DESIGN REPORT

Geotechnical and Hydrotechnical Slope Stabilization Evaluation
State Route 161 Unstable Slopes Adjacent to the St. John River
Allagash and St. Francis, Maine

WIN 17236.00

Submitted to:

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

Submitted by:

Golder Associates Inc.
Freeport, Maine, USA 04032
+1 207 865-4024

1659907

March 29, 2019

GOLDER

March 29, 2019 Project No. 1659907

Ms. Kate Maguire, PE
Maine Department of Transportation
Highway Program
16 State House Station
Augusta, Maine 04333-0016

DESIGN REPORT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161
ALLAGASH AND ST. FRANCIS, MAINE
WIN 17236.00

Dear Kate:

Golder Associates Inc. (Golder) is pleased to submit this Design Report to the Maine Department of Transportation (MaineDOT) summarizing our geotechnical and hydrotechnical evaluations for the proposed Route 161 slope stabilizations adjacent to the St. John River in Allagash and St. Francis, Maine. This report presents the findings, evaluations, recommendations and design features for our work on this project since the fall of 2016 that support the MaineDOT's Preliminary Design Report (PDR) dated December 5, 2018 and final PIC drawings dated December 13, 2018. Our work was conducted in accordance with the scope and budgets described in our original project contract dated September 16, 2016 and subsequent Contact Modifications #2, #3 and #4 dated June 14, 2017, May 9, 2018 and February 25, 2019, respectively. The terms and conditions governing the work are stated in our General Consultant Agreement with MaineDOT dated June 4, 2015.

We appreciate the opportunity to assist MaineDOT on this interesting project and it has been a pleasure working with you and your colleagues and consultants. Please contact us if you have any questions concerning our report or require additional information.

Sincerely,
Golder Associates Inc.

Jeffrey D. Lloyd, PE
Senior Engineer

A. Kammereck

Andreas Q. Kammereck, PE (WA)
Principal

MARK S. PETERSON #4787

Mark S. Peterson, PE
Principal

JDL/MSP/drb

https://golderassociates.sharepoint.com/sites/106608/project files/6 deliverables/final report/final/cover letter.docx

Executive Summary

For roughly the past 16 years the Maine Department of Transportation (MaineDOT) has developed an increasing concern about the stability of St. John River riverbank slopes adjacent to State Route 161 between Fort Kent and Allagash. Over this period, four riverbank slope areas experiencing surficial sloughing were repaired with riprap stabilization. Since 2014 two new unstable riverbank slope areas have developed that present a heightened concern because of their proximity to the edge of pavement and the height and length of the slope areas.

The Allagash unstable riverbank slope is about 1,100 feet long and 48 feet (ft) high, containing bare slope surfaces as steep as 1H:1V (Horizontal:Vertical) and slide headscarps located as close as 5 ft from the edge of pavement on State Route (Rt.) 161. The unstable slope at the St. Francis site is located about 12 miles downstream of the Allagash site. The St. Francis slope is about 1,300 ft long and 37 ft high, with bare slope surfaces as steep as 0.5H:1V and slide headscarps within 20 ft of the edge of pavement. At both sites, mature trees and vegetative undergrowth on the slopes are being undermined and removed through a progressive erosion and instability process. Both sites are also susceptible to unpredictable and rapid slope failures due to high ice erosion forces and rapid drawdown instability effects from the formation and release of ice jams on the St. John River in this region. Ground surveys completed between 2010 and 2016 indicate the slope faces had retreated laterally an average of about 5 ft (Allagash) and 8 ft (St. Francis) over this six-year period.

In 2016 the Department engaged Golder Associates Inc. (Golder) to investigate the conditions at both sites and to work with MaineDOT to develop a strategy and design for long term slope stabilization. Concurrent with Golder's preliminary work, MaineDOT evaluated the feasibility of revising the alignment of Rt. 161 away from the unstable slopes. Golder's site investigations included surficial geologic and geomorphic reconnaissance/mapping, test borings and dynamic cone penetration testing, and geotechnical laboratory testing. The findings from the site investigations, site history research, survey data and LiDAR data (from FEMA) were used to develop hydraulic models (using HEC-RAS and TUFLOW) and stability models (using the SLIDE program) to assess river/ice erosion and slope performance and design criteria. Interpreted slope instability mechanisms were found to be similar for both sites including:

1) Bank erosion from hydraulic forces
2) Bank erosion from ice forces
3) Slope instability from oversteepened slopes and seepage
4) Slope instability due to rapid drawdown conditions
5) Bank toe erosion, and
6) River toe scour

Sixteen stabilization options were identified to address the erosion mechanisms causing the slope instability. The stabilization options included combinations of riprap armor of various sizes placed in different arrangements, vegetated slopes, bendway weirs, spur dikes, anchored ring net reinforcement, cantilevered and anchored wall systems, timber cribs, ice booms, small dams and dredging. Advantages, disadvantages, construction issues and cost considerations were evaluated and discussed for the stabilization options during a coachpoint meeting on December 5, 2016. At the meeting the MaineDOT's Highway Program management team recommended that the design proceed with a similar solution for both sites incorporating large over-sized riprap on full-height regraded slopes and a series of bendway weir riprap structures extending out into the river bed along the toe of the unstable slopes.

Preliminary design evaluations for the selected stabilization scheme included the following: delineating the lateral limits of slope stabilization for both sites; hydraulic criteria for fluvial and ice slope erosion for 100-year return events; riprap size requirements to resist fluvial and ice erosion; global slope stability analyses for alternative slope angles and riprap layer thickness; grading plans focused on balancing cuts and fills; the suitability of reusing cut materials; the impacts of alternative bendway weir structure sections and layouts on the hydraulic behavior and scour mitigation at each site; and preliminary material quantities and estimated construction costs.

