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GEOTECHNICAL DESIGN REPORT
REPLACEMENT OF HARTS RIVER ROAD BRIDGE (LARGE CULVERT) #0093
RIVER ROAD OVER HARTS BROOK
LEWISTON, MAINE
MAINEDOT WIN 27230.00

PREPARED FOR:

Stantec Consulting Services, Inc.
Portland, Maine

PREPARED BY:

Isabel V. Schonewald, P.E.
Schonewald Engineering Associates, Inc. (SchonewaldEA)
Cumberland, Maine

August 2025

SchonewaldEA Project No. 24-108

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129 MIDDLE ROAD, CUMBERLAND, MAINE 04021
phone 207/829-5226
cell 207/272-9879

VIA EMAIL

August 28, 2025
Project No. 24-108

Sarah Williams, P.E.
Katherine Wight, P.E.
Stantec Consulting Services, Inc.
2211 Congress Street, Suite 380
Portland, ME 04102

Re: Geotechnical Design Report
Replacement of Harts River Road Bridge (Large Culvert) #0093
River Road over Harts Brook
Lewiston, Maine
MaineDOT WIN 27230.00

Dear Sarah and Katherine:

Schonewald Engineering Associates, Inc. (SchonewaldEA) has prepared this geotechnical design report for Stantec Consulting Services, Inc. (Stantec) to support your design of the replacement of the bridge (large culvert) that carries River Road over Harts Brook in Lewiston, Maine (MaineDOT WIN 27230.00). SchonewaldEA's work included assessing subsurface conditions by completing field and laboratory programs, evaluating the geotechnical engineering properties and implications of the subsurface conditions, and preparing this report that summarizes the findings of the work and provides preliminary geotechnical recommendations for the design and construction of the replacement structure.

A quality control/ quality assurance review of the geotechnical work completed by SchonewaldEA for this project was completed by Stephen J. Rabasca, P.E. of SoilMetrics, LLC located in Cape Elizabeth, Maine. Mr. Rabasca's review included evaluating whether the interpretation of subsurface conditions and the recommendations provided are appropriate, as well as assessing whether the work and this report adequately and appropriately address the project objectives. Mr. Rabasca's comments and suggestions have been addressed.

SchonewaldEA's work on this project has been completed under a Subconsultant Agreement with Stantec that is dated December 16, 2024. This report is subject to the limitations contained in the closure section of the report.

PROJECT DESCRIPTION

SchonewaldEA understands that MaineDOT has retained Stantec to design the replacement for an existing bridge (large culvert) that carries River Road over Harts Brook in Lewiston. River Road, where it crosses Harts Brook, is in an industrial section of Lewiston. Facilities in close proximity to the project site include industrial (metal) recycling and solid waste facilities, warehouses and distribution centers, freight companies, and multiple borrow pits. River Road runs north-south at the Harts Brook crossing; the existing culvert is skewed 30 degrees to River Road.

Based on 1988 as-built plans of the current structure, the bridge is a corrugated metal pipe arch having a span of 12.5 feet and height of approximately 8 feet; the pipe arch is approximately 85 feet long. The elevation of River Road at the pipe arch is shown as approximately 165.5 feet; the bottom of the corrugated

metal structure is shown to be at approximate elevation 147 feet. The pipe arch is bedded on 12 inches of granular borrow, There is approximately 10 feet of material over the crown of the pipe. The outlet end of the pipe arch is cut flush with the west embankment slope.

The configuration of the inlet of the culvert is unique. The main channel of Harts Brook runs at and parallel to the toe of the east embankment of River Road for about 100 feet. A tributary that runs roughly perpendicular to River Road joins the main channel near the culvert inlet. It appears that where a 2H:1V or flatter slope could not be maintained, the east embankment of River Road is supported by a wall constructed of gabion baskets. The gabion wall varies in height from about 9 to 19 feet. The gabion wall is approximately 75 feet long. The inlet headwall and wingwalls are also constructed of gabion baskets. According to a recent inspection report, the lower (submerged) welded wire gabion baskets have deteriorated (rusted) and some of the gabion stone fill is not properly retained. According to the 1988 as-built drawings, granular borrow for underwater backfill was placed behind the gabion baskets; it does not appear that a geotextile separation fabric was placed between the gabion baskets and the granular borrow. Plans from a City of Lewiston Locally Administered Project (LAP) entitled “River Road Rehabilitation, MDOT WIN 11599.30,” dated November 2020 indicate alterations were made to the gabion retaining wall/ headwall as part of that work.

We understand that the proposed replacement structure is a 20-foot span by 10-foot rise precast concrete box culvert. A headwall and wing walls are necessary at the inlet of the proposed culvert due to the alignment of Harts Brook relative to River Road. The design shows that the proposed box is generally located along the existing culvert’s alignment, though the skew has been reduced from 30 degrees to 25 degrees. The box culvert will be embedded into the stream bed and the current design calls for placing two feet of special fill inside of the box such that the existing “flow line” is maintained. As proposed, the invert elevation of the concrete box structure (top of the culvert’s base slab) varies from 144.60 feet at the inlet to 143.60 feet at the outlet.

No substantive changes in the roadway’s vertical or horizontal alignments or width are proposed at the proposed structure.

The proposed culvert’s bearing surface is approximately 2 feet below the culvert structure invert to account for the thickness of the culvert’s base slab and the recommended bearing pad. This results in an approximately 21- to 24-foot deep excavation for construction. The excavation may extend to a few feet below the groundwater level that exists at the time of construction. We further understand that River Road can be closed during construction, which will greatly simplify construction phasing/ excavation support.

GEOLOGIC SETTING

Surficial geology along Harts Brook, including the project site, is mapped as braided stream alluvium (Surficial Geology of the Lewiston, Maine Quadrangle; Maine Geological Survey Open File 02-154). River Road is depicted as artificial fill where is crosses Harts Brook. “Ancient” braided stream alluvium typically consists of fluvially deposited sands, silt, gravel, and occasional organic sediment that was deposited on terraces cut into glacial deposits by the Androscoggin River as sea level regressed post-glaciation.

Bedrock in the project area is mapped as schist and granofels of the Sangerville Formation (Bedrock Geology of the Lewiston Quadrangle, Maine, Maine Geological Survey Open File 22-16). Bedrock was not encountered in the test borings drilled for this project.

SUBSURFACE EXPLORATION PROGRAM

SchonewaldEA retained New England Boring Contractors of Hermon, Maine to provide drilling and traffic control services for this project. The objectives of the test boring program included:

- Identifying the bearing soil for the proposed structure and assessing its engineering characteristics; and
- Assessing whether soft/loose and/or compressible soils or shallow bedrock was present that would impact the design of the replacement structure.

To achieve these objectives, two test borings were drilled at the bridge site to evaluate subsurface conditions. The test borings were designated BB-LHB-101 and -102 and were located in opposite quadrants of the existing culvert. The test borings were drilled between October 23 and November 1, 2023. SchonewaldEA selected the final test boring locations in the field and drilling methods, designated the type and depth of sampling and in-situ testing as work progressed, and observed and logged the test borings on a full-time basis.

The locations of the test borings are depicted on the Boring Location Plan that is included in Appendix A. The as-drilled locations of and the ground surface elevations at the borings were surveyed by MaineDOT. The project station and offset, as well as the ground surface elevation at each boring is noted on the boring logs.

The test borings were advanced using standard cased wash boring techniques. Due to the number of buried utilities located in River Road, including a high-pressure gas main, vacuum excavation procedures were used in the upper approximately 5 to 6 feet of each boring. Both test borings were terminated at approximately 47 feet Below the Ground Surface (BGS) in medium dense to very dense glacial sands with no refusal. MaineDOT's key to soil and rock core sample descriptions dated May 2024 is provided as Appendix B. The logs of the test borings are included as Appendix C.

Standard Penetration Tests (SPTs) were completed and split-spoon soil samples were obtained near the ground surface and then typically at five-foot intervals to the bottom of each boring, except as follows. With the intent of better characterizing the bearing stratum, SPTs / split-spoon sampling was completed continuously (every 2 feet) over a 10-foot interval near the anticipated bottom of the replacement box culvert. SPTs were performed using an auto hammer that had been calibrated in general conformance with MaineDOT policy. NEBC had the auto hammer calibrated on April 21, 2023 and provided the report to SchonewaldEA. The hammer efficiency factor is recorded on the boring logs.

Groundwater levels observed within the borings are noted on the boring logs, along with the conditions (e.g., stabilization times) under which the groundwater measurements were obtained. The boreholes were backfilled using drill cuttings, supplemented by manufactured sand and gravel, and the pavement patched.

GEOTECHNICAL LABORATORY TESTING PROGRAM

Representative soil samples obtained in the test borings were submitted to the GeoTesting Express (GTX) geotechnical laboratory in Acton, Massachusetts for a soil testing program. The testing program was developed by SchonewaldEA based on the subsurface conditions encountered in the test borings with the objectives of confirming field classifications and supporting the development of the geotechnical design recommendations for the replacement structure. The laboratory testing program is summarized in the following table.

Boring No.	Sample No.	Sample Depth (ft, BGS)	Soil Material Type	Tests Performed
SPLIT-SPOON JAR SAMPLES				
BB-LHB-101	2D	10-12	fill	wash gradation with hydrometer
BB-LHB-101	3D	15-16.2	fill	wash gradation with hydrometer
BB-LHB-101	4D	21-23	glacial sands	wash gradation with hydrometer
BB-LHB-101	5D	23-25	glacial sands	wash gradation with hydrometer
BB-LHB-101	6D	25-27	glacial sands	wash gradation with hydrometer
BB-LHB-101	9D	34-36	glacial sands	wash gradation with hydrometer
BB-LHB-102	2D	10-12	fill	wash gradation with hydrometer
BB-LHB-102	5D	24-26	glacial sands	wash gradation with hydrometer
BB-LHB-102	6D	26-28	glacial sands	wash gradation with hydrometer
BB-LHB-102	7D	28-30	glacial sands	wash gradation with hydrometer
BB-LHB-102	8D	30-32	glacial sands	wash gradation with hydrometer
BB-LHB-102	10D	40-42	glacial sands	wash gradation with hydrometer

Laboratory test results are summarized on the test boring logs included as Appendix C. The laboratory test reports that include methodology/ test standards are included as Appendix D.

SUBSURFACE CONDITIONS

Subsurface conditions encountered in the test borings completed at the project site consisted of approximately 13 to 16 feet of Embankment (Granular) Fill over Glacial Sands. SchonewaldEA's interpretation of the subsurface conditions underlying the site is depicted on the Interpretive Subsurface Profile that is included in Appendix A.

Embankment (Granular) Fill: Both of the test borings encountered approximately 13 to 16 feet of embankment (granular) fill. The relative density of the fill varied from very loose to medium dense. The fill consisted of fine to coarse sand, with varying amounts of silt and gravel.

Glacial Sands: Both of the test borings encountered glacial sands below the embankment fill. The glacial sands consisted of cohesionless, medium dense to dense, typically fine or fine to medium sand, with trace to little silt, and occasionally trace gravel. Zones of the glacial sands contained coarser material, indicative of a higher energy depositional environment. The glacial sands - coarser fraction typically consisted of cohesionless, very dense, gravelly fine to medium or fine to coarse sand, little silt.

Detailed descriptions of the soils encountered in the test borings are provided on the logs included in Appendix C.

Bedrock: Both borings extended to approximately 47 feet BGS (Elevation 117 to 118 feet) without encountering refusal. The termination depths of the borings were approximately 24 feet below the bottom of proposed excavation.

Groundwater: Drilling water was used to advance both boreholes from approximately 5 feet BGS to the bottom of the borings. The water level was measured in the boreholes upon completion of drilling with no stabilization time. These water level measurements are noted on the logs included in Appendix C. These water levels do not necessarily reflect groundwater elevations. Regardless, groundwater fluctuations would be expected to vary over time due to a number of factors, most notably weather and seasonal fluctuations.

DESIGN RECOMMENDATIONS

Structure Options: A precast concrete box culvert installed on a bearing pad constructed on undisturbed glacial sand soils will provide adequate bearing resistance.

Settlement: The glacial sands are cohesionless and are medium dense to very dense. Therefore, we do not anticipate the concrete box culvert will undergo detrimental post-construction settlement.

Design Recommendations:

Design elements:

The proposed replacement structure will consist of a 20-foot span by 10-foot rise precast concrete box culvert on an approximately 25 degree skew. SchonewaldEA understands that the structural design of the concrete box culvert, headwall, and wing walls will be the responsibility of the contractor.

A concrete cutoff (toe) wall should be constructed at the inlet and outlet of the box culvert to cutoff stream flow through the bearing pad Per the project details, the bearing pad material should not extend under the toe walls. The toe wall at the outlet end will also provide some protection against piping.

Both the inlet and outlet of the culvert should be armored with riprap that is underlain by a non-woven geotextile fabric. The toe of the riprap sections should be constructed 1 foot below the streambed elevation to serve as a key.

Construction considerations:

Construction of the proposed culvert will require soil excavation. We anticipate the excavation needed to construct the bearing pad for the box culvert will extend to between approximately 21 to 24 feet below the existing road surface. Earth support systems will be required since laying back slopes does not appear feasible given the existing buried utilities located in River Road. Regardless of the method of excavation, all excavations and earth support systems shall meet all applicable OSHA regulations.

The Contractor should maintain a relatively dry excavation by controlling groundwater levels, as well as surface water infiltration and runon. This likely can be accomplished using conventional dewatering techniques and stormwater BMPs, including sumps, temporary ditches, granular drainage blankets, and other BMPs to extract/ depress groundwater and divert surface water.

The full nature of the bearing surface will not be evident until the culvert excavation is made. Any loose soils or soft or organic materials encountered in the excavation bottom should be removed and replaced with Granular Borrow Material for Underwater Backfill or in wet/saturated conditions with Crushed Stone ¾-Inch.

Bearing pad and structure backfill:

Presuming that conventional dewatering techniques can maintain a "relative dry" excavation, the bedding material should consist of a 1-foot thickness of Culvert Bedding Stone that is enveloped in a geotextile fabric for separation.

The subgrade for the bedding material should be proofrolled using multiple passes of a static roller to identify loose or weaving areas and to achieve a firm and stable surface. Any loose soils or soft or unsuitable materials encountered in the bedding layer subgrade should be removed and replaced with Granular Borrow for Underwater Backfill or in wet/saturated conditions Crushed Stone ¾-Inch.

