural fill is placed in lifts over geotextile reinforcing and faced with modular blocks. The soil and fabric create a composite material that effectively dissipates the superstructure loads into the soil. The GRS-IBS abutments can be constructed with a backhoe and does not require specialized construction knowledge.

A GRS-IBS abutment would be outside the limits of predicted scour. The abutment should be designed to the parameters in Table 1 and section 2-4 of this report. Wood guardrail posts are not to be used as they cannot penetrate the GRS-IBS structural fill. Although facing blocks are not considered structural, they should be resistant to freeze thaw cycles and salt exposure. Care shall be taken to grade so that water does not flow behind the modular facing.

3.3. Deep Foundation

A deep foundation is not recommended for this site as it does not provide an economic advantage over a shallow foundation.

4. CONSTRUCTION CONSIDERATIONS

4.1. Water Table

Groundwater was measured during the sub surface exploration method at a varying depths from 17 to 22 feet. Fluctuations with this elevation are expected with the seasonal flows of the stream. Since the bottom of footing is below this elevation dewatering will be required during construction in order to maintain construction in the dry. Discharge of pumped water should be performed in accordance with all federal, state and local regulations which may require a discharge permit.

4.2. Excavation

As required by OSHA regulations, lateral support is required for any excavation depth greater than four feet and where 1.5:1 slope cannot be maintained. Items for temporary earth support should be included in the contract documents. The design of any temporary support earth (SOE) is the responsibility of the Contractor and should be designed in accordance with MassDOT and AASHTO requirements.

The proposed abutment construction may require a water barrier system to maintain work in the dry and minimize impacts to the adjacent stream channel and/or wetlands. Portions of the existing substructure may be left in place as a temporary barrier. The water barrier system may consist of sheet pile, sand bags or a portadam. The top of water barrier will need to be set above the 2-year high water elevation.

4.3. Obstructions

Due to the existing structure not having a foundation, there are no anticipated obstructions. However, to allow for the stream to flow without obstruction during the construction process, the existing culvert shall remain in place until the proposed structure is built.

4.4. Protection of Adjacent Structures and Utilities

The only known utility that would require protection during construction is the overhead line that is located along the South side of the bridge. Coordination with the utility company shall be performed to determine required construction clearances and to determine if any temporary measures to the utility would be needed.

4.5. Sequence of Construction Activities

No traffic staging is required with the road closure. Sequencing may be required for the relocation of the overhead utility.

5. CONCLUSION

The soil conditions for the proposed bridge will allow for a GRS-IBS abutment. The bottom of footing should be set a minimum of 4 feet below grade for frost protection and should be set below estimated scour depths unless adequate scour protection is provided. Rip-rap may be an option to protect the foundation from scour. Alternatively, the footing may be supported on piles, but this would be costly in comparison to a shallow foundation.

APPENDIX

6.1. Project Locus Map


N
PLAINFIELD ROAD
STAGE ROAD
NASH ROAD
HARLOW ROAD
C-21-005
SHAW ROAD
BERKSHIRE TRAIL

APPENDIX

6.2. Surficial Geologic Map

U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with the
Commonwealth of Massachusetts
Massachusetts Geological Survey
and Executive Office for Administration and Finance

Scientific Investigations Map 3402
Quadrangle 31—Goshen

Discussion of surficial materials and description of map units available at https://doi.org/10.3133/sim3402

Base from U.S. Geological Survey, 1972

Map was scanned, processed, georeferenced, rectified, and cropped by the Massachusetts Geological Survey

Lambert Conformal Conic projection. North American Datum of 1983

Massachusetts state plane coordinate system, mainland zone

14°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2018

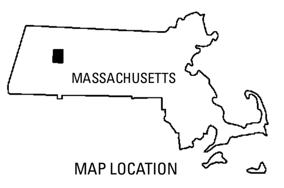
SCALE 1:24 000

1 0.5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0.5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



Map units were modified from Hatch and Warren (1982). Some shallow-bedrock areas were interpreted from analysis of topographic (lidar) and soils data. Some postglacial units were mapped using 2005 orthophoto images.

Thin till—Nonsorted, nonstratified matrix of sand, some silt, and little clay containing scattered pebble, cobble, and boulder clasts; large surface boulders are common; unit was mapped where till is generally less than 10 to 15 ft thick including areas of shallow bedrock. Predominantly consists of upper till of the last glaciation; loose to moderately compact, generally sandy, commonly stony. Two facies are present in some places: a looser, coarser grained ablation facies, melted out from supraglacial position; and an underlying more compact, finer grained lodgement facies deposited subglacially. In general, both ablation and lodgement facies of upper till derived from fine-grained bedrock are finer grained, more compact, less stony and have fewer surface boulders than upper till derived from coarse-grained crystalline rocks. Across Massachusetts, fine-grained bedrock sources include the red Mesozoic sedimentary rocks of the Connecticut Valley lowland, marble in the western river valleys, and fine-grained schists in upland areas