Design evaluations suitable for the Department’s Preliminary Design Report (PDR) and Plans Impact Complete (PIC) documents were completed by Golder with plan detailing assistance from HNTB Corporation who were engaged for the project by the MaineDOT in mid-2018. Slope stabilization limits for each site were developed for a 25-year period based on the erosion rates measured from 2010 to 2016, the proximity of slide scarps to the edge of pavement, property acquisition issues, and cost considerations. Designs were then developed for 1.75H:1V riprap slopes meeting top-of-slope setback requirements from edge of pavement and considered balancing cuts and fills with minimizing toe of slope intrusion into the riverbed. A minimum D_{100} riprap size of 4 ft was selected for final slope design based on considerations for resisting ice erosion and the maximum rock size expected to be generated from local quarry operations. The recommended slope riprap section is 5 ft thick overlying a 1 ft thick aggregate cushion and geotextile. Nine bendway weir structures are recommended at each site extending from about 31 ft to 100 ft out into the St. John River from the toe of the riprap slopes to mitigate scour erosion at the base of the slopes. Design recommendations are also provided for downspouts and stone ditches embedded into the riprap slopes to carry runoff flows from culvert replacements planned across Rt. 161 within the project areas. Design plans and details are shown on the Department’s Final PDR-PIC plan set dated December 13, 2018.

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1.0 INTRODUCTION

This design report presents the findings and results of geotechnical and hydrotechnical evaluations for the assessment and design of stabilization measures for two unstable slope segments adjacent to State Route 161 between the roadway and the St. John River in Allagash and St. Francis, Maine (Figure 1). The unstable slopes are located about 12 miles apart (Figure 2) and are relatively long, high and steep slopes exhibiting similar stability concerns. At both sites mature trees and vegetative undergrowth on the slopes are being undermined and removed through a progressive erosion and instability process that has exposed bare slopes and slide headscarps in close proximity to the edge of roadway pavement. In 2016 the Maine Department of Transportation (MaineDOT) engaged Golder Associates Inc. (Golder) to evaluate the geotechnical and hydrotechnical site conditions as a basis for developing alternative slope stabilization concepts and final designs for the selected alternative. During the 2016 site investigations Golder engaged Dr. John Field of Field Geology Services (Farmington, Maine) as a subconsultant to aid the fluvial geomorphic assessments of the reverine environment on the St. John River and impacts of riverbank stabilization alternatives. In 2018 the MaineDOT added HNTB Corporation (Westbrook, Maine) to the design team to aid in detailing Golder's design drawings for MaineDOT drawing standards and to assist with roadway design and drainage aspects of the work. Information in this design report supports the project design elements presented in the MaineDOT's Preliminary Design Report (PDR).

The results of this work are incorporated in the MaineDOT's Highway Preliminary Design Report dated December 5, 2018[1] and the Final PDR-PIC plan set dated December 13, 2018[2]. Golder's scope of work for these services is described in our initial proposal dated September 2, 2016 and subsequent Project Contract Modifications dated July 14, 2017, May 9, 2018, and February 25, 2019. PS&E phase documents are scheduled for completion in January 2020. Slope stabilization construction is currently scheduled to commence in 2020.

1.1 Background

For roughly the past 16 years the MaineDOT has developed an increasing concern about the stability of St. John River riverbank slopes adjacent to State Route 161 between Fort Kent and Allagash. Over this period four riverbank slope areas experiencing surficial sloughing were repaired with riprap stabilization. Since 2014 two new unstable riverbank slope areas have developed at Allagash and St. Francis that present a heightened concern because of their proximity to the edge of pavement and the height and length of the slope areas. Slope stabilization concepts of rebuilding and regrading the existing slopes using riprap, or alternatively moving the existing roadway further back from the slope crest were previously evaluated by MaineDOT in 2014, but the work did not proceed to a preliminary design. 2016 observations by MaineDOT personnel of continued erosion at both sites in close proximity to Route 161 caused MaineDOT to engage Golder to assess stabilization alternatives.

The Allagash unstable riverbank slope is about 1,100 feet long and 48 feet (ft) high, containing bare slope surfaces as steep as 1H:1V (Horizontal:Vertical) and slide headscarps located as close as 5 ft from the edge of pavement on Rt. 161. The St. Francis slope is about 1,300 ft long and 37 ft high, with bare slope surfaces as steep as 0.5H:1V and slide headscarps within 20 ft of the edge of pavement. A comparison of existing conditions at each site is presented on Table 1-1. At both sites a progressive process of erosion, over steepening, slides and loss of vegetation is causing a southern lateral retreat of the slope faces. Both sites are also susceptible to

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[1] MaineDOT (2018a). "MaineDOT – Highway Preliminary Design Report, Project Name: Allagash & St. Francis, Rte, 161 Slope Stabilization, WIN: 17236.00 (Allagash)/17236.10 (St. Francis)", Draft Distribution Date: 10/1/2018, Final Distribution Date: 12/4/2018, prepared by MaineDOT and Golder Associates Inc.

[2] MaineDOT (2018b). Plan set titled (Allagash-St. Francis, Aroostook County, Route 161, State Project No. 17236.00, Project Length: 0.45 Miles", Sheet Nos 1-10, Final PDR-PIC December 13, 2018.

unpredictable and rapid slope failures due to high ice erosion forces and rapid drawdown instability effects from the formation and release of ice jams on the St. John River in this region.

Table 1-1: Comparison of Existing Site Conditions

Existing Site Conditions		
Item	**St. Francis**	**Allagash**
Slope Height	37 ft	48 ft
Top of Slope El (ft)	562	628
Toe of Slope El (ft)	525 – 530	580
Slope Angles	1.2H:1V to 1.5H:1V	1.1H:1V to 1.4H:1V
Length of Site Area (including transitions)	~1,300 ft	1,100 ft

1.2 Site Conditions

1.2.1 Allagash Site

The Allagash slope segment is positioned at the confluence of the Allagash River and the St. John River as shown on Figure 3. Figure 4 shows 2014 site topography and features in plan view, and Appendix A.1 presents photographs of site conditions in 2016. The roughly 48 ft high slope (measured from the slope crest to the base of the alluvial slope at the toe) ranges from about 1H:1V to 1.4H:1V and is partially vegetated. According to three ground surveys completed by MaineDOT between 2010 and 2016 a lateral retreat of the slope face ranging from about 4 to 7 ft occurred during this six-year period. Existing site conditions of the Allagash site include the following primary features:

- The section of Route 161 between Stations (Sta) 107+50 and 112+50, where the erosion has encroached to within about 5 ft of the north edge of pavement.
- The slope ranges in height from about 45 to 48 ft. The upper riverbank has an approximate 1H:1V slope angle, steepening to 0.7H:1V to almost vertical at the headscarp near the crest. The alluvial slope, below the riverbank, has a shallow slope, about 4H:1V.
- Three culverts daylight onto the slope. According to MaineDOT, significant erosion has occurred at the culvert outlets, and riprap was placed around the culvert outlets to mitigate the localized erosion. The riprap appears to have prevented further erosion at the crest of the slope. The riprap at the culvert outlets is limited to the mid-slope and does not extend to the bottom of the slope.
- Surficial vegetation and organic soils on the slope surface are raveling to the bottom of the slope due to erosion. Trees and their root masses are sliding down to the bottom of the slope, forming an extensive head scarp, and are eventually removed by the river during high water events. The headscarp is as close as 5 ft from the north edge of the pavement.