The Culvert Bedding Stone shall meet the criteria for MaineDOT Standard Specification 703.22 – Underdrain Backfill Material, Type C.

The geotextile fabric used to envelope the Culvert Bedding Stone and under riprap shall meet the criteria for MaineDOT Standard Specification 722.01 – Stabilization/ Reinforcement Geotextile.

The soil envelope and backfill should consist of Granular Borrow Material for Underwater Backfill with a maximum particle size of 4 inches. The granular borrow backfill should be placed in lifts of 8 to 12 inches loose measure and compacted to the box culvert manufacturer's specifications or, in the absence of manufacturer's specifications, to at least 92 percent of the AASHTO T-180 maximum dry density. In no case should the backfill soil be compacted to less than 92 percent of the AASHTO T-180 maximum dry density.

Box culvert structural design:

The following geotechnical design parameters should be used for the structural design of the 20-foot span (20-foot wide base slab) box culvert. Calculations that include methodology/ references are included in Appendix E.

- Parameters assigned to bedding and backfill materials should be as indicated for Soil Type 4 in Table 3-3 (Material Classification) in the MaineDOT Bridge Design Guide, specifically:
  - Internal friction angle (φ) equal to 32 degrees; and
  - Total unit weight (γ_t) equal to 0.125 kips per cubic foot (kcf);
- For service limit state analyses, the factored bearing resistance of a minimum 1-foot thick compacted bedding layer overlying undisturbed native glacial sand soils should not exceed 6 kips per square foot (ksf);
- For strength limit state analyses, the factored bearing resistance of a minimum 1-foot thick compacted bedding layer overlying undisturbed native glacial sand soils should not exceed 10 ksf;
- The modulus of subgrade reaction for the compacted bedding layer overlying undisturbed native glacial sand soils should not exceed 30 pounds per cubic inch (for the 20-foot wide culvert base slab);
- For evaluation of sliding on the base of the precast concrete box, the friction angle between the precast concrete structure and the underlying granular bedding material should be taken as 26 degrees;
- A restrained condition should be assumed and, therefore, an at-rest coefficient of lateral earth pressure, K_o, equal to 0.47 should be used for the determination of lateral earth pressure acting on the walls of the box culvert.

Wing walls:

The wing walls should bear on cast-in-place footings. The bottom of footing elevation should be at least 4.5 feet below the lowest finished grade on the outside of the wall for frost protection. Supporting information is included with the design calculations in Appendix E.

The footings should be bedded on a 1-foot thick layer of compacted Granular Borrow Material for Underwater Backfill with a maximum particle size of 4 inches that is underlain by geotextile fabric for separation. The subgrade for the bedding material should be proofrolled using multiple passes of a static roller to identify loose or weaving areas and to achieve a firm and stable surface. Any loose soils or soft or unsuitable materials encountered in the bedding layer subgrade should be removed and replaced with Granular Borrow for Underwater Backfill or in wet/saturated conditions Crushed Stone ¾-Inch.

Regardless of the calculated bearing resistance, the footings should be at least 3 feet wide.

The following geotechnical design parameters should be used for the structural design of the footings and/or wing walls, whether precast or cast-in-place. Calculations that include methodology/ references are included in Appendix E.

- Parameters assigned to bedding and backfill materials should be as indicated for Soil Type 4 in Table 3-3 (Material Classification) in the MaineDOT Bridge Design Guide, specifically:
  - Internal friction angle (φ) equal to 32 degrees; and
  - Total unit weight (γ_t) equal to 0.125 kips per cubic foot (kcf);
- For service limit state analyses, the factored bearing resistance of the compacted bedding layer overlying undisturbed native glacial sand soils should not exceed 4 ksf;
- For strength limit state analyses, the factored bearing resistance of the compacted bedding layer overlying undisturbed native glacial sand soils should not exceed 7 ksf;
- For evaluation of sliding on the base of the footing, the friction angle between the cast-in-place concrete and the underlying bedding material should be taken as 26 degrees;
- Design calculations should account for eccentric loading;
- The concrete wingwalls should be designed to resist lateral earth pressures, vehicular loads, creep and temperature and shrinkage deformations of the precast concrete frame, if used. The wingwalls should be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil of 2.0 feet or 250 pounds per square foot (psf);
- Wingwalls and the headwall should be allowed to rotate independently of the precast concrete box culvert and should be designed using the Coulomb active earth pressure coefficient, Ka, equal to 0.46 assuming a 2H:1V backslope. The interface details between the precast concrete box culvert and the wingwalls and headwall should be provided with the contractor's submittal package.

Slopes above the wingwalls should be constructed with riprap surface treatment and should be no steeper than 2H:1V.

Details should address surface water controls behind the top of the wall, groundwater controls behind the wall, and measures to limit erosion at the toe of the wall resulting from high water conditions in Harts Brook.

CLOSURE

This report has been prepared for the use of Stantec Consulting Services, Inc. for specific application to the design of a replacement of the bridge (large culvert) that carries River Road over Harts Brook in Lewiston, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

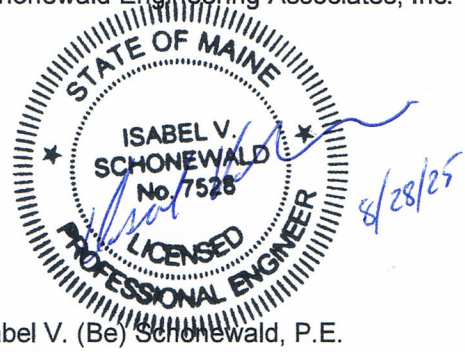
In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes in design.

These analyses and recommendations are based in part upon a limited subsurface investigation at discrete exploratory locations completed at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also become necessary to re-evaluate the recommendations made in this report.

It is recommended that a geotechnical engineer be provided the opportunity to review the design documents in order that the design recommendations and construction considerations presented in this report are properly interpreted and implemented in the design and specifications. It is also recommended that a geotechnical engineer be on site to observe excavation and subgrade preparation operations for the box culvert construction.

SchonewaldEA appreciates the opportunity to be of service to Stantec and MaineDOT. If you have any questions regarding the work completed by SchonewaldEA or the information provided in this geotechnical design report, please call/reply at your convenience.

Sincerely,
Schonewald Engineering Associates, Inc.



Isabel V. (Be) Schonewald, P.E.
President

Enclosures

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APPENDICES

APPENDIX A

FIGURES

CURVE DATA
PI = 4007+32.31
D = 08°48'53.05"
Δ = 18°30'13.55" (LT)
R = 650.00'
L = 209.92'
T = 105.88'
E = 8.57'

HART'S BROOK

PC = 4006+26.43

PT = 4008+36.34

25'-0"

C 20'-0" Span x 10'-0" Rise
Concrete Box Culvert
Sta. 4005+21.00

BB-LHB-101

BB-LHB-102

RIVER ROAD

N04°13'07.11"W

N22°43'20.67"W

To Durham

To Lewiston

Flow

4003+00

4004+00

4005+00

4006+00

4007+00

4008+00

4009+00

PLAN

25 0 25 50
Scale of Feet

LEGEND
CASED WASH BORING

PRELIMINARY
NOT FOR CONSTRUCTION

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

2723000

WIN 27230.00

BRIDGE PLANS

0093

DRAFT PDR
SEPTEMBER 2024

	SIGNATURE	P.E. NUMBER	DATE

BY	DATE
KLW	SEP 2024
VS @ SEA	SEP 2024
VS @ SEA	

PROJ. MANAGER	J. BRASK
DESIGN-DETAILED	VS @ SEA
CHECKED-REVIEWED	VS @ SEA
DESIGN2-DETAILED2	
DESIGN3-DETAILED3	
REVISIONS 1	
REVISIONS 2	
REVISIONS 3	
REVISIONS 4	
FIELD CHANGES	

LEWISTON
RIVER ROAD

BORING LOCATION PLAN

SHEET NUMBER
1
OF 2

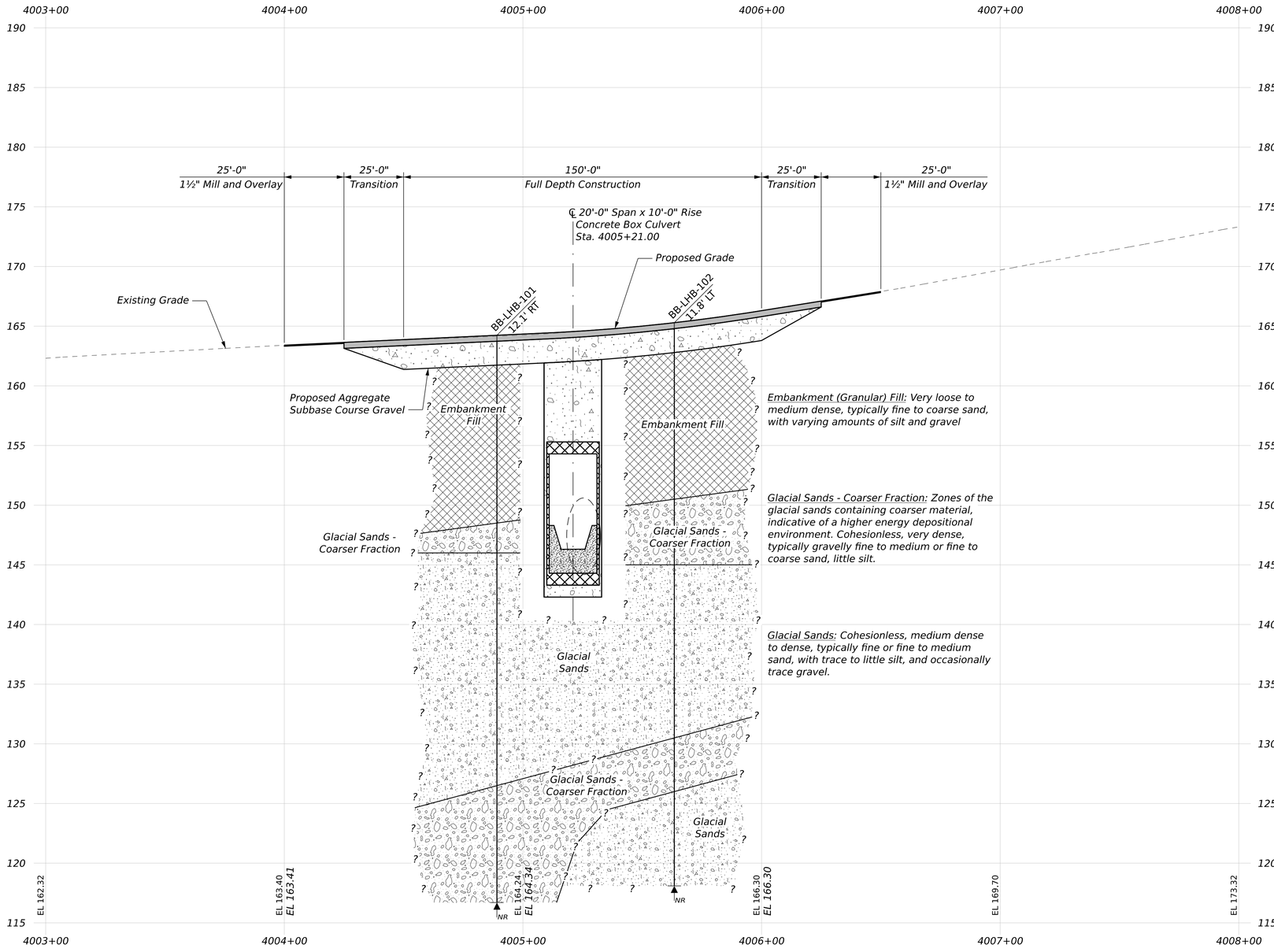
Schonewald Engineering Associates, Inc.

Stantec

Date: 9/30/2024

Username: kwight

Filename: U:\179450746\transportation\drawings\27230.00\00\BRIDGE_boring_location_plan.dgn



Embankment (Granular) Fill: Very loose to medium dense, typically fine to coarse sand, with varying amounts of silt and gravel

Glacial Sands - Coarser Fraction: Zones of the glacial sands containing coarser material, indicative of a higher energy depositional environment. Cohesionless, very dense, typically gravelly fine to medium or fine to coarse sand, little silt.

Glacial Sands: Cohesionless, medium dense to dense, typically fine or fine to medium sand, with trace to little silt, and occasionally trace gravel.

PROFILE

HORIZ 25 0 25 50

VERT 5 0 5 10

SCALE

LEGEND

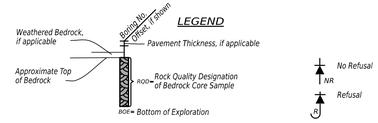
CASED WASH BORING

KEY

NR = No Refusal surface encountered

bgs = below ground surface

BB = Bridge Boring



Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

PRELIMINARY
NOT FOR CONSTRUCTION

Date: 10/2/2024

Username: kwight

Filename: U:\179450746\transportation\drawings\27230.00\00\BRIDGE_isp.dgn

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

2723000

WIN 27230.00

BRIDGE PLANS

0093

DRAFT PDR
SEPTEMBER 2024

	BY	DATE
PROJ. MANAGER: J. BRASK		
DESIGN-DETAILED	WS @ SEA	SEP 2024
CHECKED-REVIEWED	WS @ SEA	SEP 2024
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

LEWISTON
RIVER ROAD

INTERPRETIVE
SUBSURFACE PROFILE

SHEET NUMBER

2

OF 2

SCHONEWALD ENGINEERING ASSOCIATES, INC.

Stantec

APPENDIX B

MAINEDOT KEY TO SOIL AND ROCK DESCRIPTIONS

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS (more than half of material is larger than No. 200 sieve size)	GRAVELS (more than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS (little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly-graded gravels, gravel sand mixtures, little or no fines.
		GRAVEL WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve size)	CLEAN SANDS (little or no fines)	SW	Well-graded sands, Gravelly sands, little or no fines
			SP	Poorly-graded sands, Gravelly sand, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (more than half of material is smaller than No. 200 sieve size)	SILTS AND CLAYS (liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, Silty or Clayey fine sands, or Clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, Gravelly clays, Sandy clays, Silty clays, lean clays.
			OL	Organic silts and organic Silty clays of low plasticity.
	SILTS AND CLAYS (liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine Sandy or Silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
	HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.