Surficial Materials Map of the Goshen Quadrangle, Massachusetts

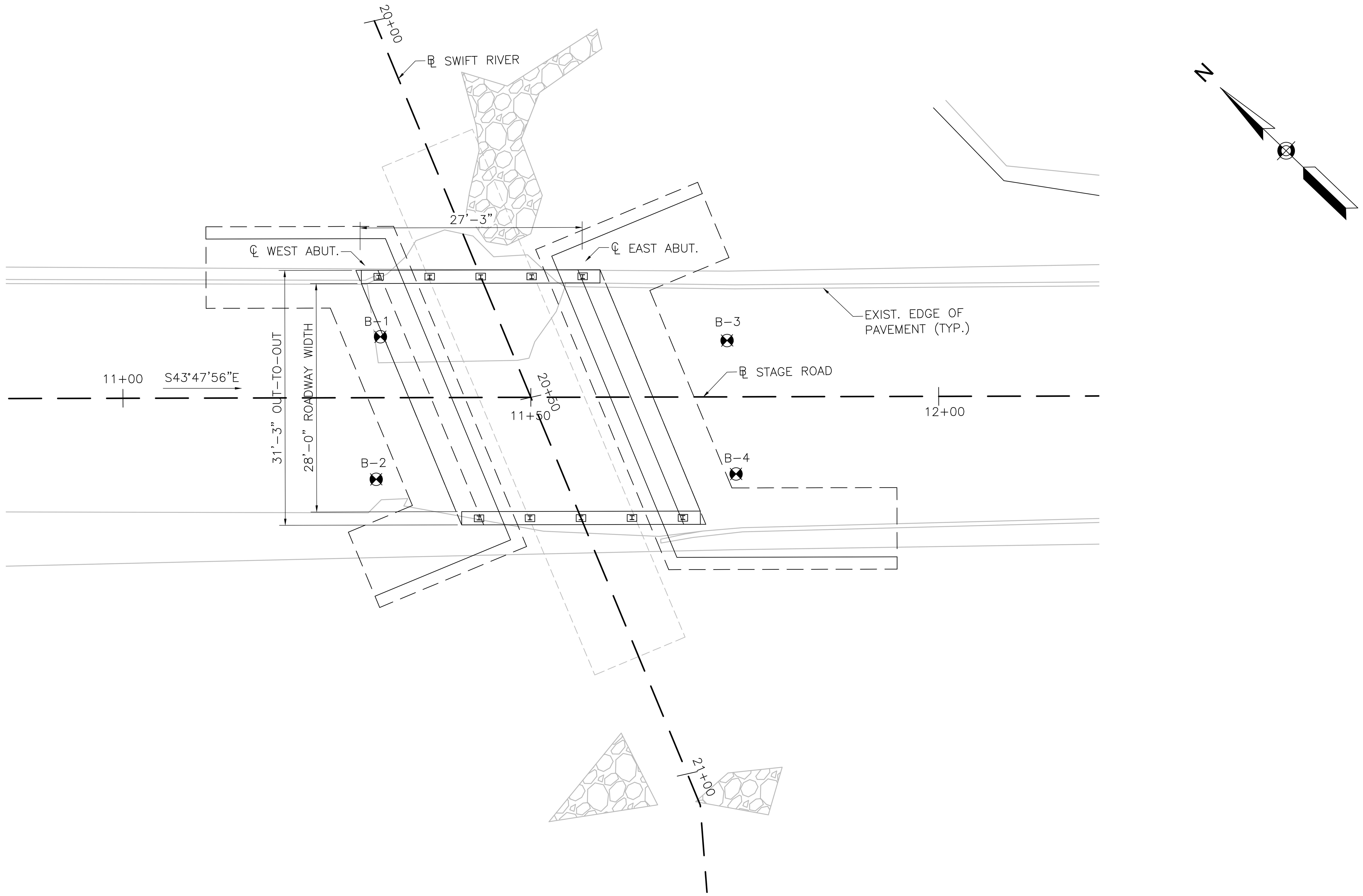
Compiled by
Janet R. Stone and Mary L. DiGiacomo-Cohen
2018

Suggested citation: Stone, J.R., and DiGiacomo-Cohen, M.L., comps., 2018, Surficial materials map of the Goshen quadrangle, Massachusetts, quadrangle 31 *in* Stone, J.R., Stone, B.D., DiGiacomo-Cohen, M.L., and Mabee, S.B., comps., Surficial materials of Massachusetts—A 1:24,000-scale geologic map database: U.S. Geological Survey Scientific Investigations Map 3402, 1 sheet, scale 1:24,000, https://doi.org/10.3133/sim3402.

ISSN 2329-132X (online)
https://doi.org/10.3133/sim3402

APPENDIX

6.3. As-Drilled Boring Plan



BORING PLAN

SCALE: $\frac{1}{8}$" = 1'-0"

BORING NOTES:

1. LOCATION OF BORINGS ARE SHOWN ON THE PLANS THUS: ⊗
2. BORINGS ARE TAKEN FOR THE PURPOSE OF DESIGN AND SHOW CONDITIONS AT THE BORING POINTS ONLY, BUT DO NOT NECESSARILY SHOW THE NATURE OF THE MATERIALS TO BE ENCOUNTERED DURING CONSTRUCTION.
3. WATER LEVELS SHOWN ON THE BORING LOGS WERE OBSERVED AT THE TIME OF TAKING BORINGS AND DO NOT NECESSARILY SHOW THE TRUE GROUND WATER LEVEL.
4. FIGURES IN COLUMNS INDICATE NUMBER OF BLOWS REQUIRED TO DRIVE A 1$\frac{3}{8}$" I.D. SPLIT SPOON SAMPLER 6" USING A 140 POUND WEIGHT FALLING 30".
5. BORING SAMPLES ARE STORED AT GILL ENGINEERING ASSOCIATES, 63 KENDRICK STREET NEEDHAM, MA 02494. THE CONTRACTOR MAY EXAMINE THE SOIL AND SAMPLES BY CONTACTING GILL ENGINEERING ASSOCIATES.
6. BORINGS WERE MADE ON 11/24/2020.
7. ALL BORINGS WERE MADE BY NEW ENGLAND BORING CONTRACTORS OF 40 FORDWAY STREET DERRY, NH 03038.
8. ASSUMED DATUM IS USED THROUGHOUT.