- MaineDOT also placed riprap at one of the slope headscarps between Sta 110+50 to 110+80. The riprap appears to have slowed the erosion in this area, however since the riprap does not extend to the bottom of the slope, continued erosion at the toe is causing the riprap to slide downslope.
- Gravel fans are present below the culvert outlets, indicating that material is being eroded from the bank by water discharging from the culverts.
- A pile of uncontrolled fill/trash containing glass, cans and metal was located at the crest of the slope between Sta 106+45 and 106+60.

1.2.2 St. Francis Site

The St. Francis unstable slope segment is located directly downstream of a valley constriction that occurs just downstream of the confluence of the St. Francis River and the St. John River as shown on Figure 5. Figure 6 shows 2016 site topography and features in plan view, and Appendix A.2 presents photographs of site conditions in 2016. The roughly 37 ft high slope generally ranges from about 1.2H:1V to 1.5H:1V and is unvegetated with exposed soil over much of the slope face. Existing site conditions of the St. Francis site include the following primary features:

- The section of Route 161 between Sta 7+00 and 13+00, where the erosion has encroached to within about 20 ft of the north edge of pavement.
- The slope ranges in height from about 29 to 37 ft, as measured from the slope crest to the base of the alluvial slope at the toe.
- Initial observations of this site indicated the surficial vegetation, organic soils, and root mats are eroding downslope as the underlying sands and gravels are eroded away by the river. The upper riverbank has an approximate 0.75H:1V slope angle, steepening to 0.5H:1V at the crest. The alluvial slope at the base of the riverbank has a shallow slope of about 4H:1V.
- MaineDOT observations indicate the riverbank was previously heavily forested and that continued erosion causes the trees to fall to the toe of the slope with subsequent removal by the river during high-water events. In 2016, several trees were observed to be nearly horizontal with root masses detached from the slope.
- Erosion is not limited to the area where the headscarps are located close to the edge of the road.
- A layer of gray fine-grained soils (silts and clays) exists at the toe of the slope.
- During our May 2016 site visit, groundwater seeps were observed at the top of the fine-grained soil layer, including pockets of moss and algae indicating these groundwater flows are near constant.
- Comparison of 2010 and October 2016 topographic surveys indicates horizontal slope loss of as much as 8 ft, indicating an average loss rate of about 1.3 ft/year.
- A historical dump/uncontrolled fill site, containing silt, sand, gravel, cobbles, asphalt debris, trash, glass, and metal, including railroad debris, is present on the riverbank between approximate Sta 11+50 and 12+50.

2.0 GEOLOGIC SETTING

2.1 Regional Surficial Geology

The unstable slope sites are located in extreme northern Maine within the St. John River Lowlands, a small subunit of the New England Upland section Physiographic Province[3,4]. Pleistocene-aged glacial till is widespread in the area, lying on the bedrock surface. The till consists of a heterogeneous mixture of boulders, cobbles, gravel, sand, silt, and clay, and is rarely stratified. Two types of till occur: a basal (or lodgment) till, typically fine grained and very dense, with low permeability; and an overlying ablation (or melt-out) till, typically coarser, less dense, and moderately permeable[5,6]. Two tills representing two different glacial advances may be present in the area: St. Francis Till, derived from the local underlying bedrock (Seeboomook Group; see below) and deposited by ice moving west to east; and the overlying Van Buren Till, containing drift derived from the Canadian shield (e.g., Precambrian granite gneiss), deposited by ice moving southeast. Both of these tills contain basal and ablation till fabrics, and may be separated by outwash sediments[7,8]. Ice contact landforms (such as kames and moraines) are common in the valleys, but the widest reaches of the valleys are dominated by a sequence of Holocene-aged (Recent), lacustrine fine-grained deposits, peat, and coarse-grained alluvium, overlying either till or bedrock. The lacustrine unit consists of gray, unfossiliferous silt with rhythmites (i.e., varves, <0.1 to 1.2 inches thick). This unit is interpreted to be post-glacial, with an erosional unconformity separating the overlying coarser alluvium. The alluvium consists of mostly horizontally bedded, sandy pebble to cobble gravel, commonly cemented by iron and manganese oxides with overlying channel fill silts[9].

2.2 Regional Bedrock Geology

Regional bedrock geologic mapping indicates the bedrock consists of the Early Devonian Seeboomook Group, consisting of medium- to dark-gray, thin- to thick-bedded, locally calcareous greywacke, gray slate, and cyclically bedded gray slate and sandstone, that has been metamorphosed to greenschist or subgreenschist facies. The greywacke is massive to weakly foliated, with foliation developed parallel or nearly parallel to original bedding. These rocks are often complexly folded, dip steeply and are overturned. Bedding and attendant fold axes and foliation strikes roughly northeast-southwest[10,11].

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[3] Kite, J.S. and Stuckenrath, R., 1989. Postglacial Evolution of Drainage in the Middle and Upper St. John River Basin, Maine and New Brunswick. Maine Geological Survey, Studies in Maine Geology: Volume 6, p. 135-142.

[4] Olcott, P.G., 1995. Groundwater Atlas of the United States: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island and Vermont. U.S. Geological Survey, Hydrogeologic Atlas HA 730-M.

[5] Genes, W.N., 1981. Surficial Geology of the St. Francis Quadrangle, Maine. Maine Geological Survey Open-File Report 81-15, scale 1:62,500.

[6] Lowell, T. V., 1986. Surficial Geology of the Allagash Quadrangle, Maine. Maine Geological Survey Open-File Report 86-40, scale 1:62,500.