Desired Soil Observations (in this order, if applicable):

Color (Munsell color chart)
Moisture (dry, damp, moist, wet)
Density/Consistency (from above right hand side)
Texture (fine, medium, coarse, etc.)
Name (Sand, Silty Sand, Clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc.,)
Cementation (weak, moderate, or strong)
Geologic Origin (till, marine clay, alluvium, etc.)
Groundwater level

Maine Department of Transportation
Geotechnical Section
Key to Soil and Rock Descriptions and Terms
Field Identification Information

MODIFIED BURMISTER SYSTEM

Descriptive Term	Portion of Total (%)
trace	0 - 10
little	11 - 20
some	21 - 35
adjective (e.g. Sandy, Clayey)	36 - 50

TERMS DESCRIBING DENSITY/CONSISTENCY

Coarse-grained soils (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) Silty or Clayey gravels; and (3) Silty, Clayey or Gravelly sands. Density is rated according to standard penetration resistance (N-value).

Density of Cohesionless Soils	Standard Penetration Resistance N_{60}-Value (blows per foot)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

Fine-grained soils (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) Gravelly, Sandy or Silty clays; and (3) Clayey silts. Consistency is rated according to undrained shear strength as indicated.

Consistency of Cohesive soils	SPT N_{60}-Value (blows per foot)	Approximate Undrained Shear Strength (psf)	Field Guidelines
Very Soft	WOH, WOR, WOP, <2	0 - 250	Fist easily penetrates
Soft	2 - 4	250 - 500	Thumb easily penetrates
Medium Stiff	5 - 8	500 - 1000	Thumb penetrates with moderate effort
Stiff	9 - 15	1000 - 2000	Indented by thumb with great effort
Very Stiff	16 - 30	2000 - 4000	Indented by thumbnail
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

$$RQD\ (\%) = \frac{\text{sum of the lengths of intact pieces of core* > 4 inches}}{\text{length of core advance}}$$

*Minimum NQ rock core (1.88 in. OD of core)

Rock Quality Based on RQD

Rock Quality	RQD (%)
Very Poor	≤25
Poor	26 - 50
Fair	51 - 75
Good	76 - 90
Excellent	91 - 100

Desired Rock Observations (in this order, if applicable):

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Rock Type (granite, schist, sandstone, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
-dip (horiz - 0-5 deg., low angle - 5-35 deg., mod. dipping - 35-55 deg., steep - 55-85 deg., vertical - 85-90 deg.)
-spacing (very close - <2 inch, close - 2-12 inch, mod. close - 1-3 feet, wide - 3-10 feet, very wide >10 feet)
-tightness (tight, open, or healed)
-infilling (grain size, color, etc.)
Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock quality (very poor, poor, etc.)
ref: ASTM D6032 and FHWA NHI-16-072 GEC 5 - Geotechnical Site Characterization, Table 4-12
Recovery (inch/inch and percentage)
Rock Core Rate (X.X ft - Y.Y ft (min:sec))

Sample Container Labeling Requirements:

WIN
Bridge Name / Town
Boring Number
Sample Number
Sample Depth
Blow Counts
Sample Recovery
Date
Personnel Initials

APPENDIX C

BORING LOGS

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Harts River Road Bridge #0093
River Road over Harts Brook
Location: Lewiston, ME

Boring No.: BB-LHB-101

WIN: 27230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	163.9	**Auger ID/OD:**	vac excavate to 5.6 ft
Operator:	McDougal/ Share	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-53 track (NEBC-28)	**Hammer Wt./Fall:**	140 lbs/30 inches
Date Start/Finish:	11/1/23; 0940-1615	**Drilling Method:**	cased wash boring	**Core Barrel:**	n/a
Boring Location:	Sta 4004+89, 12.1 RT	**Casing ID/OD:**	HW(4.0/4.5)-17'/NW(3.0/3.5)-19'	**Water Level*:**	23.6 ft (open, 0 hrs stab)
Hammer Efficiency Factor: 0.765		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							VAC	163.5		5 inches HMA (0.4)	
										0.4 to 3.0 ft: Many small cobbles noted.	
										3 ft: Apparent bottom of road gravels.	
5	1D		5.0 - 5.6	GRAB SAMPLE	--		HW			GRAB SAMPLE: Brown, moist, fine to coarse SAND, some gravel, trace to little silt, (Fill). 5.6 ft: Bottom of vacuum excavation.	
							77				
							45				
							30				
							29				
10	2D	24/7	10.0 - 12.0	2-2-2-2	4	5	PUSH			Brown, loose, fine to coarse SAND, little to some silt, trace to little gravel, (Fill) .	GTX#747690 G=A-2-4(0)
15	3D	14/11	15.0 - 16.2	6-26-50/2"	--		RC			Red brown, Gravelly, fine to coarse SAND, little silt, (Fill).	GTX#747691 G=A-1-b(0)
							NW	147.7		(16.2) 16.2 to 17.8 ft: Very boney; difficulty advancing borehole.	
							RC	146.1		(17.8)	
							OPEN				
20											
	4D	24/11	21.0 - 23.0	12-13-13-13	26	33				Red brown, dense, fine to medium SAND, little silt, trace coarse sand, trace fine gravel, (Glacial Sand).	GTX#747692 G=A-2-4(0)
	5D	24/11	23.0 - 25.0	9-10-10-11	20	26				Red brown, medium dense, fine SAND, trace to little silt, (Glacial Sand).	GTX#747693 G=A-2-4(0)
25											

Remarks:

Vacuum excavation completed on 10/23/23.
Borehole grouted to 5.1 ft BGS with cement-bentonite grout; peastone to approx. 0.5 ft BGS; cold patch.

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Harts River Road Bridge #0093
River Road over Harts Brook
Location: Lewiston, ME

Boring No.: BB-LHB-101

WIN: 27230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	163.9	**Auger ID/OD:**	vac excavate to 5.6 ft
Operator:	McDougal/ Share	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-53 track (NEBC-28)	**Hammer Wt./Fall:**	140 lbs/30 inches
Date Start/Finish:	11/1/23; 0940-1615	**Drilling Method:**	cased wash boring	**Core Barrel:**	n/a
Boring Location:	Sta 4004+89, 12.1 RT	**Casing ID/OD:**	HW(4.0/4.5)-17'/NW(3.0/3.5)-19'	**Water Level*:**	23.6 ft (open, 0 hrs stab)
Hammer Efficiency Factor: 0.765		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_V = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	6D	24/12	25.0 - 27.0	8-10-11-14	21	27				Red brown-tan, medium dense, fine SAND, little silt, trace medium sand, (Glacial Sand).	GTX#747694 G=A-2-4(0)
	7D	24/12	27.0 - 29.0	13-14-15-17	29	37				Red brown-tan, dense, fine to medium SAND, trace to little silt, (Glacial Sand).	
	8D	24/12	29.0 - 31.0	16-17-19-30	36	46				Red brown-tan, dense, fine to medium SAND, trace to little silt, with one 1-inch seam fine to coarse SAND, trace silt, (Glacial Sand).	
30											
	9D	24/14	34.0 - 36.0	19-10-11-18	21	27				Brown, medium dense, fine to medium SAND, little silt, little gravel, trace coarse sand; somewhat layered, (Glacial Sand).	GTX#747695 G=A-2-4(0)
35											
								126.4		37.5	
	10D	24/21	39.0 - 41.0	30-33-33-61	66	84				Brown, very dense, layered (composite sample): fine to medium SAND, trace silt; fine to coarse SAND; and Gravelly fine to medium SAND, little to some silt, trace coarse sand, (Glacial Sand-Coarse Fraction).	
40										42.3 to 42.7 ft: Boney layer.	
										43.8 to 44.1 ft: Boney layer.	
45	11D	5/4	45.0 - 45.4	50/5"	--					Grey brown, fine to medium SAND, little to some silt, little gravel, trace coarse sand, (Glacial Sand-Coarse Fraction). 45.4 to 47.1 ft: Boney layer.	
								116.7		47.2	
										Bottom of Exploration at 47.2 feet below ground surface. No refusal.	
50											

Remarks:

Vacuum excavation completed on 10/23/23.
Borehole grouted to 5.1 ft BGS with cement-bentonite grout; peastone to approx. 0.5 ft BGS; cold patch.

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Harts River Road Bridge #0093
River Road over Harts Brook
Location: Lewiston, ME

Boring No.: BB-LHB-102

WIN: 27230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	165.1	**Auger ID/OD:**	vac excavate to 5.8 ft
Operator:	McDougal/ Share	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-53 track (NEBC-28)	**Hammer Wt./Fall:**	140 lbs/30 inches
Date Start/Finish:	10/31; 0855-11/1/23; 0915	**Drilling Method:**	cased wash boring	**Core Barrel:**	NQ2
Boring Location:	Sta 4005+64, 11.8 LT	**Casing ID/OD:**	HW(4.0/4.5)-30'/NW(3.0/3.5)-40'	**Water Level*:**	39.0 ft (open, 0 hrs stab)
Hammer Efficiency Factor: 0.765		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_v = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							VAC	164.7		5 inches HMA (0.4)	
										0.4 to 3.5 ft: Many small cobbles noted.	
										3.5 ft: Apparent bottom of road gravels.	
5	1D		5.5 - 5.8	GRAB SAMPLE	--		HW			GRAB SAMPLE: Brown, moist, fine to coarse SAND, some gravel, little silt, (Fill).	
							69			5.8 ft: Bottom of vacuum excavation.	
							58				
							69				
							74				
10	2D	24/7	10.0 - 12.0	9-10-14-17	24	31	63			Brown and grey, somewhat layered, dense, fine to medium SAND, little gravel, little silt, trace coarse sand, (Fill).	GTX#747696 G=A-1-b(0)
							89				
							111				
							103	151.6		(13.5)	
							118+			13.5 ft: Very boney; difficult to advance borehole.	
15	MD	2/0	15.0 - 15.2	50/2"	--		RC			No recovery. Roller cone through 6- to 9-inch cobble/boulder; very boney to 20 feet.	
20	3D	24/5	20.0 - 22.0	40-30-15-18	45	57	142			Grey brown, very dense, fine to coarse Sandy GRAVEL, little Silt, (Glacial Sand-Coarse Fraction).	
							131	144.1		(21.0)	
	4D	24/5	22.0 - 24.0	15-8-7-8	15	19	92			Grey brown, medium dense, fine to medium SAND, little silt, (Glacial Sand).	
							77				
25	5D	24/10	24.0 - 26.0	9-8-9-6	17	22	78			Grey brown, medium dense, fine SAND, some silt, (Glacial Sand).	GTX#747697 G=A-2-4(0)

Remarks:

Vacuum excavation completed on 10/23/23.
Borehole grouted to 7.7 ft BGS with cement-bentonite grout; peastone-hydraulic cement to approx. 0.5 ft BGS; cold patch

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

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

Boring No.: BB-LHB-102

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Harts River Road Bridge #0093
River Road over Harts Brook
Location: Lewiston, ME

Boring No.: BB-LHB-102

WIN: 27230.00

Driller:	New England Boring Contractors	**Elevation (ft.)**	165.1	**Auger ID/OD:**	vac excavate to 5.8 ft
Operator:	McDougal/ Share	**Datum:**	NAVD88	**Sampler:**	standard split-spoon
Logged By:	Schonewald	**Rig Type:**	Mobile Drill B-53 track (NEBC-28)	**Hammer Wt./Fall:**	140 lbs/30 inches
Date Start/Finish:	10/31; 0855-11/1/23; 0915	**Drilling Method:**	cased wash boring	**Core Barrel:**	NQ2
Boring Location:	Sta 4005+64, 11.8 LT	**Casing ID/OD:**	HW(4.0/4.5)-30'/NW(3.0/3.5)-40'	**Water Level*:**	39.0 ft (open, 0 hrs stab)
Hammer Efficiency Factor: 0.765		**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
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SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Rig Specific Annual Calibration Value
N_{60} = SPT N-uncorrected Corrected for Hammer Efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
T_V = Pocket Torvane Shear Strength (psf)
WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25							102				
	6D	24/12	26.0 - 28.0	4-9-13-15	22	28	99			Grey brown, medium dense, Silty fine SAND. Color change from grey to brown with 1/8-in thick layer cemented silt at 27 ft, (Glacial Sand).	GTX#747698 G=A-4(0)
							134				
	7D	24/15	28.0 - 30.0	9-11-15-22	26	33	98			Grey brown grading to tan with occasional rust varves, dense, fine SAND, little to some silt, trace medium sand, (Glacial Sand).	GTX#747699 G=A-2-4(0)
							111				
30	8D	24/12	30.0 - 32.0	18-12-14-16	26	33	NW RC			Tan with occasional rust varves, dense, fine SAND, some silt, trace medium sand, trace gravel, (Glacial Sand).	GTX#747700 G=A-2-4(0)
								130.4		34.7	
35	MR	36/--	35.0 - 38.0	BOULDER			NQ2			34.7 to 35.0 ft: Solid grind with roller cone. 35.0 ft: Attempt rock core; break though boulder at 36.3 ft.	
	9D	12/11	38.0 - 39.0	12-15	--		--			Brown, fine to medium SAND, trace to little silt, with 3 in thick layer fine to coarse Sandy GRAVEL, trace silt. (composite sample), (Glacial Sand-Coarse Fraction).	
							120	126.1		39.0	
40	10D	24/13	40.0 - 42.0	15-17-17-16	34	43	OPEN			Red brown, dense, fine to medium SAND, trace to little silt, (Glacial Sand).	GTX#747701 G=A-2-4(0)
45	11D	24/15	45.0 - 47.0	9-11-13-15	24	31				Red brown, dense, fine to medium SAND, trace silt, (Glacial Sand).	
								118.1		47.0	
										Bottom of Exploration at 47.0 feet below ground surface. No refusal.	
50											

Remarks:

Vacuum excavation completed on 10/23/23.
Borehole grouted to 7.7 ft BGS with cement-bentonite grout; peastone-hydraulic cement to approx. 0.5 ft BGS; cold patch