BORING LOCATIONS						
BORING NO.	NORTHING	EASTING	STATION	OFFSET	SURFACE ELEV.	H.B.E
B-1	2998830.97	286298.82	20+36.07	14.19' RT	1130.99	1104.00±
B-2	2998819.21	286285.81	20+50.07	21.36' RT	1130.88	1099.00±
B-3	2998799.84	286327.82	20+50.80	24.89' LT	1132.46	1101.00±
B-4	2998787.75	286316.75	20+68.33	19.63' LT	1132.15	1106.00±

GILL ENGINEERING
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NEEDHAM, MA 02494
781-355-7100
781-355-7101 (FAX)

03_C21005 BORING LOGS.dwg Plotted on 27-Mar-2024 2:51 PM

DATE	DRW. BY	CALC. BY	APPRV. BY	DESCRIPTION

REGISTERED PROFESSIONAL ENGINEER

DATE

PROPOSED BRIDGE REPLACEMENT

TOWN OF CUMMINGTON

BRIDGE REPLACEMENT OF CUMMINGTON C-21-005
STAGE ROAD OVER SWIFT RIVER

BORING PLAN

APPENDIX

6.4. Boring Logs

Comprehensive Environmental Inc.

Boring No. B-1

City/Town: Cummington	Bridge Number: C-21-005	Project File Number:	Contract Number:	
Location: Stage Road over North Branch of Swift River		Date & Time Started: 6/9/2020 8:00AM		Total Hours: 3
Groundwater Depth (Feet): 20	Date & Time: 6/9/2020 9:30AM	Date & Time Completed: 6/9/2020 11:00AM		
Coordinates: N2998853 E286283		Driller's Name: Mike St. John of New England Boring Contractors		
Ground Elevation (Feet): 1131.0		Inspector's Name: Nick Shaw of CEI		

Depth (Feet)	Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minutes per Foot	Recovery (inches)	Field Description	Strata Changes
-	S1	0-2	14-10-10-13	8	Dry, medium dense, brown, SAND, some gravel	
-						
-						
-						
5	S2	5-7	5-8-14-18	6	Dry, medium dense, brown, SAND, some gravel	
-						
-						
-						
-						
10	S3	10-12	9-15-14-13	17	Dry, medium dense, brown, SAND some silt	
-						
-						
-						
-						
15	S4	15-17	6-7-7-5	8	Dry, loose to medium dense, brown, SAND. some silt	
-						
-						
-						
-						
20	S5	20-22	12-9-31-80	12	Wet, medium dense to dense, brownish grey, SAND, little gravel	
-						
-						
-						
-						25'
25	S6	25-27	58-43-251/3"	15	Wet, very dense, brownish grey, SAND and GRAVEL, augered through rock to take final sample at 30-32'	
-						
-						
-						
-						30'
30	S7	30-32	130-141/3"	9	Wet, very dense, grey, GRAVEL Practical refusal and end of exploration @ 31'	

Remarks: Autohammer used for both split spoon sampler and driving Casing.	Arrow-Board: 0 Signs: 2 Cones: 2	Protective Device – Stand: Box: Well Depth: Solid Pipe: Stick Up Pipe: Screen Pipe:

Penetration Resistance (N) Guide			
Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 – 4	Very Soft	0 – 2
Loose	4 – 10	Soft	2 – 4
Medium Dense	10 – 30	Medium Stiff	4 – 8
Dense	30 – 50	Stiff	8 – 15
Very Dense	Over 50	Very Stiff	15 – 30
		Hard	Over 30

N = Sum of Second and Third 6" Blow counts

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig:

Casing Type: HW Size: 4in
Hammer Weight:140 lbs
Fall: 30in
Depth: 31ft

Sampler Type: Split Spoon Size:2in
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight:
Fall:

Core Barrel Type: NX Size: 2.125in

Comprehensive Environmental Inc.