[7] Lowell, T.V., Becker, D.A. and Calkin, P.E., 1986. Quaternary Stratigraphy in Northwestern Maine: A Progress Report. Géographie Physique et Quaternaire, vol. 40, no. 1, p 71-84.

[8] Rappol, M., 1989. Glacial History and Stratigraphy of Northwestern New Brunswick. Géographie Physique et Quaternaire, vol. 43, no. 2, p 191-206.

[9] Genes, A.N., 1980. Outline of the Pleistocene Geology of Northern Maine and Adjacent Canada, in: A Guidebook to The Geology of Northeastern Maine and Neighboring New Brunswick, 72nd Annual Meeting New England Intercollegiate Geological Conference, Presque Isle, Maine, October 10-13, 1980, p. 22-30.

[10] Boudette, E.L., Hatch, N.L.Jr., Harwood, D.S., 1976. Reconnaissance Geology of the Upper St. John and Allagash River Basins, Maine. U.S. Geological Survey Bulletin 1406, 37 p.

[11] Roy, D.C., Pollock, S.G., and Hanson, L.S., 1991. Bedrock Geology of the Upper St. John River Area, Northwestern Maine. Maine Geological Survey Open-File Report No. 81-8, scale 1:62,500.

3.0 SITE INVESTIGATIONS

3.1 Reconnaissance of Existing Nearby Riprap Slopes

In September 2016 Golder completed a reconnaissance of five existing riprap slopes on the St. John River in the vicinity of the two project sites. The riprap slope locations and a photo-log of observed conditions are shown in Appendix B. Table 3-1 summarizes the conditions noted from the reconnaissance. Construction of these slopes is estimated to have occurred between about 2000 and 2014. Slope angles varied between about 1.5H:1V and 2H:1V and slope heights were generally in the range of 15 to 25 ft. The rock type at Sites A, B, C and D was a similar platy phyllite/slate/metagraywacke and at Site E was a metalimestone. The observed D_{100} (maximum diameter) rock sizes were generally in the range of 3.0 ft or less with D_{50}'s in the range of 1.5 ft. The platy structure of the predominant rock type resulted in rectangular shaped riprap. The slopes were generally considered to be in good condition with some downslope migration of the riprap and evidence of degradation (weathering) of the phyllite/slate/metagraywacke rock type. MaineDOT design drawings for the Site B slope[12] indicate the slope was designed to be at a 1.75H:1V angle with a 2 ft to 4 ft thick layer of Heavy Riprap per MaineDOT Specification 703.28, with the base of the riprap layer extending up to 14 ft below the riverbed at the toe of slope for scour protection.

Table 3-1: Summary of Conditions at Nearby Riprap Slopes *(site locations shown in Appendix B)*

Site	Location	Slope Angle	Height [ft]	Riprap Size [ft]	Riprap Quality	Construction Date/Condition
A	Allagash River, Allagash (Rt. 161)	1.5H:1V (~35°)	20-25	3x1x1	phyllite/slate/ metagraywacke (platy)	~10 yrs ago; good
B	St. John River, St. Francis (Rt. 161)	2H:1V (~27°)	16.5	5x3x1 & 2x1.5x0.75	phyllite/slate/ metagraywacke (platy)	late 2007; good, some downslope migration
C	St. John River, St. Francis (Rt. 161)	1.5H:1V (~33°)	25-30	2.5x2x1 & 1.5x1x0.75	metagraywacke (platy)	~15 yrs ago; good
D	St. John River, St. John (Rt. 161)	2H:1V (~27°)	35-40	3x2x1 & 1x1x0.5	phyllite/slate/ metagraywacke (platy)	2005; some downslope migration, frost shatter
E	St. John River at new Clair – Ft. Kent Bridge	1.75H:1V (~29°)	15-20	1.5x1.5x1	metalimestone (equigranular)	2014; good

3.2 2014 MaineDOT Test Borings

On July 23 and 24, 2014 MaineDOT completed one geotechnical boring at both the St. Francis (HB-STFR-101) and Allagash (HB-ALLA-101) sites. The borings were drilled with a CME 45C rig using solid stem auger (SSA) and drive and wash methods. The Allagash boring was drilled to a depth of about 57 ft below ground surface (bgs) with standard penetration testing (SPT) completed at approximately 5 ft intervals. The St. Francis boring

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[12] MaineDOT (2007). Plan set titled "St. Francis, Aroostook, Route 161, Project No. 016476.30, Project Length: 0.035 mi., Collector Improvement Program", Sheet Nos. 1-10, dated September 17, 2007.

was drilled to a depth of about 36 ft bgs with SPT completed at approximately 5 ft intervals. Locations of these borings are shown on Figures 7 and 8, and boring logs are included in Appendix E.

3.3 2016 Golder Site Investigations

In September 2016 Golder completed a series of field investigations at both unstable slope sites including geologic mapping, geomorphic assessments, dynamic cone penetration (DCP) testing, and test boring drilling. The locations and ground surface elevation of test borings and DCP tests were surveyed by MaineDOT and provided to Golder October 25, 2016. Locations are referenced to project stationing and the NAD83 (98) ME 2000 East Zone coordinate system. Elevations reference the North American Vertical Datum of 1988 (NAVD88).

3.3.1 Geologic Mapping

Golder performed surficial reconnaissance geologic mapping at both sites on September 27-28, 2016. A Golder geologist mapped surficial slope conditions, aided with shallow hand-dug test pits to detect or confirm geologic contacts and other field information. The field team also reviewed the conditions of previous rip rap slope repairs along Rt. 161 between Allagash and Ft. Kent. Geologic maps of both sites are presented in Appendix C. The maps include noted geomorphic features, known/inferred/covered geologic contacts, surface and subsurface investigation locations, cross section locations, and seeps.

3.3.2 Geomorphic Assessment

Dr. John Field of Field Geology Services was onsite on September 26, 2016 during the field test boring program to access the fluvial geomorphology and watershed conditions at the Allagash and St. Francis sites. Dr. Field also made a visit to the local historical society to access historical documentation of the river conditions. A summary of Dr. Field's site reconnaissance and assessment of geomorphic conditions at both sites is presented in his report[13] included in Appendix D.