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

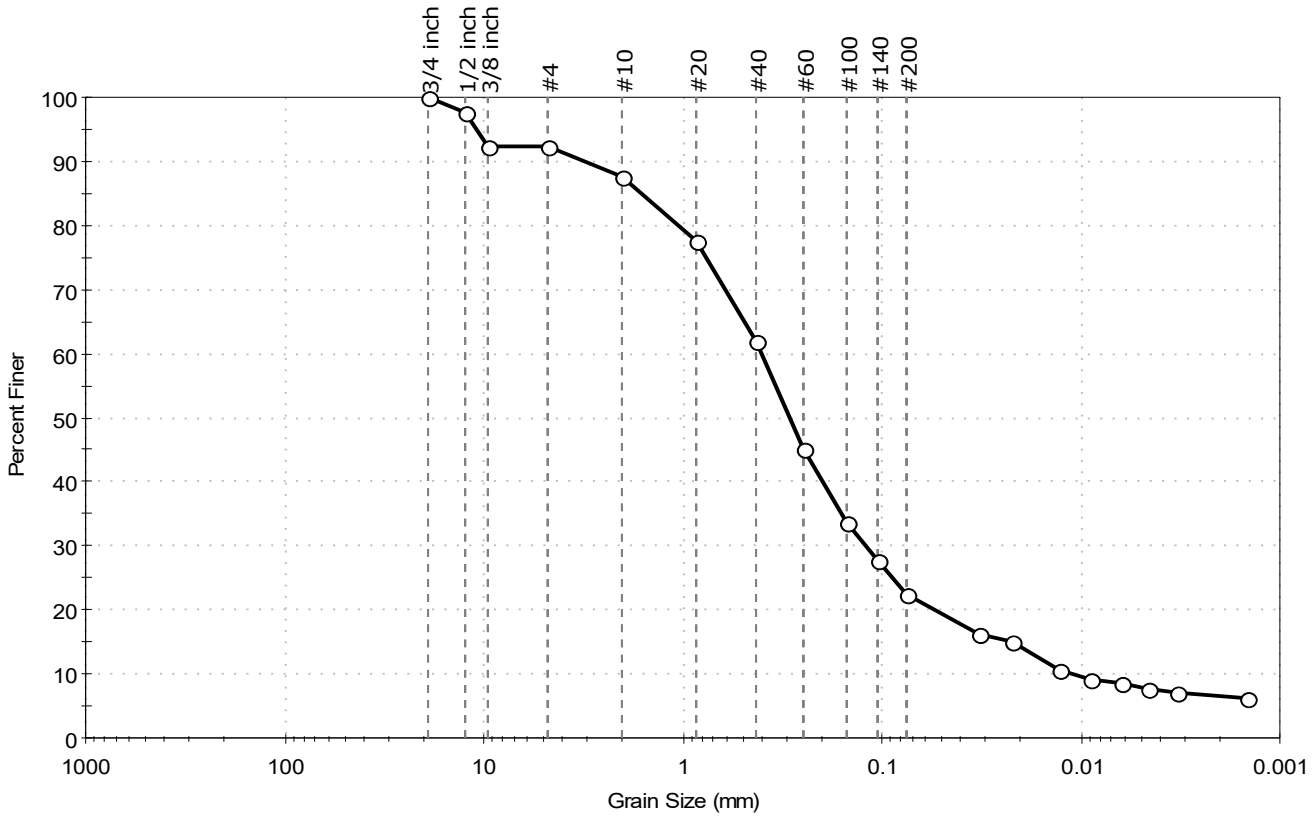
* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

APPENDIX D

RESULTS OF LABORATORY TESTS ON SOIL SAMPLES

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-101	Sample Type:	jar	Tested By:	ckg
Sample ID:	2D	Test Date:	12/07/23	Checked By:	ank
Depth :	10-12	Test Id:	747690		
Test Comment:	---				
Visual Description:	Moist, brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	7.5	70.1	22.4

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/4 inch	19.00	100		
1/2 inch	12.50	98		
3/8 inch	9.50	92		
#4	4.75	92		
#10	2.00	87		
#20	0.85	78		
#40	0.42	62		
#60	0.25	45		
#100	0.15	34		
#140	0.11	28		
#200	0.075	22		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0327	16		
---	0.0225	15		
---	0.0130	11		
---	0.0089	9		
---	0.0063	8		
---	0.0046	8		
---	0.0033	7		
---	0.0015	6		

Coefficients

D_{85} = 1.6178 mm	D_{30} = 0.1218 mm
D_{60} = 0.4010 mm	D_{15} = 0.0230 mm
D_{50} = 0.2913 mm	D_{10} = 0.0110 mm
C_u = 36.455	C_c = 3.363

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

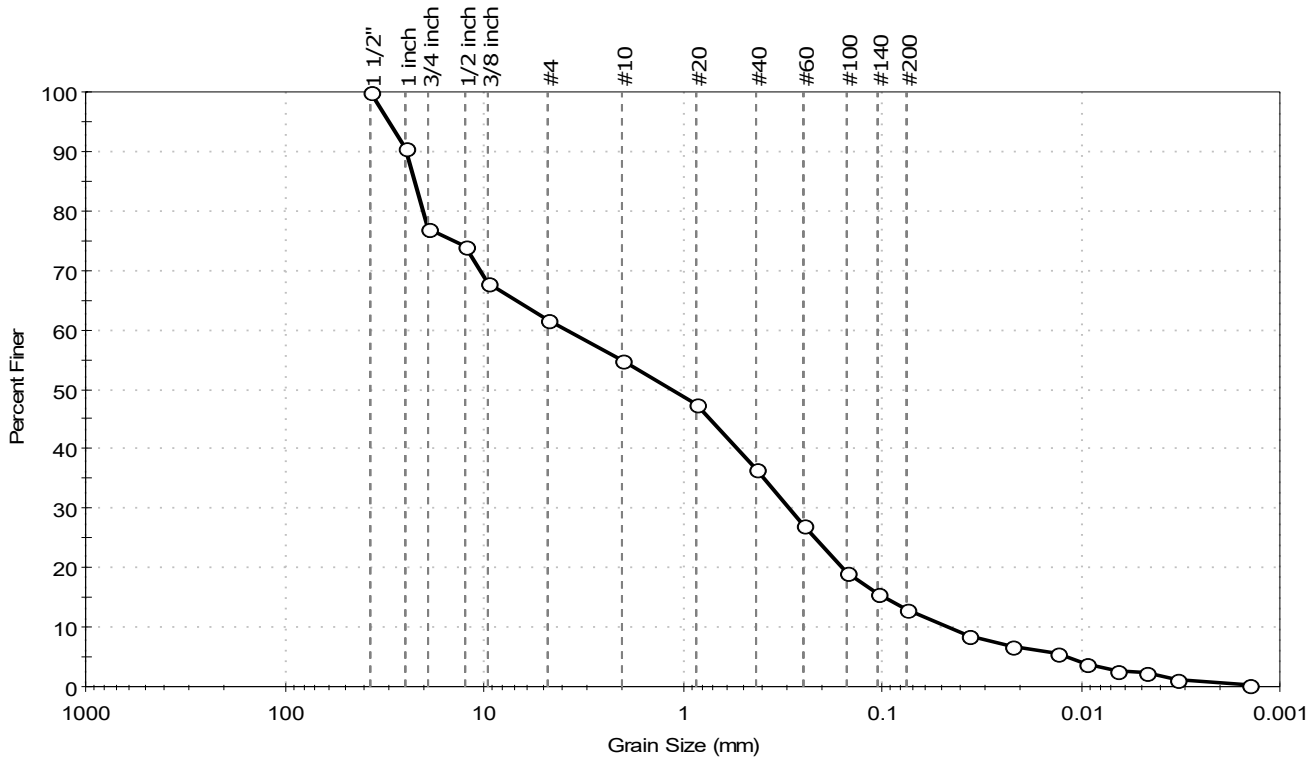
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-101	Sample Type:	jar	Tested By:	ckg
Sample ID:	3D	Test Date:	12/05/23	Checked By:	ank
Depth :	15-16.2	Test Id:	747691		
Test Comment:	---				
Visual Description:	Moist, brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
--	38.4	48.5	13.1

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 1/2"	37.50	100		
1 inch	25.00	91		
3/4 inch	19.00	77		
1/2 inch	12.50	74		
3/8 inch	9.50	68		
#4	4.75	62		
#10	2.00	55		
#20	0.85	48		
#40	0.42	37		
#60	0.25	27		
#100	0.15	19		
#140	0.11	16		
#200	0.075	13		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0364	9		
---	0.0224	7		
---	0.0131	6		
---	0.0093	4		
---	0.0066	3		
---	0.0047	2		
---	0.0033	1		
---	0.0014	0		

Coefficients

D_{85} = 22.3442 mm
D_{30} = 0.2939 mm
D_{60} = 3.8740 mm
D_{15} = 0.0969 mm
D_{50} = 1.1338 mm
D_{10} = 0.0457 mm
C_u = 84.770
C_c = 0.488

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

Dispersion Device : Apparatus A - Mech Mixer

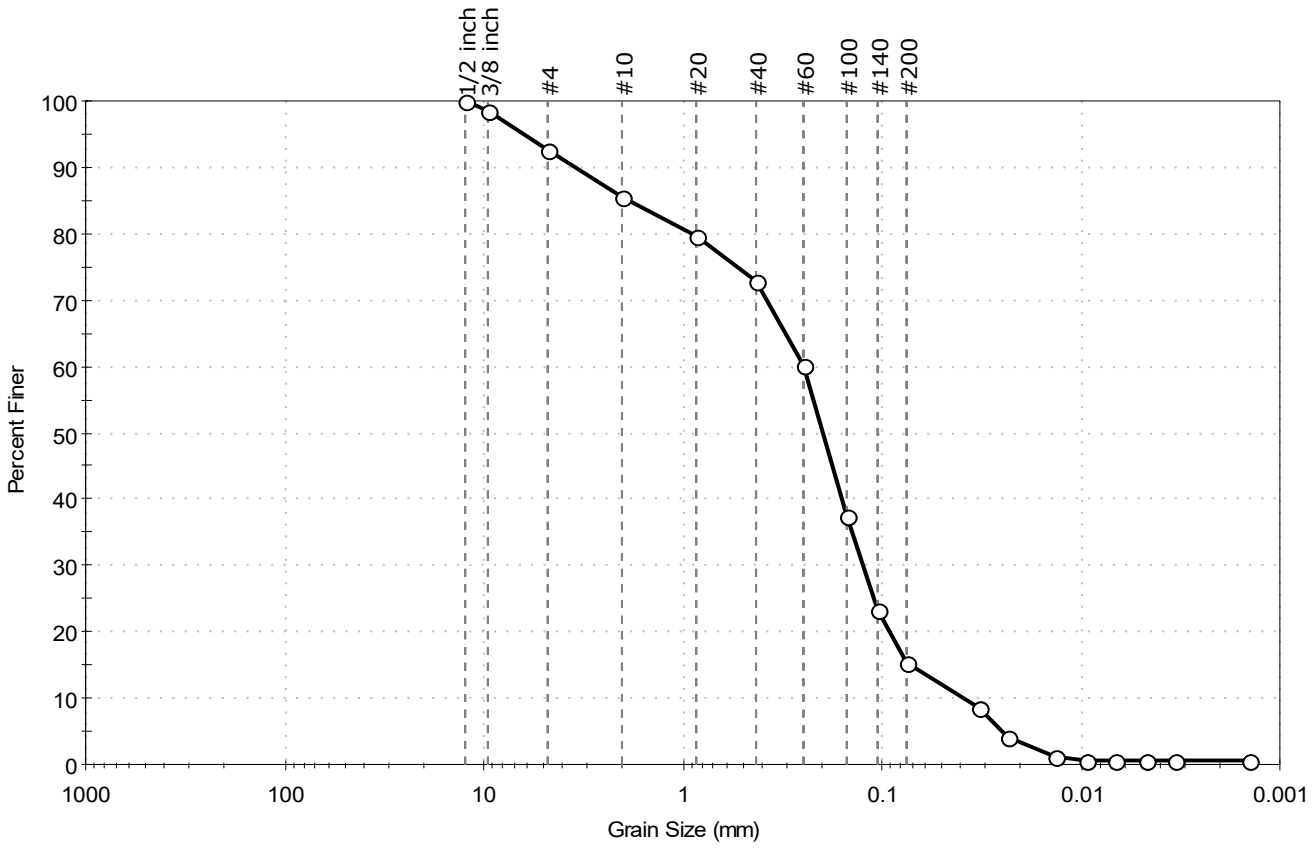
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-101	Sample Type:	jar	Tested By:	ckg
Sample ID:	4D	Test Date:	12/06/23	Checked By:	ank
Depth :	21-23	Test Id:	747692		
Test Comment:	---				
Visual Description:	Moist, brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	7.5	77.0	15.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1/2 inch	12.50	100		
3/8 inch	9.50	99		
#4	4.75	93		
#10	2.00	86		
#20	0.85	80		
#40	0.42	73		
#60	0.25	60		
#100	0.15	37		
#140	0.11	23		
#200	0.075	15		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0327	9		
---	0.0232	4		
---	0.0134	1		
---	0.0095	1		
---	0.0067	1		
---	0.0047	1		
---	0.0034	1		
---	0.0014	1		

Coefficients

D_{85} = 1.8376 mm	D_{30} = 0.1249 mm
D_{60} = 0.2489 mm	D_{15} = 0.0708 mm
D_{50} = 0.1988 mm	D_{10} = 0.0384 mm
C_u = 6.482	C_c = 1.632