Boring No. B-2

City/Town: Cummington	Bridge Number: C-21-005	Project File Number:	Contract Number:
Location: Stage Road over North Branch of Swift River		Date & Time Started: 6/9/2020 11:30AM	Total Hours: 3.5
Groundwater Depth (Feet): 17	Date & Time: 6/9/2020 1:00PM	Date & Time Completed: 6/9/2020 3:00PM	
Coordinates: N2998857 E286260		Driller's Name: Mike St. John of New England Boring Contractors	
Ground Elevation (Feet): 1131.0		Inspector's Name: Nick Shaw of CEI	

Depth (Feet)	Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minutes per Foot	Recovery (inches)	Field Description	Strata Changes
-	S1	0-2	7-8-6-10	12	Dry, medium dense, brown, SAND, some gravel	
-						
-						
-						
5	S2	5-7	7-15-17-14	16	Dry, medium dense, brown, SAND trace gravel	
-						
-						
-						
-						
10	S3	10-12	10-5-5-8	16	Dry, medium dense, brown, SAND some silt	
-						
-						
-						
-						
15	S4	15-17	8-7-6-5	6	Wet, loose to medium dense, brown, SAND some gravel	
-						
-						
-						
-						20'
20	S5	20-22	19-15-12-44	10	Wet, dense to very dense, brown SAND and GRAVEL	
-						
-						
-						
-						25'
25	S6	25-27	23-23-45-16	5	Wet, dense to very dense, grey, GRAVEL	
-						
-						
-						
-						
30	S7	30-32	191-132/4"	10	Wet, very dense, grey, GRAVEL, some till Practical refuse and end of exploration @ 31'	

Remarks: Autohammer used for both split spoon sampler and driving Casing.	Arrow-Board: 0 Signs: 2 Cones: 2	Protective Device – Stand: Box: Well Depth: Solid Pipe: Stick Up Pipe: Screen Pipe:

Penetration Resistance (N) Guide

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 – 4	Very Soft	0 – 2
Loose	4 – 10	Soft	2 – 4
Medium Dense	10 – 30	Medium Stiff	4 – 8
Dense	30 – 50	Stiff	8 – 15
Very Dense	Over 50	Very Stiff	15 – 30
		Hard	Over 30

N = Sum of Second and Third 6" Blow counts

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig:

Casing Type: HW Size: 4in
Hammer Weight:140 lbs
Fall: 30in
Depth: 31ft

Sampler Type: Split Spoon Size:2in
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight:
Fall:

Core Barrel Type: NX Size: 2.125in

Comprehensive Environmental Inc.			Boring No. B-3 Page 1 of 1
City/Town: Cummington	Bridge Number: C-21-005	Project File Number:	Contract Number:
Location: Stage Road over North Branch of Swift River		Date & Time Started: 6/8/2020 8:00AM	Total Hours: 6.5
Groundwater Depth (Feet): 22	Date & Time:6/8/2020 10:00AM	Date & Time Completed: 6/8/2020 2:30PM	
Coordinates: N2998822 E286311		Driller's Name: Mike St. John of New England Boring Contractors	
Ground Elevation (Feet): 1132.5		Inspector's Name: Nick Shaw of CEI	

Depth (Feet)	Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minutes per Foot	Recovery (inches)	Field Description	Strata Changes
-	S1	0-2	8-8-7-8	22	Dry, medium dense, brown, SAND, trace asphalt	
-						
-						
-						
5	S2	5-7	9-5-4-7	14	Dry, loose to medium dense, brown, SAND, some silt	
-						
-						
-						
-						
10	S3	10-12	13-5-7-8	21	Dry, loose to medium dense, brown, SAND, and silt	
-						
-						
-						
-						
15	S4	15-17	6-24-21-7	7	Dry, medium dense, dark brown, SAND and silt	
-						
-						
-						
-						
20	S5	20-22	43-33-35-65	14	Wet, very dense, dark brown/grey, SAND, some silt	
-						
-						
-						
-						25'
25	S6	25-27	55-230-105-108	19	Wet, very dense, dark brown/grey, TILL/ WEATHERED ROCK, some sand	
-						
-						
-						
-						30'
30	RC1	30-35	4:48		30'-35' Conglomerate. Clasts are rounded to subangular, primarily cobbled sized but range to fine gravel sized. REC=36"/60"=60%	
-			3:11			
-			7:08			
-			8:51			
-			6:27			
35						
-	RC2	36-40	5:46		36-40' Conglomerate. Clasts are rounded to subangular, primarily cobble sized, but range to fine and gravel sized. REC= 60"/60" = 100%	
-			8:19			
-			6:31			
-			9:52			
40			4:01			

Remarks	Traffic Control	Well
Remarks: Autohammer used for both split spoon sampler and driving Casing.	Arrow-Board: 0 Signs: 2 Cones: 2	Protective Device – Stand: Box: Well Depth: Solid Pipe: Stick Up Pipe: Screen Pipe:

Penetration Resistance (N) Guide			
Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 – 4	Very Soft	0 – 2
Loose	4 – 10	Soft	2 – 4
Medium Dense	10 – 30	Medium Stiff	4 – 8
Dense	30 – 50	Stiff	8 – 15
Very Dense	Over 50	Very Stiff	15 – 30
		Hard	Over 30
N = Sum of Second and Third 6" Blow counts			
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less			

Type of Drill Rig:

Casing Type: HW Size: 4in
Hammer Weight:140 lbs
Fall: 30in
Depth: 31ft

Sampler Type: Split Spoon Size:2in
Automatic Hammer Weight: 140 lbs
Safety Hammer Weight:
Donut Hammer Weight:
Fall:

Core Barrel Type: NX Size: 2.125in

Comprehensive Environmental Inc.