3.3.3 DCP Testing

Golder performed a total 12 of dynamic cone penetration (DCP) tests at the locations shown in Figures 7 and 8 on September 27, 2016. The DCP apparatus consists of a sacrificial 60° cone 20 mm in diameter connected to a 16 mm diameter steel rod. The cone is advanced using a 17.6-lb hammer dropped 575 mm and the depth of penetration caused by 5 blows (i.e. hammer drops) was recorded. At the Allagash site DCP-ALLA-1 was performed next to HB-ALLA-203 for data correlation to measured SPT N values. The test was stopped early due to excessive shaft deflection caused by a piece of gravel. A new test (DCP-ALLA-1b) was offset approximately 1 foot from the original location to supplement the data. The remaining 3 DCP tests at the Allagash site were completed along the toe of slope to provide soil strength data in site areas inaccessible by the test boring drill rig. The Allagash DCP tests ranged from 1.3 to 2.9 ft bgs. A total of seven DCP tests (extending 1.1 to 2.2 ft bgs) were performed at the St. Francis site: one test (DCP-STFR-1) was tested next to HB-STFR-203 to correlate to observed SPT N values, one test (DCP-STFR-5) was performed in an outcrop of fines on the slope, one test (DCP-STFR-6) was completed in an area of colluvium, and the remaining four tests were completed at the toe of the slope approximately in line with the geotechnical borings drilled at the create of the riverbank slope. A summary of the DCP test results is provided in Table 1 at the end of this report including calculated correlations

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[13] Field Geology Services (2017). "Report titled "Geomorphic Assessment of St. John River in Allagash and St. Francis, ME", prepared by John Field, PhD for Golder Associates, dated February 2, 2017.

between the DCP Penetration Index and the Standard Penetration Test N-Value based on criteria developed by Minnesota DOT[14].

3.3.4 Test Borings

From September 19 through September 28, 2016 two drill crews working at the Allagash and St. Francis sites completed eight (8) geotechnical test borings. One drill rig, a trailer mounted CME 45C, was operated and logged by MaineDOT personnel while the other drill rig, a truck mounted B53, was operated by New England Boring Contractors and was logged by a Golder geotechnical engineer. Four of the borings were drilled at the Allagash site and completed depths ranging from about 41 to 82 ft bgs. Four borings were also drilled at the St. Francis site and were completed to depths ranging from about 50 to 72 ft bgs. Boring HB-STFR-203 was terminated short of the target depth at about 72 ft bgs due to refusal in very dense basal till materials. Boring HB-STFR-204 was terminated short of target depth at about 50 ft bgs due to broken casing, approximately 35 ft of which was left in the ground. Standard Penetration Testing (SPT) was completed using automatic hammers in all borings, typically at approximately five foot interval spacing. The calibrated efficiencies of the automatic hammers used on the CME 45C and B53 rigs were 94.3% and 56.9%, respectively. Field vane tests were attempted within the layer of fines at the St. Francis site, but the tests could not be completed due to the sizeable fine sand content within the layer. Boring locations are shown on Figures 7 and 8, and boring logs are included in Appendix E.

Standpipe piezometers were installed at both sites to measure stabilized groundwater levels. Piezometers were constructed of 1-inch Schedule 40 flush threaded PVC pipes and the well screen sections were machine slotted approximately 0.01-inch in size. At the Allagash site a single piezometer was installed in HB-ALLA-202 with a screen interval from about 30 to 55 ft bgs. Number 1S sand was used to fill from the bottom of the hole to approximately 2 ft above the top of screen which was subsequently overlain by about a 3 ft thick bentonite chip plug. The remainder of the hole was backfilled with a combination of 1S sand and drill cuttings and was capped with a road box mounted just below the asphalt road surface. At the St. Francis site two piezometers were installed in HB-STFR-203; one well (Well 1) was screened from about 39.5 to 49.5 ft bgs, and the second well (Well 2) was screened from about 19.5 to 24.5 ft bgs. Number 1S sand was used to backfill the hole with the exception of two bentonite chip plugs; plug number one was located from about 37 to 34.5 ft bgs and plug number 2 was located from about 17.5 to 15.5 ft bgs. Piezometer installation notes are included on the boring logs in Appendix E.

A summary of the test boring information is included in Table 2 at the end of this report.

4.0 LABORATORY TESTING PROGRAM

Geotechnical laboratory tests were performed on representative soil samples collected during the 2014 and 2016 subsurface investigations to assist in soil classification. Testing included index testing for grain size distribution, moisture content and plasticity (Atterberg Limits). MaineDOT's materials testing laboratory in Bangor, Maine conducted the testing of the samples from the 2014 borings (100 series) and 2016 borings (200 series). Laboratory work was performed in accordance with applicable AASHTO and American Society for Testing Materials (ASTM) testing procedures. A listing of the total number of tests, type and procedure is summarized in Table 4-1 below. The combined testing performed for the investigation is summarized below. A summary of all completed laboratory testing and the results of all testing is provided in Appendix F. Table 3 at the end of this

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[14] Minnesota Department of Transportation, Office of Minnesota Road Research (1996). "User Guide to the Dynamic Cone Penetrometer", Figure 11.

report provides a summary of SPT N_{60} values, laboratory testing results and soil classifications for all soil samples retrieved. Selected test results are also presented on the boring logs in Appendix E.

Table 4-1: Summary of Completed Laboratory Testing

Soil Laboratory Test	Testing Procedure	Number of Tests Completed
Grain Size Analysis, sieve only	AASHTO T88, ASTM D422	19 – Allagash 16 – St. Francis
Grain Size Analysis including Hydrometer	AASHTO T88, ASTM D422	10 – Allagash 13 – St. Francis
Natural Moisture Content	AASHTO T265, ASTM D2216	29 – Allagash 29 – St. Francis
Atterberg Limits	AASHTO T89 & T90, ASTM D4318	1 – Allagash 4 – St. Francis

5.0 INTERPRETED SITE AND SUBSURFACE CONDITIONS

5.1 Allagash Site

5.1.1 Soil Conditions

Subsurface conditions encountered in the test borings at this site generally consisted of pavement, alluvium, and a sand and gravel layer (interpreted as glacial outwash), underlain by glacial till. Surface conditions encountered during geologic mapping consisted of colluvium and alluvium. Bedrock was not encountered in the test borings or observed during geologic mapping. Four interpreted subsurface profile sketches depicting the site stratigraphy encountered at the Allagash site are presented in Appendix G.1. A representative profile delineating the major soil layers encountered is shown on Figure 9, and representative grain size curves for the major soil units are presented on Figure 11. The following paragraphs discuss the encountered subsurface conditions at Allagash in more detail.