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR

Sand/Gravel Hardness : HARD

Dispersion Device : Apparatus A - Mech Mixer

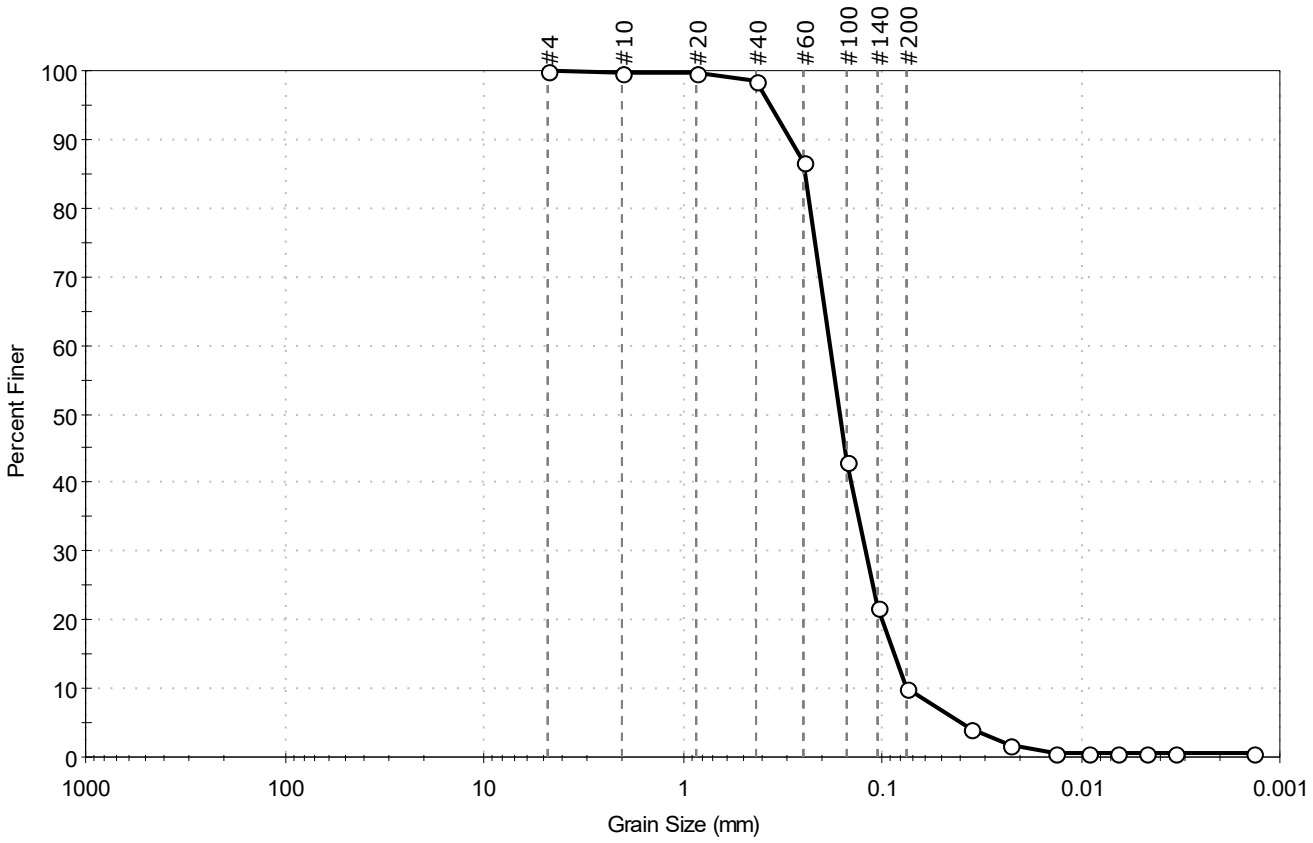
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-101	Sample Type:	jar	Tested By:	ckg
Sample ID:	5D	Test Date:	11/30/23	Checked By:	ank
Depth :	23-25	Test Id:	747693		
Test Comment:	---				
Visual Description:	Moist, brown sand with silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.1	89.9	10.0

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	98		
#60	0.25	87		
#100	0.15	43		
#140	0.11	22		
#200	0.075	10		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0361	4		
---	0.0225	2		
---	0.0134	0		
---	0.0092	0		
---	0.0066	0		
---	0.0047	0		
---	0.0034	0		
---	0.0014	0		

Coefficients

D_{85} = 0.2451 mm	D_{30} = 0.1211 mm
D_{60} = 0.1830 mm	D_{15} = 0.0866 mm
D_{50} = 0.1629 mm	D_{10} = 0.0746 mm
C_u = 2.453	C_c = 1.074

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

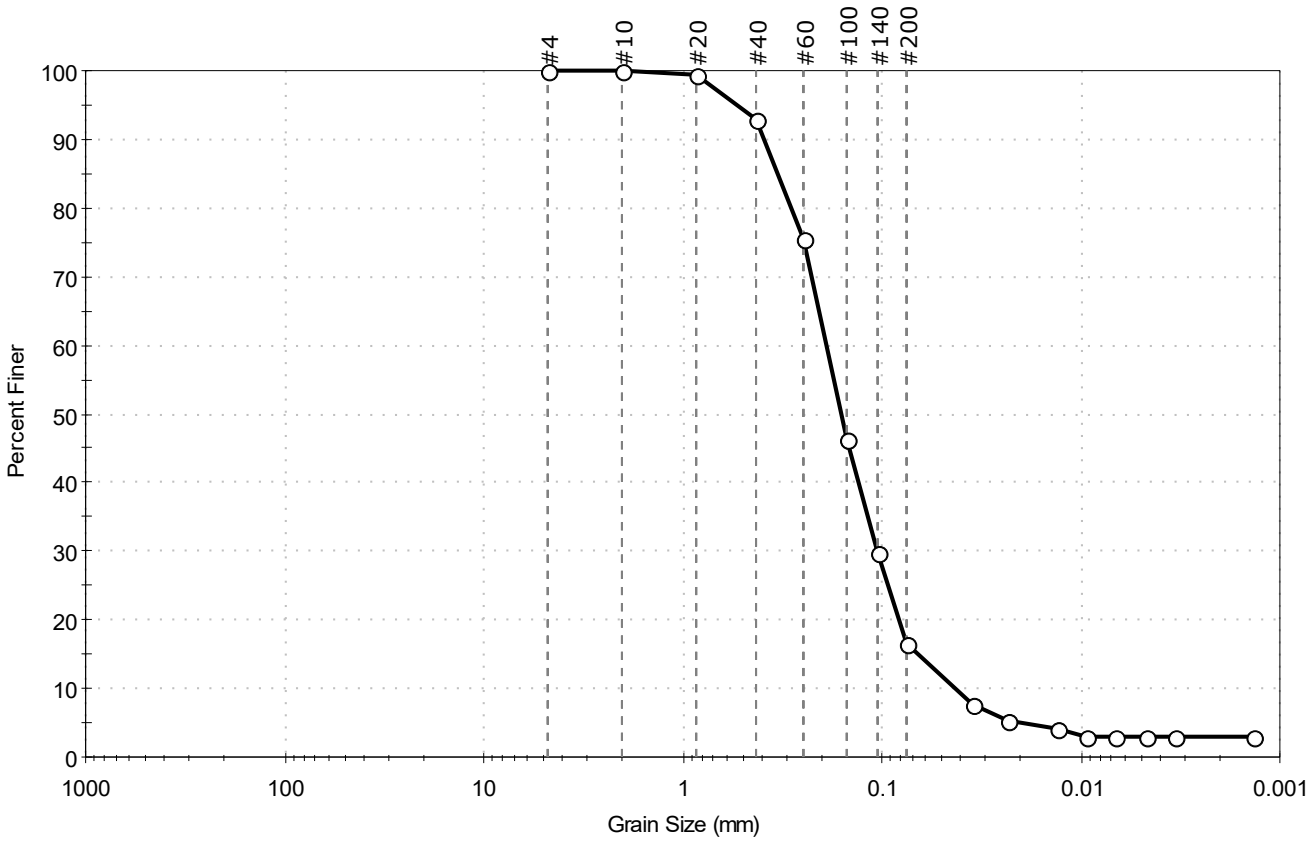
Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

GeoTesting EXPRESS

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-101	Sample Type:	jar	Tested By:	ckg
Sample ID:	6D	Test Date:	11/30/23	Checked By:	ank
Depth :	25-27	Test Id:	747694		
Test Comment:	---				
Visual Description:	Moist, brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.1	83.4	16.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	100		
#40	0.42	93		
#60	0.25	76		
#100	0.15	46		
#140	0.11	30		
#200	0.075	17		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0347	8		
---	0.0232	5		
---	0.0133	4		
---	0.0093	3		
---	0.0067	3		
---	0.0047	3		
---	0.0034	3		
---	0.0014	3		

Coefficients

D_{85} = 0.3333 mm	D_{30} = 0.1064 mm
D_{60} = 0.1906 mm	D_{15} = 0.0658 mm
D_{50} = 0.1601 mm	D_{10} = 0.0428 mm
C_u = 4.453	C_c = 1.388

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

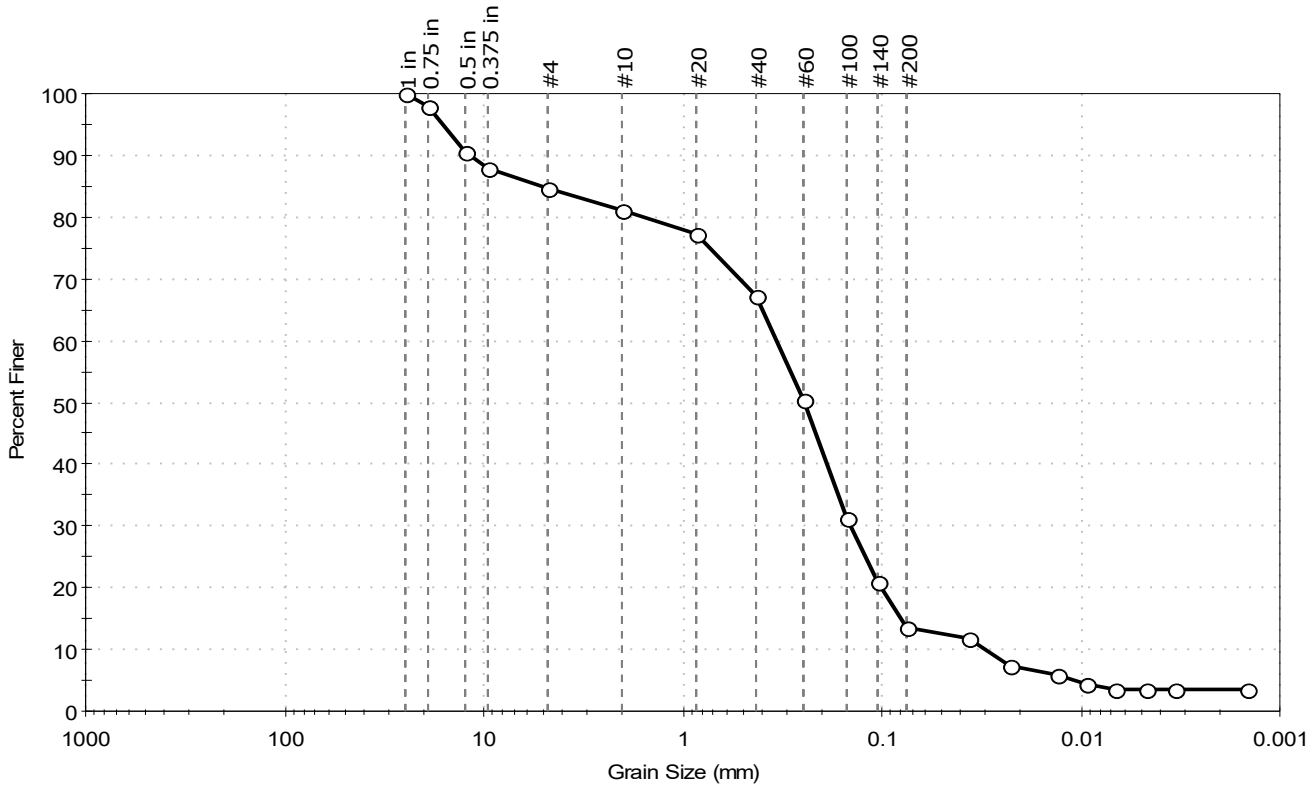
Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

GeoTesting EXPRESS

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-101	Sample Type:	jar	Tested By:	ckg
Sample ID:	9D	Test Date:	12/06/23	Checked By:	ank
Depth :	34-36	Test Id:	747695		
Test Comment:	---				
Visual Description:	Moist, brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
--	15.4	71.1	13.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
1 in	25.00	100		
0.75 in	19.00	98		
0.5 in	12.50	91		
0.375 in	9.50	88		
#4	4.75	85		
#10	2.00	81		
#20	0.85	77		
#40	0.42	67		
#60	0.25	50		
#100	0.15	31		
#140	0.11	21		
#200	0.075	14		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0371	12		
---	0.0225	7		
---	0.0133	6		
---	0.0095	4		
---	0.0067	4		
---	0.0047	4		
---	0.0034	4		
---	0.0015	4		

Coefficients

D_{85} = 5.1544 mm
D_{30} = 0.1442 mm
D_{60} = 0.3391 mm
D_{15} = 0.0804 mm
D_{50} = 0.2477 mm
D_{10} = 0.0302 mm
C_u = 11.228
C_c = 2.030

Classification

ASTM N/A

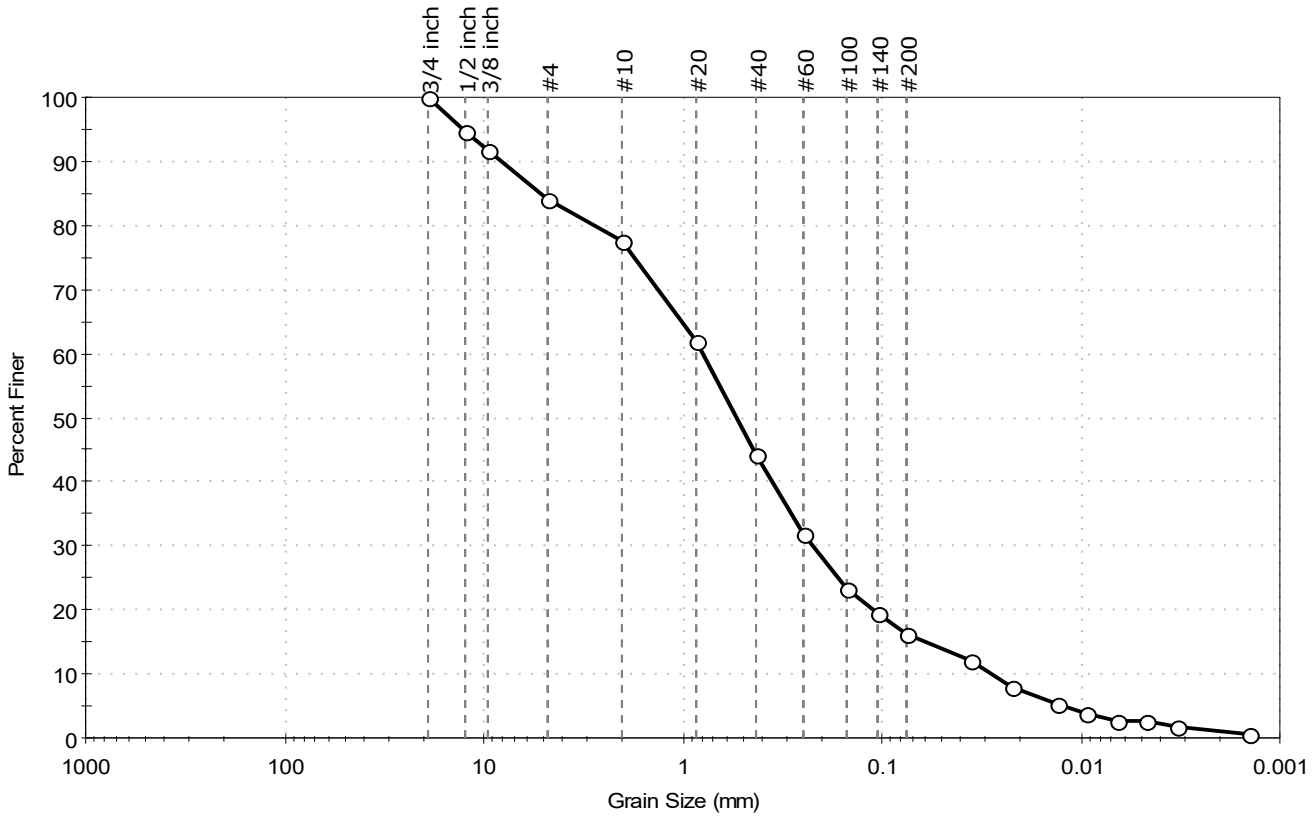
AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ANGULAR
Sand/Gravel Hardness : HARD
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-102	Sample Type:	jar	Tested By:	ckg
Sample ID:	2D	Test Date:	12/06/23	Checked By:	ank
Depth :	10-12	Test Id:	747696		
Test Comment:	---				
Visual Description:	Moist, light brown silty sand with gravel				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	16.0	67.8	16.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
3/4 inch	19.00	100		
1/2 inch	12.50	95		
3/8 inch	9.50	92		
#4	4.75	84		
#10	2.00	78		
#20	0.85	62		
#40	0.42	44		
#60	0.25	32		
#100	0.15	23		
#140	0.11	20		
#200	0.075	16		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0362	12		
---	0.0224	8		
---	0.0132	5		
---	0.0094	4		
---	0.0067	3		
---	0.0047	3		
---	0.0033	2		
---	0.0014	0		

