To: Stephen Madden, Geotechnical Engineer, Lead Project Engineer

From: Matthew Riegel, Geotechnical Engineer, P. E., Geotechnical Task Lead

Date: June 26, 2023

Subject: Lyndon – IM 091-3(53) **FINAL** Interpretive Insight Letter

1.0 INTRODUCTION

As requested by the Vermont Agency of Transportation (VTrans), HNTB has completed an interpretive insight letter providing geotechnical subsurface interpretation into installation methods, potential construction challenges, and baseline parameters. The Lyndon IM 091-3(53) project is located on VT Interstate 91 Northbound (NB) and Southbound (SB), just north of Exit 24 at Mile Marker (MM) 141.3, in Lyndon, VT. This project consists of replacing two existing Corrugated Galvanized Metal Pipe (CGMP) culverts that cross underneath I-91 NB and SB, including an associated headwall at both the inlet and outlet orifice. Geotechnical borings were performed to evaluate the subsurface conditions for the assessment of the Base Technical Concept. Results of the field and lab sampling, and all subsequent boring logs are found under a separate cover in the Geotechnical Data Report.

2.0 SOIL PROFILE

A thorough review of the boring logs and laboratory test results was conducted to establish the general stratigraphy of the site. The purpose of "stratifying" a site is to group similar soil materials that have the same geologic origin. Stratification not only aids in visualizing the subsurface conditions, but also facilitates computations since the soil material thoughout a stratum usually exhibits similar engineering characteristics.

The interpretation of soil and groundwater conditions at the project site is based on information obtained at the boring locations and the culvert inlet and outlets. This information has been used as the basis for the conclusions and recommendations contained in this report. Significant variations at areas not explored by the project borings may require re-evaluation of the findings and conclusions contained herein if found during construction.

The boundaries between strata are approximate and idealized, and have been developed through interpretations of widely spaced borings and samples. Actual soil transitions vary and may be more erratic than indicated. The subsurface conditions are discussed below:

Stratum 1: Fill

The layer generally consists of coarse to fine silty sand and sandy clayey silt, with varying amounts of gravel. For the borings performed in the grass swale adjacent to roadway embankments (B-1, B-3, B-6, & B-10), this layer was encountered within the top 4 to 10 feet from ground surface. For the remaining borings performed along the roadway embankment, this layer was encountered within the top 64 to 81 feet below the ground surface. Cobbles and boulders, ranging in sizes of 0.5 to 5 feet, were noted in several borings along the roadway embankment, at depths varying from 40 to 60 feet, during advancement. Below the sand and gravel with intermittent boulders, a layer of fine grained soils was encountered within the fill. The site's history includes development of the I-91 Interstate in the 1950's and 1960's. The borings indicate the presence of a perched water table, which generally sits above the existing culvert, as a result of a low permeable fine grained soil layer. The material within the upper 10 feet is primarily loose to medium dense. Below the upper 10 feet, the material is primarily medium dense to very dense with corrected field SPT N_{60}-values varying from 12 to over 50 blows per foot (bpf).

Stratum 2: Glacial Till

The glacial till was deposited as the glaciers advanced and retreated and scraped away rock more susceptible to erosion, creating a well sorted very dense stratum. The till consists of varying amounts of sand, silt, and gravel. The SPT N_{60}-values within this stratum generally varied from 20 to over 50 bpf which corresponds to a relative density of medium dense to very dense.

Stratum 3: Bedrock

Bedrock was encountered below the Glacial Till down to the termination depth on several borings where rock was confirmed. The bedrock throughout the site consists of carbonaceous Phyllite, generally strong and unweathered.

The subsurface stratification at each boring location is provided in **Table 1**:

Table 1: Subsurface Stratification

Boring No.	Ground Elev[1] (ft)	GW Elev[2] (ft)	Strata Depth Range (ft)		
			1-Fill	2-Glacial Till	3-Bedrock
B-1	861.2	837.3	0 – 8	8 – 32	32 – 49
B-3	834.1	790.6	0 – 18	18 – 66	-
B-4A	856.6	784.3	0 – 75	75 – 86	86 – 96
B-5B	857.5	808.0	0 – 77	77 – 79	-
B-6	785.5	773.8	0 – 11	11 – 20	20 – 30
B-8	825.8	777.0	0 – 64	-	-
B-9A	827.4	774.3	0 – 74	74 – 83	83-93
B-10	760.5	754.2	0 – 4	4 – 50	-
B-11B	854.8	797.7	0 - 81	81 – 94	-
B-12A	823.1	767.2	0 – 66	66 – 87	-

1. Ground Elevations provided by VTrans.
2. Groundwater Elevations averaged from manual ground water readings shown in Geotechnical Data Report.

3.0 INTERPRETIVE PARAMETERS

Stratigraphy and geotechnical design parameters were derived from in-situ testing and published correlations, as well as from field and laboratory classification provided in the boring logs, sample photographs, and in some instances engineering judgement. In accordance with MREI 10-01, values were provided for the internal friction angle, unit weight, poisson's ratio, soil modulus, friction factor, and at-rest earth pressure coefficient of each design strata. General design parameters were provided for each stratum described in the boring logs.

Soil properties were determined based on correlation to corrected SPT N values. SPT N values were corrected for calibrated hammer energy efficiencies of 58, 85, and 87 percent and were also corrected for overburden stress. The calibrated hammer energy efficiencies vary based on the drill rig used during sampling intervals, as noted in the Geotechnical Data Report. SPT N_{60} values and $N_{1(60)}$ were capped at 50 and 70 bpf, respectively, to reduce excessively high design parameters. The friction angles were correlated from SPT N_{60} and $N_{1(60)}$ values using equations from AASHTO LRFD Bridge Design Specification Table C10.4.6.2.4-3.

A summary of the averaged engineering properties for each boring stratum are provided in **Table 2**.

Table 2: Soil Properties

Stratum	N_{60} (bpf)	$N_{1(60)}$ (bpf)	γ (pcf)	φ (deg)	ν (dim)	E (ksi)	G (ksi)	k_o (dim)	f (dim)
Fill	29	29	130	36	0.22	4.01	2.79	0.40	0.50
Glacial Till	50	58	139	41	0.20	8.12	2.87	0.34	0.58

Where:
N_{60} = SPT-N Value corrected for hammer efficiency
$N_{1(60)}$= SPT-N Value corrected for overburden pressure
γ = Total Unit Weight of Soil
v = Poisson's Ratio
φ = Friction Angle of Soil
E = Elastic Modulus of Soil
G = Shear Modulus of Soil
K_o = At-Rest Earth Pressure Coefficient
f = Coefficient of Friction of Soil

4.0 SITE CONDITIONS

The embankment cover above the existing culverts ranges from minimal to up to 75 feet. The embankment material consists of dense to very dense cohesionless sand and silt with little gravel and occasional cobbles and boulders. The invert of the existing Corrugated Galvanized Metal Pipe (CGMP) culverts lies close to very dense glacial till and bedrock.

Potential obstructions along the alignment include cobbles and boulders and abandoned boring drill strings from boreholes B-8, B-8C, and B-9A, and possible unidentified obstructions in the embankment material.

Water level readings from monitoring wells indicate that a perched water table condition exists up to 26 feet higher than the crown elevation of the existing NB culvert and 16 feet higher than the crown elevation of the existing SB culvert, within the embankment fill.

HNTB's scope did not include delination of wetlands, therefore, wetlands impacts have not been considered in the site accessibility assessment.