- **Pavement:** A surficial layer of asphaltic pavement about 4 to 6 in thick was encountered at the ground surface at borings HB-ALLA-101, HB-ALLA-201 and HB-ALLA-202.
- **Alluvium:** Alluvium within the riverbed was only observed during geologic mapping, and not encountered in the borings. The alluvium consists of brown and brown-gray, sandy and silty gravel, cobbles and boulders. The boulder size ranges from < 1 ft diameter to blocks up to about 4 ft long (but average size smaller than at St. Francis site); are mostly flat; are rounded to subrounded to subangular in texture, and form a weak imbrication dipping upstream in the riverbed. The gravel, cobble and boulder lithology is mostly consistent with the local Seeboomook Formation. Alluvium was not encountered in the borings. The thickness of the alluvium, based on the DCP probes, is estimated to be at least 2.9 ft. The SPT N_{60}-values calculated from the DCP probes (DCP-STFR-2 through -7) range from 17 to 33, with an average of 24, indicating a medium dense to dense consistency.
- **Colluvium:** Colluvium (i.e., slope wash) was observed on the riverbank, consisting of sloughed materials from exposed glacial outwash deposits (see below). The colluvium forms discontinuous tree root-mass supported slumps and veneers (generally less than 2 to 4 ft thick) over much of the riverbank, and talus

cones at the outflows of drainage structures. The slumps have formed continuous scarps up to 250 ft long. Colluvium was not encountered in the borings.

- **Glacial Outwash:** A layer of glacial outwash was encountered at the ground surface or beneath the pavement in all five borings. This layer consisted of brown, olive-brown, tan, gray-brown, gray and dark gray, dry to wet, fine to coarse sand, with little to some gravel and little to some silt, and occasional cobbles; gravelly fine to coarse sand, with little to some silt, and occasional cobbles; and fine sandy silt. The thickness of this layer ranges from about 21 to 44 ft thick. This unit is exposed on the riverbank slope, under a thin, discontinuous veneer of colluvium and tree root-supported forest duff. Boulders up to 1.5 ft in diameter were noted during field geologic mapping of the colluvium developed from this layer on the riverbank slope. The borings had SPT N_{60}-values ranging from 13 to 77 blows per foot (bpf), with an average of 38 bpf, indicating medium dense to very dense consistencies. Regional geologic mapping indicates this unit is interpreted as a kame terrace (i.e., ice-contact deposit).

- **Glacial Till:** Underlying the outwash is a glacial till consisting of gray-brown, brown, orange-brown, and gray, wet, gravely fine to coarse sand, with little to some silt, little to some clay, and occasional cobbles; moderately plastic silty clay with some sand; and fine sand with some silt, and trace clay and gravel; and gravely fine sand with some silt and trace clay. The upper portions of the glacial till are interpreted to be covered by colluvial wash or alluvium on the riverbank slope. The SPT N_{60}-values within this layer ranged from 30 to 119 bpf, with an average of 69 bpf, which indicates medium dense to very dense consistencies. The upper approximately 22 to 37 ft of this layer is interpreted to be either a reworked till or a melt-out (ablation) till, with N_{60}-values ranging between 30 bpf and 119 (average of 64 bpf), overlying a denser basal (lodgment) till, with N_{60}-values of refusal.

5.1.2 Groundwater

Groundwater levels during drilling were observed in three borings (HB-ALLA-202, HB-ALLA-203, and HB-ALLA-204). The observed groundwater levels in the cased borings ranged from about 16 to 46.3 ft bgs and are interpreted to represent a regional groundwater body hydraulically connected to the river. A piezometer was installed in HB-ALLA-202 to obtain more accurate measurements of the groundwater surface. On September 29, 2016, the measured groundwater elevation for the piezometer (screened across the contact between the glacial outwash sediments and the ablation till) was about 46.5 ft bgs. No seeps were mapped during the geologic field reconnaissance.

5.2 St. Francis Site

5.2.1 Soil Conditions

Subsurface conditions encountered in the test borings at this site generally consisted of pavement, a fill sand layer, a sand and gravel layer (interpreted as glacial outwash) containing a fine grained clayey silt deposit (interpreted as lacustrine), underlain by glacial till. Surface conditions encountered during geologic mapping consisted of colluvium and alluvium. Bedrock was not encountered in the test borings or observed during geologic mapping. Four interpreted subsurface profile sketches depicting the site stratigraphy encountered at the St. Francis site are presented in Appendix G.2. A representative profile delineating the major soil layers encountered is shown on Figure 10 and representative grain size curves for the major soil units are presented on Figure 12. The following paragraphs discuss the encountered surface and subsurface conditions in more detail.

- **Pavement:** A surficial layer of asphaltic pavement about 5 to 7.5 in thick was encountered at the ground surface at borings HB-STFR-101, HB-STFR-201 and HB-STFR-204.

- **Fill:** A layer of fill was encountered either at the ground surface or immediately beneath the pavement at borings HB-STFR-101, HB-STFR-201, and HB-STFR-204. This layer consisted of brown to dark brown, dry to damp, fine to coarse sands with trace to some gravel, and little to some silt. The thickness of the fill layer ranges from approximately 2 to 6.8 ft. The three borings that penetrated this layer had SPT N_{60} values ranging from 13 to 61 blows per foot (bpf) with an average of 32 bpf indicating loose to very dense consistencies.

- **Alluvium:** Alluvium within the riverbed was only observed during geologic mapping, and not encountered in the borings. The alluvium consists of brown and brown-gray, sandy and silty gravel, cobbles and boulders. The boulder size ranges from < 1 ft diameter to blocks up to about 4 ft x 2.75 ft x 1 ft; are mostly flat with a length:width ratio of 2:1 to 3;1; are rounded to subrounded to subangular in texture, and form a weak imbrication dipping upstream in the riverbed. The gravel, cobble and boulder lithology is mostly consistent with the local Seeboomook Formation. Alluvium was not encountered in the borings. The thickness of the alluvium, based on the DCP borings, is estimated to be at least 2.2 ft. The SPT N_{60}-values calculated from the DCP probes (DCP-STFR-2, -3, -4 and -7) range from 17 to 28, with an average of 22, indicating a medium dense consistency.