Coefficients

D_{85} = 5.2107 mm	D_{30} = 0.2248 mm
D_{60} = 0.7907 mm	D_{15} = 0.0606 mm
D_{50} = 0.5340 mm	D_{10} = 0.0284 mm
C_u = 27.842	C_c = 2.250

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

Dispersion Device : Apparatus A - Mech Mixer

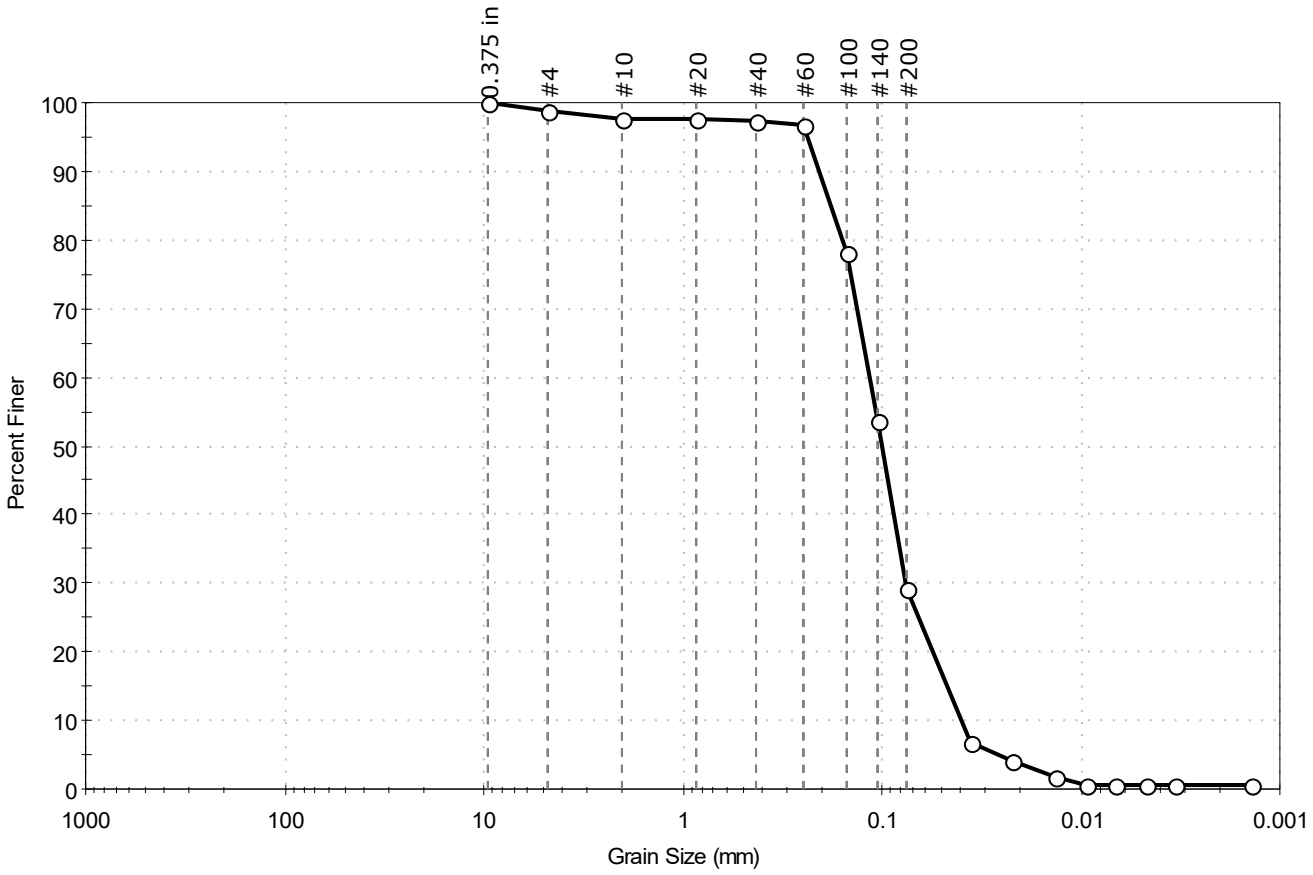
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-102	Sample Type:	jar	Tested By:	ckg
Sample ID:	5D	Test Date:	11/30/23	Checked By:	ank
Depth :	24-26	Test Id:	747697		
Test Comment:	---				
Visual Description:	Moist, gray silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	1.3	69.5	29.2

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.375 in	9.50	100		
#4	4.75	99		
#10	2.00	98		
#20	0.85	98		
#40	0.42	97		
#60	0.25	97		
#100	0.15	78		
#140	0.11	54		
#200	0.075	29		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0357	7		
---	0.0224	4		
---	0.0133	2		
---	0.0095	0		
---	0.0067	0		
---	0.0047	0		
---	0.0033	0		
---	0.0014	0		

Coefficients

D_{85} = 0.1806 mm	D_{30} = 0.0759 mm
D_{60} = 0.1160 mm	D_{15} = 0.0470 mm
D_{50} = 0.1007 mm	D_{10} = 0.0398 mm
C_u = 2.915	C_c = 1.248

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

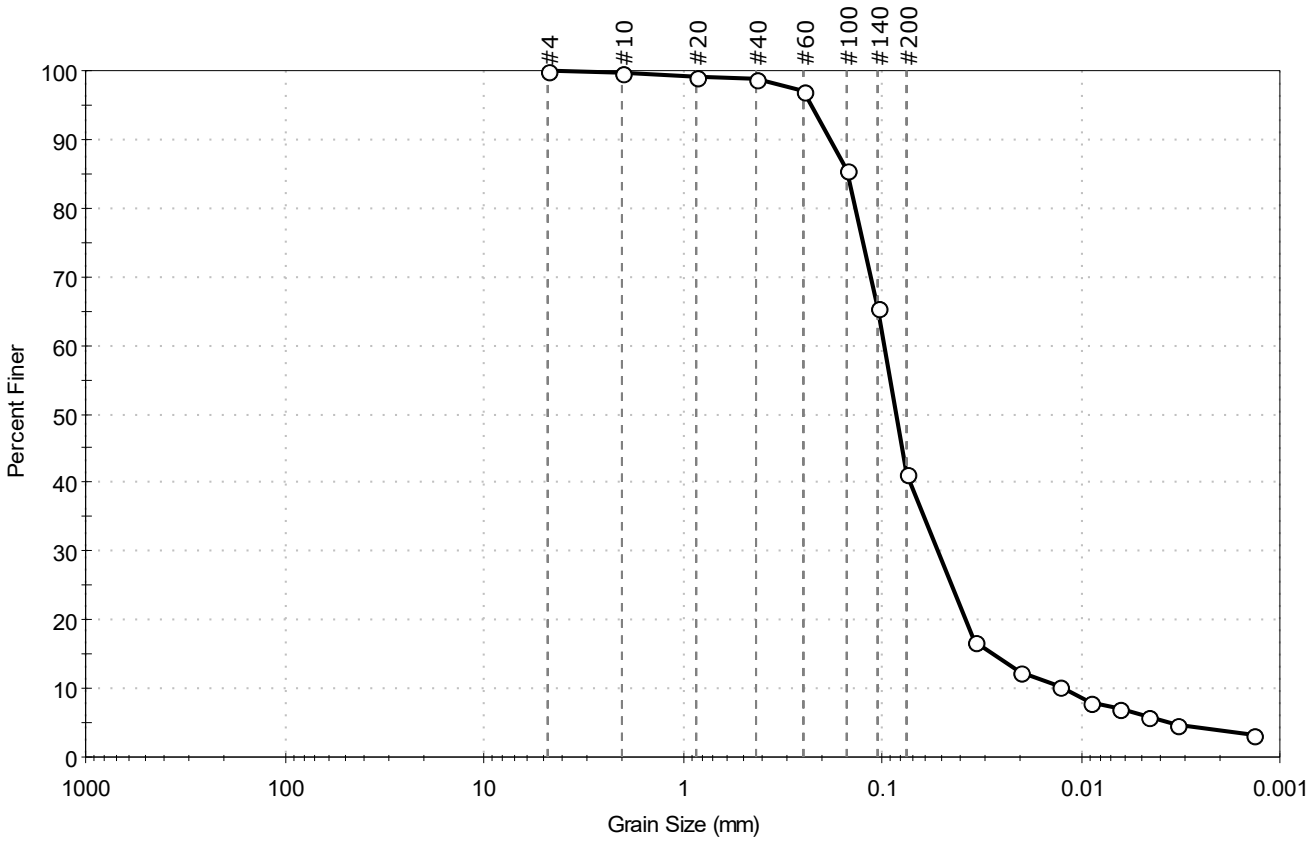
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-102	Sample Type:	jar	Tested By:	ckg
Sample ID:	6D	Test Date:	11/30/23	Checked By:	ank
Depth :	26-28	Test Id:	747698		
Test Comment:	---				
Visual Description:	Moist, brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	58.7	41.3

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	99		
#40	0.42	99		
#60	0.25	97		
#100	0.15	86		
#140	0.11	65		
#200	0.075	41		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0341	17		
---	0.0204	12		
---	0.0128	10		
---	0.0089	8		
---	0.0065	7		
---	0.0046	6		
---	0.0033	5		
---	0.0014	3		

Coefficients

D_{85} = 0.1486 mm	D_{30} = 0.0521 mm
D_{60} = 0.0981 mm	D_{15} = 0.0274 mm
D_{50} = 0.0850 mm	D_{10} = 0.0122 mm
C_u = 8.041	C_c = 2.268

Classification

ASTM N/A

AASHTO Silty Soils (A-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

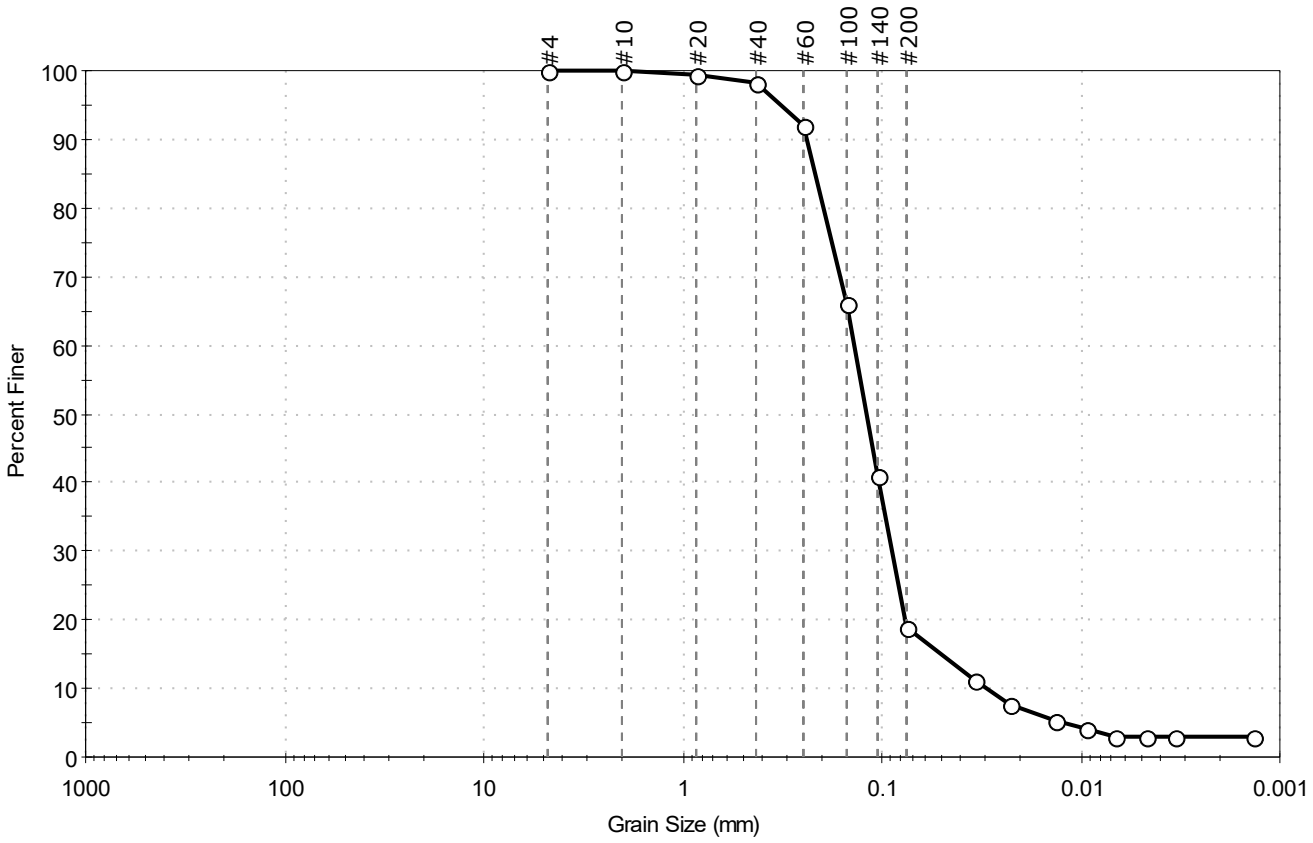
Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