Boring No. B-4

City/Town: Cummington	Bridge Number: C-21-005	Project File Number:	Contract Number:	
Location: Stage Road over North Branch of Swift River		Date & Time Started: 6/10/2020 8:00AM		Total Hours: 4
Groundwater Depth (Feet): 21	Date & Time:6/10/2020 9:30AM	Date & Time Completed: 6/10/2020 12:00PM		
Coordinates: N2998802 E286290		Driller's Name: Mike St. John of New England Boring Contractors		
Ground Elevation (Feet): 1132.0		Inspector's Name: Nick Shaw of CEI		

Depth (Feet)	Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minutes per Foot	Recovery (inches)	Field Description	Strata Changes
-	S1	0-2	10-8-7-5	13	Dry, medium dense, brown, SAND, some gravel	
-						
-						
-						
5	S2	5-7	12-11-8-8	19	Dry, medium dense, brown, SAND trace gravel	
-						
-						
-						
-						
10	S3	10-12	4-5-9-16	15	Dry, loose to medium dense, brown, SAND, Some silt	
-						
-						
-						
-						
15	S4	15-17	21-25-20-26	14	Dry, dense, grey, SAND, trace gravel	
-						
-						
-						
-						
20	S5	20-22	28-40-38-39	16	Wet, very dense, brown/grey, SAND and GRAVEL	
-						
-						
-						
-						
25	S6	25-27	43-182/5"	12	Wet, very dense, brown/grey, SAND and GRAVEL, augered through boulder or rock to Take sample at 30-32'	
-						
-						
-						
-						25'
30	S7	30-35	140-162/3"	9	Wet, very dense, grey, GRAVEL Practical refusal and end of exploration at 31'	31'

Remarks: Autohammer used for both split spoon sampler and driving Casing.	Arrow-Board: 0 Signs: 2 Cones: 2	Protective Device – Stand: Box: Well Depth: Solid Pipe: Stick Up Pipe: Screen Pipe:

Penetration Resistance (N) Guide				
Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)		Type of Drill Rig:
Relative Density	Penetration Resistance	Consistency	Penetration Resistance	Casing Type: HW Size: 4in Hammer Weight:140 lbs Fall: 30in Depth: 31ft
Very Loose	0 – 4	Very Soft	0 – 2	
Loose	4 – 10	Soft	2 – 4	
Medium Dense	10 – 30	Medium Stiff	4 – 8	Sampler Type: Split Spoon Size:2in Automatic Hammer Weight: 140 lbs Safety Hammer Weight: Donut Hammer Weight: Fall:
Dense	30 – 50	Stiff	8 – 15	
Very Dense	Over 50	Very Stiff	15 – 30	
		Hard	Over 30	
N = Sum of Second and Third 6" Blow counts				
Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less				Core Barrel Type: NX Size: 2.125in

APPENDIX

6.5. Preliminary Design Calculations

Soil Strength

References:
(1) AASHTO LRFD Bridge Design Manual, 9th Edition.
(2) Boring Logs, provided by CEI.

Soil Strength Calculation

γ_w = 0.062 kcf
γ_{sat} = 0.120 kcf
γ' = 0.058 kcf = 0.120 kcf - 0.062 kcf

$$\sigma'_v = \gamma_{sat} \times h_1 + \gamma' \times h_2$$

$$C_N = .77 \times \log_{10}\left(\frac{40}{\sigma'_v}\right) < 2$$ (1) 10.4.6.2.4

$$N1 = C_N N$$ (1) Eq. 10.4.6.2.4-1

$$N_{60} = \left(\frac{ER}{60\%}\right)N$$ (1) Eq. 10.4.6.2.4-2

ER = 0.80 for automatic trip hammer

$$N1_{60} = C_N N_{60}$$ (1) Eq. 10.4.6.2.4-3

Boring B-1

Water Table = 20.00 ft (2)

To Depth (ft)	h_1, Depth Above Water Table (ft)	h_2, Depth Below Water Table (ft)	σ'_v (ksf)	C_N	N blows/ft	$N1 = C_N N$ blows/ft	N_{60} = (ER/60%)N blows/ft	$N1_{60} = C_N N_{60}$ blows/ft
2.00	2.00	0.00	0.24	1.71	20.00	34.22	26.67	45.62
7.00	7.00	0.00	0.84	1.29	22.00	28.42	29.33	37.90
12.00	12.00	0.00	1.44	1.11	29.00	32.24	38.67	42.98
17.00	17.00	0.00	2.04	1.00	14.00	13.93	18.67	18.58
22.00	20.00	2.00	2.52	0.93	40.00	37.01	53.33	49.34
27.00	20.00	7.00	2.80	0.89	43.00	38.22	57.33	50.96
32.00	20.00	12.00	3.09	0.86	130.00	111.30	173.33	148.41

Boring B-2

Water Table = 17.00 ft (2)

To Depth (ft)	h_1, Depth Above Water Table (ft)	h_2, Depth Below Water Table (ft)	σ'_v (ksf)	C_N	N blows/ft	$N1 = C_N N$ blows/ft	N_{60} = (ER/60%)N blows/ft	$N1_{60} = C_N N_{60}$ blows/ft
2.00	2.00	0.00	0.24	1.71	14.00	23.95	18.67	31.94
7.00	7.00	0.00	0.84	1.29	32.00	41.34	42.67	55.12
12.00	12.00	0.00	1.44	1.11	10.00	11.12	13.33	14.82
17.00	17.00	0.00	2.04	1.00	13.00	12.94	17.33	17.25
22.00	17.00	5.00	2.33	0.95	27.00	25.68	36.00	34.24
27.00	17.00	10.00	2.62	0.91	68.00	62.02	90.67	82.69
32.00	17.00	15.00	2.90	0.88	191.00	167.52	254.67	223.36