- **Colluvium:** Colluvium (i.e., slope wash) was observed on the riverbank, consisting of sloughed materials from exposed upper post-glacial stream deposits (see below). The colluvium formed discontinuous veneers (generally less than 2 ft thick) and talus cones on the lower half of the river bank. Colluvium was not encountered in the borings.

- **Upper Post-glacial Stream Deposits:** All five borings encountered alluvial sediments derived from post-glacial outwash sediments. These deposits are exposed on the riverbank, and geologic mapping indicates they consist of yellowish tan to light brown, horizontally bedded, sandy pebble to cobble gravel, with one gravel/cobble layer weakly cemented by iron and manganese oxides (ferricrete). The rounded cobbles generally have a maximum diameter of about 3 in. The sand portion texture ranges from subangular to subrounded. The ferricrete cemented gravel layers (two to three) are generally about 0.25 to 0.5 ft thick, occur about 4 to 8 ft above the lacustrine deposits (see below), and are fairly persistent laterally (greater than 50 ft). As observed in the borings, this deposit consists of brown, dark brown, grayish-brown, gray, olive, damp to wet, gravely fine to coarse sand, with little to some silt, some clay, and occasional small gravels; and fine to medium, silty sand. The thickness of this layer ranges from approximately 11 to 23 ft. The five borings had SPT N_{60} values ranging from 24 to 112 bpf, with an average of 50 bpf, indicating medium dense to very dense consistencies.

- **Post-glacial Lacustrine Deposits:** A layer of silty clay to clayey silt with little to trace sand was encountered in four of the five explorations below the upper post-glacial stream deposits (i.e., in HB-STFR-201, HB-STFR-202, HB-STFR-203 and HB-STFR-204). These deposits are also exposed at the base of the riverbank beneath a thin veneer of colluvium and dumped uncontrolled fill/debris materials. Geologic mapping indicates they consist of light to medium olive gray, tan-orange brown, and medium to dark gray, horizontally bedded, moist to saturated, weakly laminated/varved, gravelly clayey silt and silty clay. The gravel is more common in the lower portion of this unit. The thickness as measured in exposures on the river bank ranges from at least 6 to 8 ft, as the lower contact is not exposed; and ranges from about 5 to 19 ft, as encountered in the borings. Laboratory testing indicates that the material is classified as CL, ML and CL-ML based on the Unified Classification System (UCS), and A-4 (silty soil) based on the AASHTO classification system. The four borings that encountered these deposits had SPT N_{60} values ranging from 12 to 31 bpf, with an average of 21 bpf, indicating stiff to hard consistencies. Laboratory tests indicated a natural moisture content ranging from 14.6 to 25.6%, with an average of 19.7%. The tests also indicated an average LL 25, an average PL of 21, and an average PI of 3. Field pocket penetrometer unconfined strength tests of the exposed, non-reworked clayey silt and silty clay ranged from 0.4 to 3.4 tons/ft^2 (800 to 6,800 psf), with an average of 1.8 tons/ft^2 (3,600 psf). The lower portion of this layer tends to have lower strength (generally < 2 tons/ft^2 [4,000 psf]), as exposed in the riverbank and in the borings (e.g., in HB-STFR-204). Torvane measurements from HB-STFR-204 ranged from 0.250 to 0.475 tons/ft^2 (500 to 950 psf). The SPT N_{60}-values calculated from the DCP probes (DCP-STFR-5 and -6) range from 13 to 25, with an average of 20, indicating a stiff to very stiff consistency.

- **Lower Post-glacial Stream Deposits:** Three borings on the east side of the site area (HB-STRF-101, HB-STFR-201 and HB-STFR-202) encountered interpreted alluvial sediments derived from glacial till. These deposits are not exposed on the riverbank. Based on geologic mapping and borehole observations, these deposits may represent post-glacial outwash sediments eroded from glacial till and deposited before the lacustrine layer. As observed in the borings, this deposit consists of brown to gray, wet, fine to coarse sand, with some to little silt, and occasional cobbles; and gravely fine to coarse sand. The thickness of this layer ranges from approximately 13 to 33 ft. The three borings had SPT N_{60} values ranging from 23 to 49 bpf, with an average of 37 bpf, indicating a medium dense to dense consistency.
- **Glacial Till:** Four of the five borings encountered glacial till underlying the lower post-glacial stream and lacustrine deposits (HB-STFR-201, HB-STFR-202, HB-STFR-203, and HB-STFR-204). The glacial till is not exposed in the riverbank. The till consists of gray, wet, silty, gravelly, fine to coarse sand, with little to some gravel, and trace to some clay. The thickness of this layer is unknown as bedrock was not encountered in the borings, but is at least 43 ft as observed in HB-STFR-203. The SPT N_{60}-values within this layer ranged from 25 bpf to refusal, with an average of 71 bpf, indicating medium dense to very dense consistencies. The upper approximately 12 to 14 ft of this layer is interpreted to be either a reworked till or a melt-out (ablation) till, with N_{60}-values ranging between 25 bpf and refusal (average of 47 bpf), overlying a denser basal (lodgment) till, with N_{60}-values ranging between 48 and 101 bpf (average of 86 bpf).

5.2.2 Groundwater

Groundwater levels during drilling were observed in four borings (HB-STFR-201, HB-STFR-202, HB-STFR-203 and HB-STFR-204). The observed groundwater level in the cased borings ranged from about 15 to 33 ft bgs. These measurements were interpreted to represent both a locally perched groundwater body above the lacustrine layer, and a lower regional groundwater body hydraulically connected to the river. As such, a nested piezometer was installed in HB-STFR-203 to obtain more accurate measurements of these two groundwater surfaces. On September 29, 2016, the measured groundwater elevation for the shallow piezometer (screened within the outwash sediments just above the lacustrine deposits) was about 19.6 ft bgs; and the measured groundwater elevation for the deep piezometer (screened within the glacial till) was about 39.7 ft bgs. Four seeps in the alluvium were mapped during the geologic field reconnaissance, lying either at the toe of the riverbank or exposed in the riverbed, as shown on figures in Appendix C.2. Flow from the seeps was estimated to range from 0.1 to 2 gallons per minute.