GeoTesting EXPRESS

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-102	Sample Type:	jar	Tested By:	ckg
Sample ID:	7D	Test Date:	11/30/23	Checked By:	ank
Depth :	28-30	Test Id:	747699		
Test Comment:	---				
Visual Description:	Moist, light brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.1	81.0	18.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	99		
#40	0.42	98		
#60	0.25	92		
#100	0.15	66		
#140	0.11	41		
#200	0.075	19		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0342	11		
---	0.0229	8		
---	0.0133	5		
---	0.0094	4		
---	0.0067	3		
---	0.0047	3		
---	0.0034	3		
---	0.0014	3		

Coefficients

D_{85} = 0.2175 mm	D_{30} = 0.0892 mm
D_{60} = 0.1379 mm	D_{15} = 0.0500 mm
D_{50} = 0.1201 mm	D_{10} = 0.0296 mm
C_u = 4.659	C_c = 1.949

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

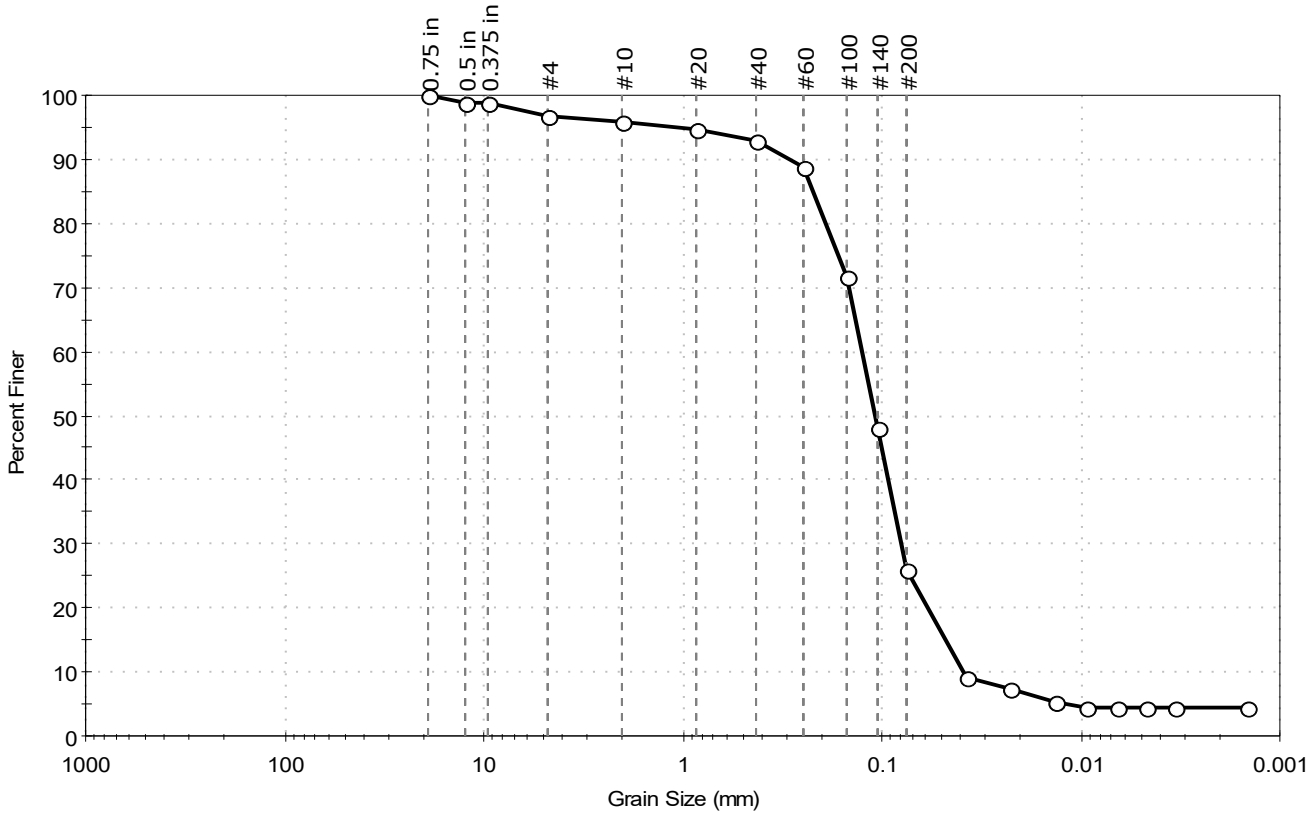
Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-102	Sample Type:	jar	Tested By:	ckg
Sample ID:	8D	Test Date:	12/06/23	Checked By:	ank
Depth :	30-32	Test Id:	747700		
Test Comment:	---				
Visual Description:	Moist, light brown silty sand				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
–	3.4	70.7	25.9

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
0.75 in	19.00	100		
0.5 in	12.50	99		
0.375 in	9.50	99		
#4	4.75	97		
#10	2.00	96		
#20	0.85	95		
#40	0.42	93		
#60	0.25	89		
#100	0.15	72		
#140	0.11	48		
#200	0.075	26		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0377	9		
---	0.0230	7		
---	0.0134	5		
---	0.0095	5		
---	0.0066	5		
---	0.0047	5		
---	0.0034	5		
---	0.0015	5		

Coefficients

D_{85} = 0.2234 mm D_{30} = 0.0800 mm
D_{60} = 0.1264 mm D_{15} = 0.0479 mm
D_{50} = 0.1092 mm D_{10} = 0.0390 mm
C_u = 3.241 C_c = 1.298

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

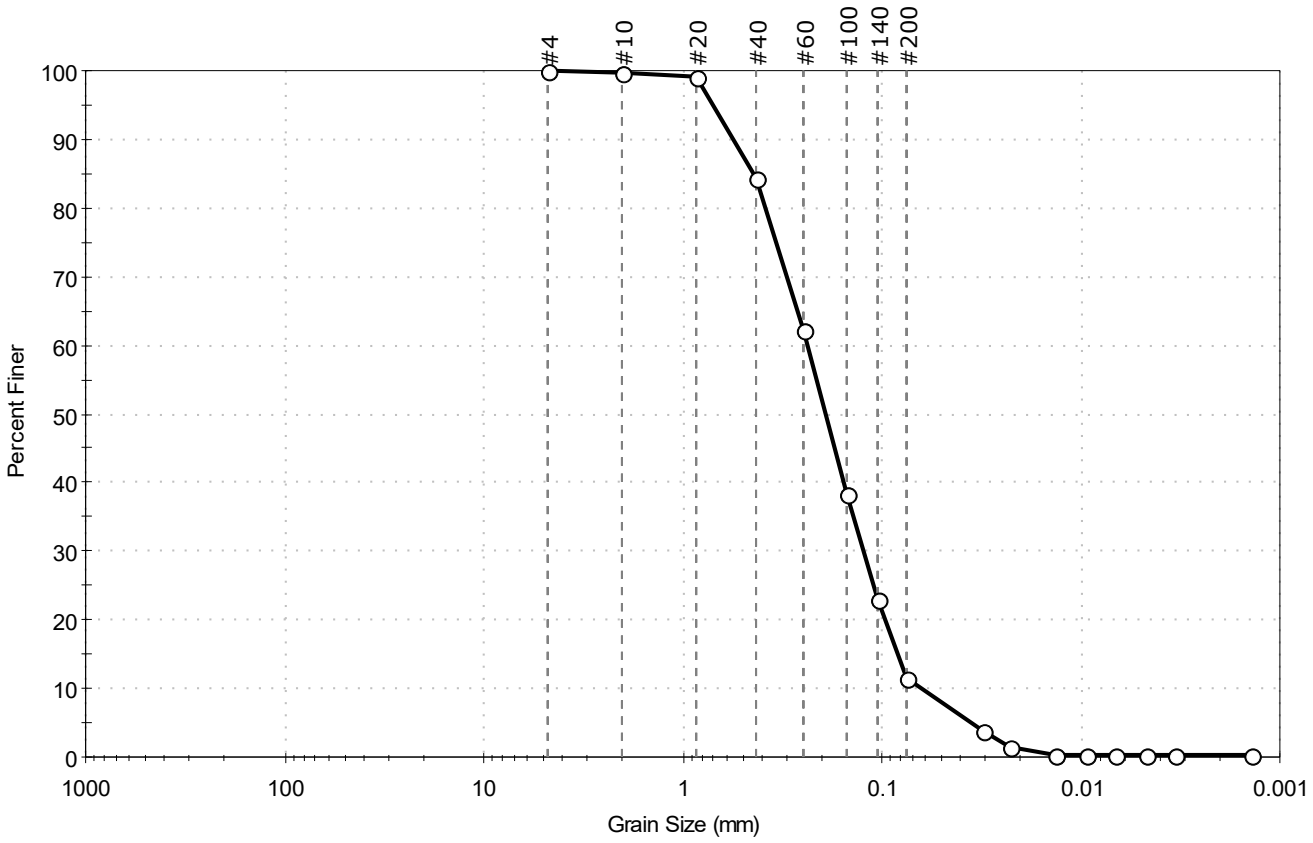
Sample/Test Description

Sand/Gravel Particle Shape : ---
Sand/Gravel Hardness : ---
Dispersion Device : Apparatus A - Mech Mixer
Dispersion Period : 1 minute
Est. Specific Gravity : 2.65
Separation of Sample: #200 Sieve

GeoTesting EXPRESS

Client:	Schonewald Engineering Associates, Inc.				
Project:	River Rd over Harts Brook				
Location:	Lewiston, ME			Project No:	GTX-318196
Boring ID:	BB-LHB-102	Sample Type:	jar	Tested By:	ckg
Sample ID:	10D	Test Date:	11/30/23	Checked By:	ank
Depth :	40-42	Test Id:	747701		
Test Comment:	---				
Visual Description:	Moist, reddish brown sand with silt				
Sample Comment:	---				

Particle Size Analysis - ASTM D6913/D7928



% Cobble	% Gravel	% Sand	% Silt & Clay Size
—	0.0	88.5	11.5

Sieve Name	Sieve Size, mm	Percent Finer	Spec. Percent	Complies
#4	4.75	100		
#10	2.00	100		
#20	0.85	99		
#40	0.42	84		
#60	0.25	62		
#100	0.15	38		
#140	0.11	23		
#200	0.075	12		
Hydrometer	Particle Size (mm)	Percent Finer	Spec. Percent	Complies
---	0.0314	4		
---	0.0228	2		
---	0.0135	0		
---	0.0094	0		
---	0.0067	0		
---	0.0047	0		
---	0.0034	0		
---	0.0014	0		

Coefficients

D_{85} = 0.4353 mm	D_{30} = 0.1244 mm
D_{60} = 0.2377 mm	D_{15} = 0.0833 mm
D_{50} = 0.1924 mm	D_{10} = 0.0631 mm
C_u = 3.767	C_c = 1.032

Classification

ASTM N/A

AASHTO Silty Gravel and Sand (A-2-4 (0))

Sample/Test Description

Sand/Gravel Particle Shape : ---

Sand/Gravel Hardness : ---

Dispersion Device : Apparatus A - Mech Mixer

Dispersion Period : 1 minute

Est. Specific Gravity : 2.65

Separation of Sample: #200 Sieve

APPENDIX E

CALCULATIONS

Project: MaineDOT Harts Bridge Replacement WIN 27230.00 **Proj. No.** 23-008

Location: Lewiston, ME **Last updated:** Oct. 24 **By** IVS

Subject: Preliminary Geotechnical Calculations **Checked:** **By**

bearing resistance evaluation - box culvert **By**

AASHTO LRFD Bridge Design Manual (9th Edition, 2020)

Service Limit State - presumptive value based on soil type and relative density/ consistency [Table C10.6.2.5.1-1]

bearing soil: silty sand and gravel AASHTO A-2-4(0) USC SM

ensity/consistency: medium dense to dense range: 4-8

very dense range: 6-10

USE 6 KSF **Service Limit State**

(resistance factor for service limit state is 1.0)

Strength Limit State - following Section 10.6.3.1

bearing soil: silty sand and gravel AASHTO A-2-4(0) USC SM

density/consistency: medium dense to dense

very dense (coarser fraction)

nominal bearing resistance (qn) = $c\ N_{cm} + \gamma\ D_f\ N_{qm}\ C_{wq} + 0.5\ \gamma\ B\ N_{\gamma m}\ C_{w\gamma}$

cohesion (c) term + surcharge (q) term + footing width (γ) term

with: $N_{cm} = N_c\ S_c$ and where N_c, N_q, and N_γ are bearing capacity factors

$N_{qm} = N_q\ S_q$ function of φ and c

$N_{gm} = N_\gamma\ S_\gamma$ Table 10.6.3.1.2a-1

C_{wq} and $C_{w\gamma}$ are correction factors for groundwater depth

function of D_w and D_f

Table 10.6.3.1.2a-2

S_c, S_q, and S_γ are correction factors for footing shape

function of B, L, φ

Table 10.6.3.1.2a-3

input parameters:

angle of internal friction	φ_f =	32	deg	N_c	=	35.5	table
		0.559	radiar	N_q	=	23.2	
soil unit weight	γ =	0.125	kcf	N_γ	=	30.2	
undrained shear strength	c =	0	ksf	S_c	=	1.15	calculated (formulas in table)
				S_q	=	1.14	
footing depth/ embedment	D_f =	2	ft	S_γ	=	0.91	
footing width	B =	20	ft	C_{wq}	=	1.0	table
footing length	L =	90	ft	$C_{w\gamma}$	=	0.5	
groundwater (relative to GS and D_f)	D_w =	D_f	(at base of footing)				

nominal bearing resistance (q_n) = $c\ N_{cm} + \gamma\ D_f\ N_{qm}\ C_{wq} + 0.5\ \gamma\ B\ N_{\gamma m}\ C_{w\gamma}$

= 23.8 ksf

resistance factor (φ_b) = 0.45 Table T10.5.5.2.2-1

bearing resistance (q_R) = $q_n * \varphi_b$

= 10.7 ksf **USE 10 KSF** **Strength Limit State**

AASHTO LRFD Bridge Design Manual (9th Edition, 2020)

Service Limit State - presumptive value based on soil type and relative density/ consistency [Table C10.6.2.5.1-1]

bearing soil: silty sand and gravel AASHTO A-2-4(0) USC SM

ensity/consistency: medium dense to dense range: 4-8

very dense range: 6-10

USE 4 KSF **Service Limit State**

(resistance factor for service limit state is 1.0)