Boring B-3

Water Table = 22.00 ft (2)

To Depth (ft)	h_1, Depth Above Water Table (ft)	h_2, Depth Below Water Table (ft)	σ'_v (ksf)	C_N	N blows/ft	$N1 = C_N N$ blows/ft	$N_{60} =$ (ER/60%)N blows/ft	$N1_{60} = C_N N_{60}$ blows/ft
2.00	2.00	0.00	0.24	1.71	15.00	25.66	20.00	34.22
7.00	7.00	0.00	0.84	1.29	9.00	11.63	12.00	15.50
12.00	12.00	0.00	1.44	1.11	12.00	13.34	16.00	17.79
17.00	17.00	0.00	2.04	1.00	45.00	44.78	60.00	59.71
22.00	22.00	0.00	2.64	0.91	68.00	61.81	90.67	82.41
27.00	22.00	5.00	2.93	0.87	335.00	292.90	446.67	390.53
35.00	22.00	13.00	3.39	0.83	N/A	N/A	N/A	N/A
40.00	22.00	18.00	3.68	0.80	N/A	N/A	N/A	N/A

Boring B-4

Water Table = 21.00 ft (2)

To Depth (ft)	h_1, Depth Above Water Table (ft)	h_2, Depth Below Water Table (ft)	σ'_v (ksf)	C_N	N blows/ft	$N1 = C_N N$ blows/ft	$N_{60} =$ (ER/60%)N blows/ft	$N1_{60} = C_N N_{60}$ blows/ft
2.00	2.00	0.00	0.24	1.71	15.00	25.66	20.00	34.22
7.00	7.00	0.00	0.84	1.29	19.00	24.55	25.33	32.73
12.00	12.00	0.00	1.44	1.11	14.00	15.56	18.67	20.75
17.00	17.00	0.00	2.04	1.00	45.00	44.78	60.00	59.71
22.00	21.00	1.00	2.58	0.92	78.00	71.52	104.00	95.36
27.00	21.00	6.00	2.87	0.88	182.00	160.44	242.67	213.92
32.00	21.00	11.00	3.15	0.85	140.00	118.93	186.67	158.57

Drained Friction Angle

(1)

Table 10.4.6.2.4-1—Correlation of *SPT* $N1_{60}$ Values to Drained Friction Angle of Granular Soils (modified after Bowles, 1977)

$N1_{60}$	ϕ_f
<4	25–30
4	27–32
10	30–35
30	35–40
50	38–43

Conservatively use lower values of range:

N160	ϕ_f
<4	25
4	27
10	30
30	35
50	38

To Depth (ft)	$N1_{60}$	$N1_{60low}$	$N1_{60high}$	ϕ_{flow}	ϕ_{fhigh}	ϕ_f
2.00	36.50	30.00	50.00	35.00	38.00	35.00
7.00	35.31	30.00	50.00	35.00	38.00	35.00
12.00	24.09	10.00	30.00	30.00	35.00	33.00
17.00	38.81	30.00	50.00	35.00	38.00	36.00
22.00	65.34	50.00	50.00	38.00	38.00	38.00
27.00	184.53	50.00	50.00	38.00	38.00	38.00
32.00	176.78	50.00	50.00	38.00	38.00	38.00

Recommended Friction Angle

Depth of Footing = 20.00 ft

Average, ϕ_f = 35°
Above Footing, ϕ_f = 35°
Below Footing, ϕ_f = 38°

Bearing Resistance

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References:

(1) FHWA Design and Construction Guidelines for Geosynthetic Reinforces Soil Abutment and Integrated Bridge Systems, 2018.

(2) AASHTO LRFD Manual for Bridge Design, 9th Edition.

Calculate Factored Bearing Resistance, q_R

$$q_R = \Phi_{bc}\left(c'_f N_c + \frac{1}{2} B' \gamma'_f N_\gamma + \gamma'_f D_f N_q\right)$$ (1) Equation 30

Bearing Resistance Factor, ϕ_{bc} = 0.65 (1) 4.3.6.2

Cohesion of Foundation Soil, c'_f = 0.00 psf

Friction angle of Foundation, ϕ_f = 35.00°

Note: Bearing Resistance Factors are dependent on the friction angle of the foundation and are taken from (1) Table 9. Bearing Resistance Factors are dimensionless.