Strength Limit State - following Section 10.6.3.1

bearing soil: silty sand and gravel AASHTO A-2-4(0) USC SM

density/consistency: medium dense to dense

very dense (coarser fraction)

nominal bearing resistance (qn) = $c\,N_{cm} + \gamma\,D_f\,N_{qm}\,C_{wq} + 0.5\,\gamma\,B\,N_{\gamma m}\,C_{w\gamma}$

cohesion (c) term + surcharge (q) term + footing width (γ) term

with: $N_{cm} = N_c\,S_c$ and where N_c, N_q, and N_γ are bearing capacity factors

$N_{qm} = N_q\,S_q$ function of φ and c

$N_{gm} = N_\gamma\,S_\gamma$ Table 10.6.3.1.2a-1

C_{wq} and $C_{w\gamma}$ are correction factors for groundwater depth

function of D_w and D_f

Table 10.6.3.1.2a-2

S_c, S_q, and S_γ are correction factors for footing shape

function of B, L, φ

Table 10.6.3.1.2a-3

input parameters:

angle of internal friction	φ_f =	32	deg	N_c =	35.5	table
		0.559	radiar	N_q =	23.2	
soil unit weight	γ =	0.125	kcf	N_γ =	30.2	
undrained shear strength	c =	0	ksf	S_c =	1.06	calculated (formulas in table)
				S_q =	1.05	
footing depth/ embedment	D_f =	4.5	ft	S_γ =	0.97	
footing width	B =	3	ft	C_{wq} =	1.0	table
footing length	L =	35	ft	$C_{w\gamma}$ =	0.5	
groundwater (relative to GS and D_f)	D_w =	D_f	(at base of footing)			

nominal bearing resistance (q_n) = $c\,N_{cm} + \gamma\,D_f\,N_{qm}\,C_{wq} + 0.5\,\gamma\,B\,N_{\gamma m}\,C_{w\gamma}$

= 16.5 ksf

resistance factor (φ_b) = 0.45 Table T10.5.5.2.2-1

bearing resistance (q_R) = $q_n * \varphi_b$

= 7.4 ksf **USE 7 KSF** **Strength Limit State**

Project: MaineDOT Harts Bridge Replacement WIN 27230.00 **Proj. No.** 23-008

Location: Lewiston, ME **Last updated:** Oct. 24 **By** IVS

Subject: Preliminary Geotechnical Calculations **Checked:** **By**

modulus of subgrade reaction **By**

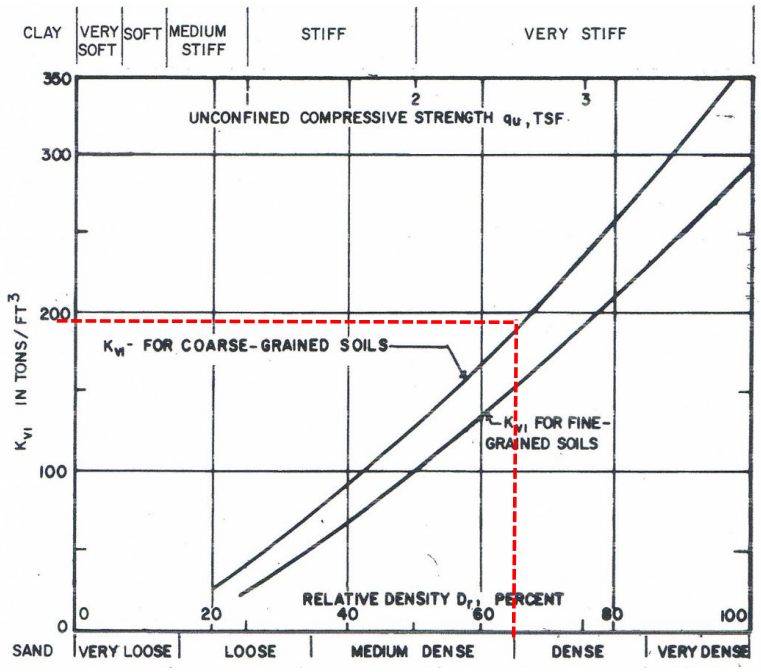
determine modulus of subgrade reaction (K_b) for the design of the base slab of the box culvert

following procedures outlined in NAVFAC DM 7-1, Chapter 5 and NAVFAC DM 7-2, Chapter 3

Step 1: select modulus of subgrade reaction for a 1-foot square plate (K_{VI})

based on relative density of coarse-grained soil (including non-plastic silt) or consistency of fine-grained soil

take from Figure 6, NAVFAC DM 7-1, Chapter 5



Note: tcf *1.157 = pci

for Lewiston Harts Brook:

soil at bedding layer subgrade consists of medium dense to very dense, silty sand and gravel (AASHTO A-2-4(0); USC SM)

from figure, K_{VI} = 190 tcf = 220 pci (for a 1-foot square plate)

since groundwater is assumed to be at or near the culvert base slab, use K_{VI} / 2 in computations

therefore, use K_{VI} = 110 pci (for a 1-foot square plate)

Step 2: determine the modulus of subgrade reaction for foundation width B (Kb)

based on K_{VI}

from NAVFAC DM 7-2, Chapter 3

for granular soils:

$$K_b = K_{VI} * \left[\frac{B+1}{2B}\right]^{\wedge 2}$$

for cohesive soils:

$$K_b = K_{VI} / B$$

for Lewiston Harts Brook:

granular soils

culvert span = 20 ft

K_b = 30 pci

Project: MaineDOT Harts Bridge Replacement WIN 27230.00 **Proj. No.** 23-008

Location: Lewiston, ME **Last updated:** Oct. 24 **By** IVS

Subject: Preliminary Geotechnical Calculations **Checked:** **By**

active earth pressure evaluation **By**

properties for MaineDOT Granular Borrow (MaineDOT BDG Table 3-3)

angle of internal friction	φ_f =	32	deg	0.559	radians
soil unit weight	γ =	0.125	kcf		
friction angle soil against concrete	δ =	24	deg	0.419	radians
vertical wall	α =	90	deg	1.571	radians
backfill level or sloped	β =	26.6	deg	0.464	radians

Coulomb active earth pressure coefficient
applies to cantilever walls having a short heel
may also be used for long-heeled walls

$$K_{a\text{-Coulomb}} = \frac{\sin(\alpha+\varphi f)^2}{\sin\alpha^2 * \sin(\alpha-\delta) * [1 + (\frac{\sin(\varphi f+\delta) * \sin(\varphi f-\beta)}{\sin(\alpha-\delta) * \sin(\alpha+\beta)}) ^1/2]^2}$$

$\sin(\alpha+\varphi_f)^2$ =	0.719
$\sin\alpha^2$ =	1.000
$\sin(\alpha-\delta)$ =	0.914
$\sin(\varphi_f+\delta)$ =	0.829
$\sin(\varphi_f-\beta)$ =	0.094
$\sin(\alpha-\delta)$ =	0.914
$\sin(\alpha+\beta)$ =	0.894

A=	$(\sin(\varphi f+\delta) * \sin(\varphi f-\beta) / \sin(\alpha-\delta) * \sin(\alpha+\beta))^1/2$ =	0.309
B=	$(1 + A)^2$ =	1.714
C=	$\sin\alpha^2 * \sin(\alpha-\delta) * B$ =	1.565
$K_{a\text{-Coulomb}}$=	$\sin(\alpha+\varphi f)^2 / C$ =	0.459

$K_{a\text{-Coulomb}}$= 0.46

Rankine active earth pressure coefficient
may be used for cantilever walls having long heels

$$K_{a\text{-Rankine}} = \cos(\beta) * [\frac{\cos(\beta) - (\cos(\beta)^2 - \cos(\varphi f)^2)^1/2}{\cos(\beta) + (\cos(\beta)^2 - \cos(\varphi f)^2)^1/2}]$$

$\cos(\beta)$ =	0.894
$\cos(\beta)^2$ =	0.800
$\cos(\varphi_f)^2$ =	0.719

A=	$\cos(\beta) - (\cos(\beta)^2 - \cos(\varphi f)^2)^1/2$ =	0.611
B=	$\cos(\beta) + (\cos(\beta)^2 - \cos(\varphi f)^2)^1/2$ =	1.178
$K_{a\text{-Rankine}}$=	$\cos(\beta) * [A / B]$ =	0.464

$K_{a\text{-Rankine}}$= 0.46

In order to estimate the depth of frost penetration at a site, Table 5-1 has been developed using the Modified Berggren equation and Figure 5-1 Maine Design Freezing Index Map. The use of Table 5-1 assumes site specific, uniform soil conditions where the Geotechnical Designer has evaluated subsurface conditions. Coarse-grained soils are defined as soils with sand as the major constituent. Fine-grained soils are those having silt and/or clay as the major constituent. If the make-up of the soil is not easily discerned, consult the Geotechnical Designer for assistance. In the event that specific site soil conditions vary, the depth of frost penetration should be calculated by the Geotechnical Designer.

Table 5-1 Depth of Frost Penetration

Design Freezing Index	Frost Penetration (in)					
	Coarse Grained			Fine Grained		
	w=10%	w=20%	w=30%	w=10%	w=20%	w=30%
1000	66.3	55.0	47.5	47.1	40.7	36.9
1100	69.8	57.8	49.8	49.6	42.7	38.7
1200	73.1	60.4	52.0	51.9	44.7	40.5
1300	76.3	63.0	54.3	54.2	46.6	42.2
1400	79.2	65.5	56.4	56.3	48.5	43.9
1500	82.1	67.9	58.4	58.3	50.2	45.4
1600	84.8	70.2	60.3	60.2	51.9	46.9
1700	87.5	72.4	62.2	62.2	53.5	48.4
1800	90.1	74.5	64.0	64.0	55.1	49.8
1900	92.6	76.6	65.7	65.8	56.7	51.1
2000	95.1	78.7	67.5	67.6	58.2	52.5
2100	97.6	80.7	69.2	69.3	59.7	53.8
2200	100.0	82.6	70.8	71.0	61.1	55.1
2300	102.3	84.5	72.4	72.7	62.5	56.4
2400	104.6	86.4	74.0	74.3	63.9	57.6
2500	106.9	88.2	75.6	75.9	65.2	58.8
2600	109.1	89.9	77.1	77.5	66.5	60.0

Note: Where the Freezing Index and/or water content is between the presented values, linear interpretation may be used to determine the frost penetration.

Design Freezing Index = 1450

Frost Penetration = 57 inches = 4.5 feet

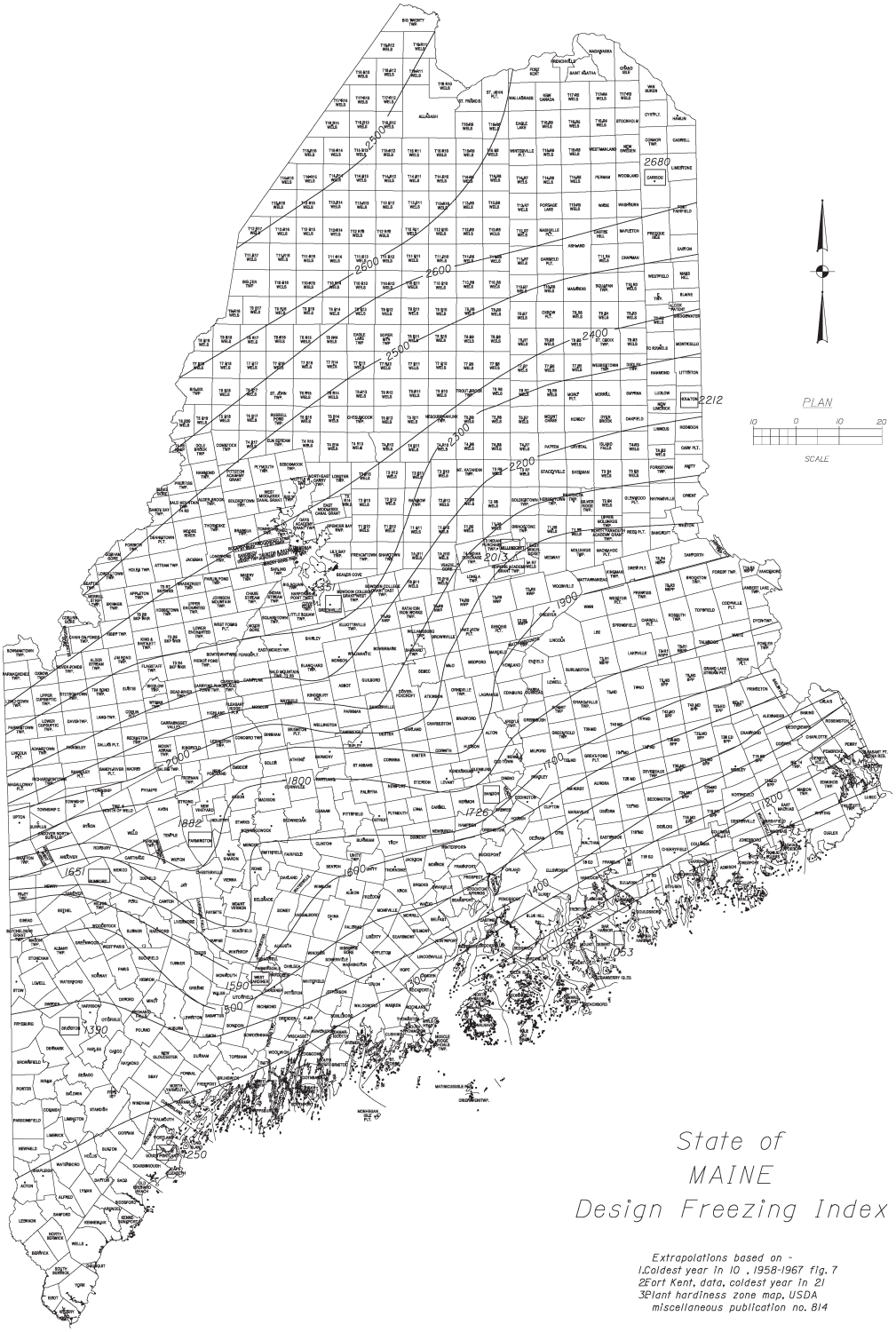


Figure 5-1 Maine Design Freezing Index Map

Frost Penetration Calculation
Lewiston Harts Brook
MaineDOT WIN 27230.00
(from MaineDOT BDG)