Bearing Resistance Factor, N_c = 46.10
Bearing Resistance Factor, N_γ = 48.00
Bearing Resistance Factor, N_q = 33.30

Effective Unit Weight of Foundation Soil, γ'_f = 57.60 pcf

Effective Foundation Width, B' = B_{RSF} = 11.00 ft
Depth of Embedment, D_f = D_{RSF} = 1.33 ft

Factored Bearing Resistance, q_R = 11.5 ksf = 0.65 x (0.00 ksf x 46.10 + 0.50 x 11.00 ft x 0.058 kcf x 48.00 + 0.058 kcf x 1.33 ft x 33.30)

Seismic Design Response Spectrum

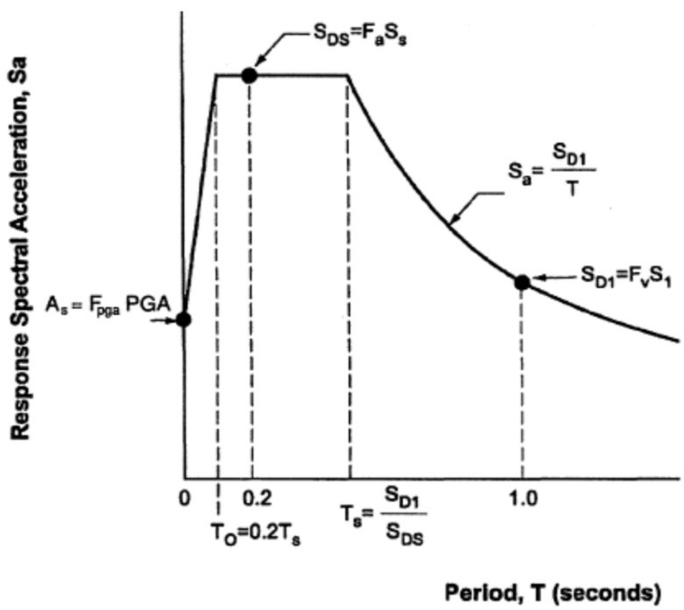
Geotechnical Calculations — Seismic Design — C-21-005

References:
(1) AASHTO LRFD Bridge Design Specifications 2020, 9th Edition.

Design Spectra Based on General Procedure

Site Class	D	*(1) Table 3.10.3.1-1*
PGA=	0.06	*(1) Figure 3.10.2.1-1*
S_S=	0.14	*(1) Figure 3.10.2.1-2*
S_1=	0.04	*(1) Figure 3.10.2.1-3*
F_{pga}=F_a=	1.6	*(1) Table 3.10.3.2-(1&2)*
F_v=	2.4	*(1) Table 3.10.3.2-3*
A_S=F_{pga} x PGA=	0.10 G	
S_{DS}=F_a x S_s=	0.224 G	
S_{D1}=F_v x S_1=	0.10 G	
Seismic Zone =	1	*(1) Table 3.10.6-1*
T_O=	0.09 Sec	
T_S=	0.43 Sec	

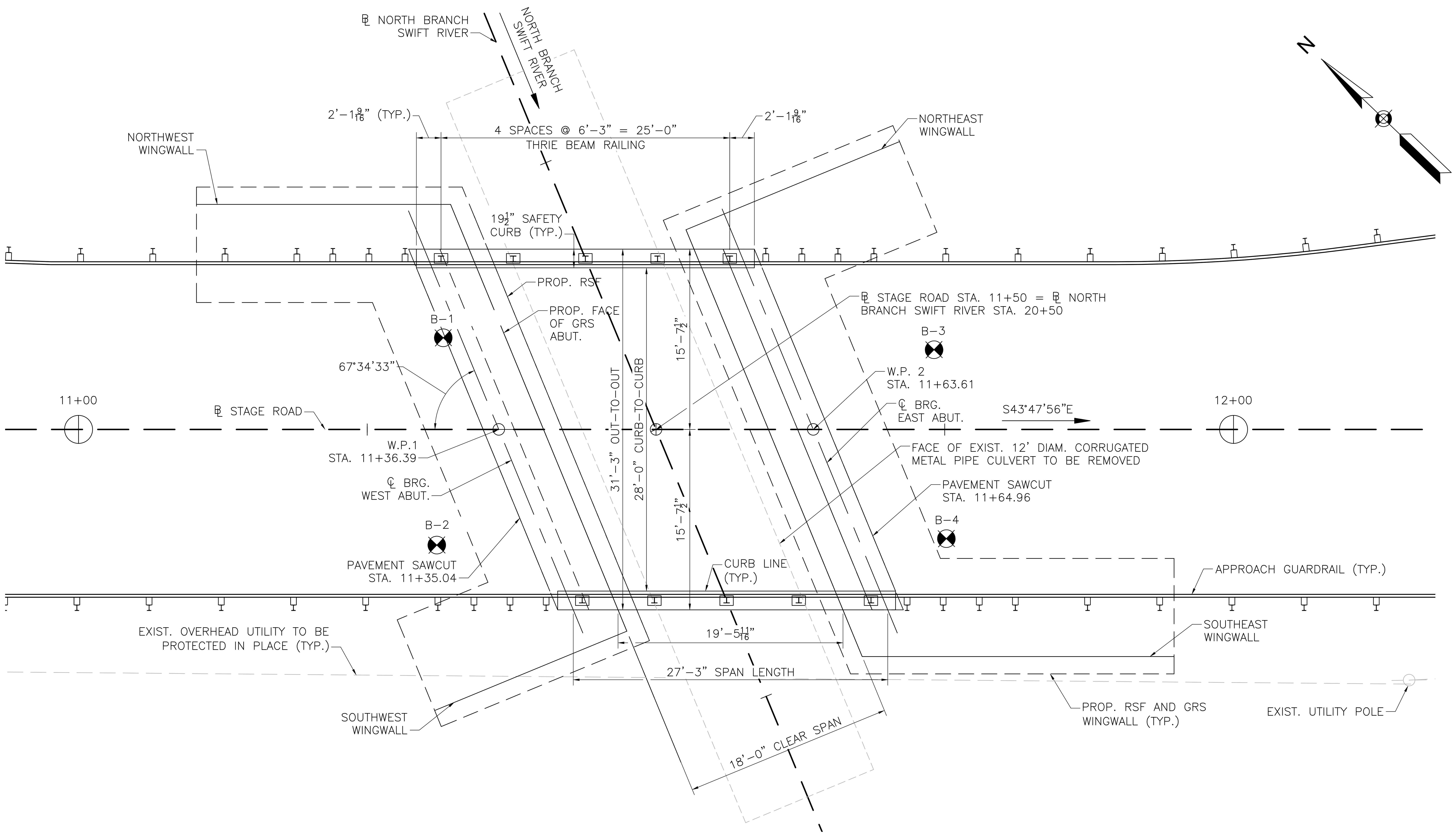
T	Sa
0.00 Sec	0.10 G
0.10 Sec	0.22 G
0.20 Sec	0.22 G
0.30 Sec	0.22 G
0.40 Sec	0.22 G
0.50 Sec	0.19 G
0.60 Sec	0.16 G
0.70 Sec	0.14 G
0.80 Sec	0.12 G
0.90 Sec	0.11 G
1.00 Sec	0.10 G
1.10 Sec	0.09 G
1.20 Sec	0.08 G



(1) Figure 3.10.4.1-1

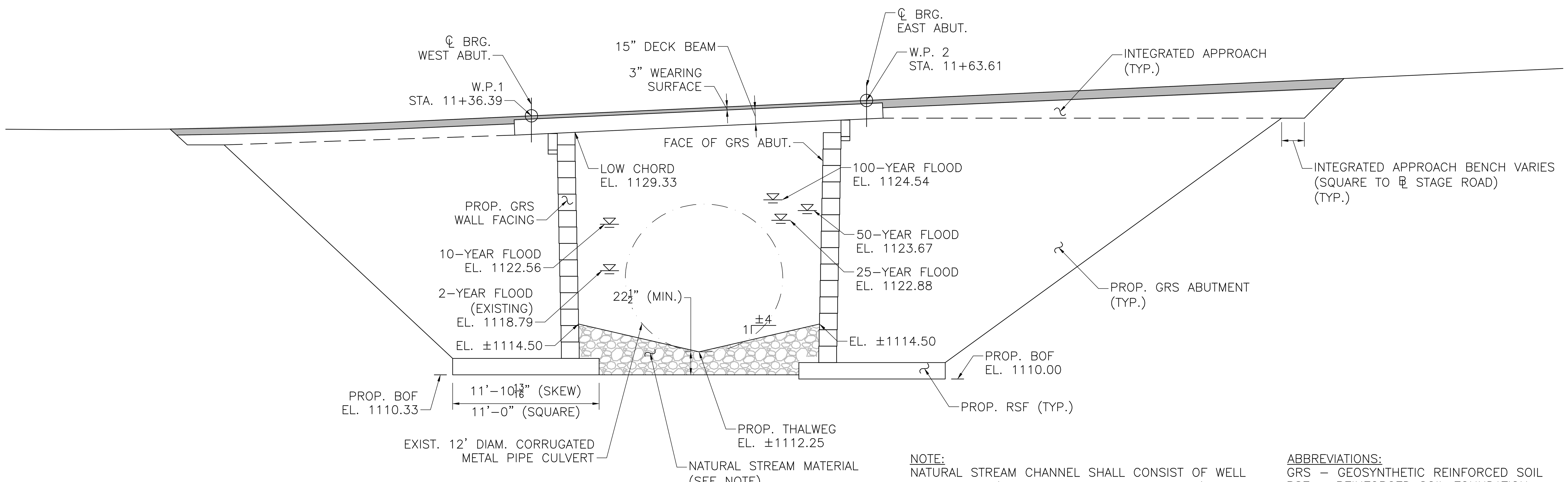
APPENDIX

6.6. Proposed Preliminary Structure Plans



GENERAL PLAN

SCALE: 3/16" = 1'-0"



LONGITUDINAL SECTION

SCALE: 3/16" = 1'-0"

NOTE:
NATURAL STREAM CHANNEL SHALL CONSIST OF WELL GRADED MIX (COMPACTED AND CONSOLIDATED) CONSISTING OF GRAVEL MATERIAL (M1.03.0 TYPE A) OVER COBBLES (6"-12"ø) AND RIP-RAP (M2.02.0).

ABBREVIATIONS:
GRS – GEOSYNTHETIC REINFORCED SOIL
RSF – REINFORCED SOIL FOUNDATION
IBS – INTEGRATED BRIDGE SYSTEM

COMMONWEALTH OF MASSACHUSETTS
MassDOT, Highway Division
APPROVED UNDER PROVISIONS OF MASS. GEN. LAWS CH 85 S 35

BRIDGE ENGINEER | DATE

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REGISTERED PROFESSIONAL ENGINEER | DATE

PROPOSED BRIDGE REPLACEMENT

TOWN OF CUMMINGTON

BRIDGE REPLACEMENT FOR CUMMINGTON C-21-005 (775)
STAGE ROAD OVER SWIFT RIVER

PLAN AND ELEV.

SHEET 5 OF 15