6.0 SLOPE EROSION TRENDS (2010-2016)

Recent slope erosion trends were assessed by comparing ground surface elevation data from three successive surveys completed by MaineDOT at Allagash in 2010, 2014 and 2016, and two surveys at St. Francis in 2010 and

2016. Slope profiles were selected from six representative sections at each site to examine the changes in profile shape over this period. A typical profile is shown on Figure 6-1 (from Allagash) that illustrates a consistent erosion trend from 2010 to 2014 of over steepened slope formation at mid to upper slope areas with some slope flattening at lower slope areas, followed in 2016 by erosion of the over steepened upper section as well as steepening of the lower section.

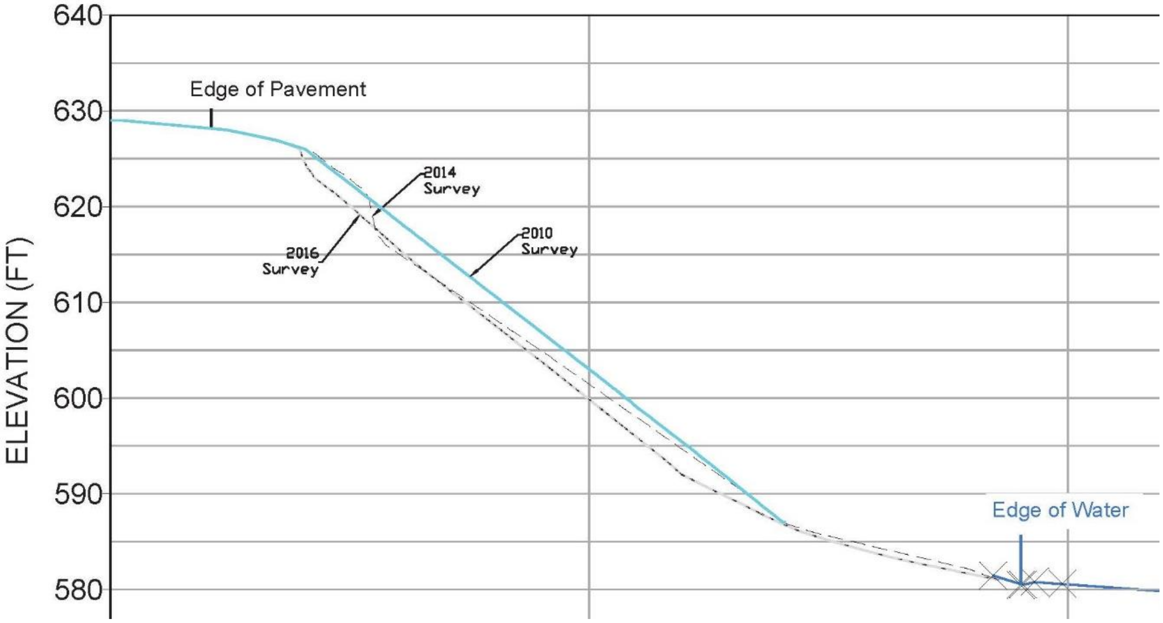

Figure 6-1: Typical Slope Profile Overlays from 2010, 2014 & 2016 Survey Data (Allagash site shown)

This data was then contoured at both sites to show locations and magnitudes of cut and fill (i.e., erosion and deposition) between 2010 and 2016. Figures 13 and 14 show the resulting pattern of erosion and deposition magnitudes and locations at Allagash and St. Francis, respectively. These figures also show the calculated 100-year flood elevations for river conditions with and without ice based on the hydraulic modeling discussed in Section 7.2. The higher erosion zones are located in mid to upper third slope areas that generally align with the calculated 100-year flood elevations. These areas appear to be more contiguous at the St. Francis site than the Allagash site.

Erosion magnitudes in terms of elevation change typically ranged from roughly 4 to 8 ft over the six-year period, which correlates to larger magnitudes of horizontal retreat since the slopes were generally flatter than 1H:1V. Average horizontal rates of retreat were roughly 0.8 and 1.3 ft/year at Allagash and St. Francis, respectively, during this period. Communications with local residents suggest average erosion rates are higher than this over approximately the past 50 years.

7.0 EVALUATIONS

Preliminary evaluations focused on identifying conditions interpreted to be causing the unstable conditions at both sites, hydraulic modeling, assessment of ice conditions on the St. John River, scour analyses and development of a list of possible slope stabilization alternatives. Based on discussions and meetings with MaineDOT a combination of stabilization features were selected and subsequent evaluations focused on riprap sizing criteria, global stability and preliminary grading plans for stabilizing the slopes to provide a basis for preliminary construction cost estimating. The following parts of Section 7 provide summary discussions of these evaluations and related conclusions for design. Design recommendations are discussed in Section 8.

7.1 Slope Erosion Mechanisms

Based on the conditions identified from the site investigations and our review of historical information, six primary slope erosion processes were identified as contributing to the development of unstable conditions at both project sites. The six processes are shown schematically on Figure 7-1 and include the following:

1) Bank Erosion from Hydraulic Forces: Defined as erosion along the upper portion of the bank slopes resulting from elevated river water levels and correspondingly high velocity flows occurring during defined floods.

2) Bank Erosion from Ice Forces: Defined as erosion along the upper portions of the bank slopes, or extending down to the toe of the slope, resulting from ice formations in motion (vertically and horizontally) in direct contact with the slope.

3) Slope Instability (from over steepening, unstable soil materials and/or seepage conditions): Defined as global slope instability for slopes with slip surfaces with factors of safety close to 1.0 due to a combination of steep slope angle, low strength soils and/or adverse groundwater conditions.

4) Slope Instability from Rapid Drawdown: Defined as instability resulting from the development of high groundwater pressures, high soil weights from saturated conditions, and a rapid drop in river water level (e.g., from an ice dam break).

5) Bank Toe Erosion: Defined as erosion that is generally limited to the area around the toe of the slope during flood events, thereby undercutting the upper portion of the slope and resulting in instability extending further up the slope (i.e., upper bank areas slough down to the toe), and,

6) River Toe Scour: Defined as scour that occurs in the river channel during peak events, either as a function of general or local scour, or from meandering thalweg alignment, and results in a lowering to the bed in the area at the base of the slope, undercutting it and causing further instability further up the slope.

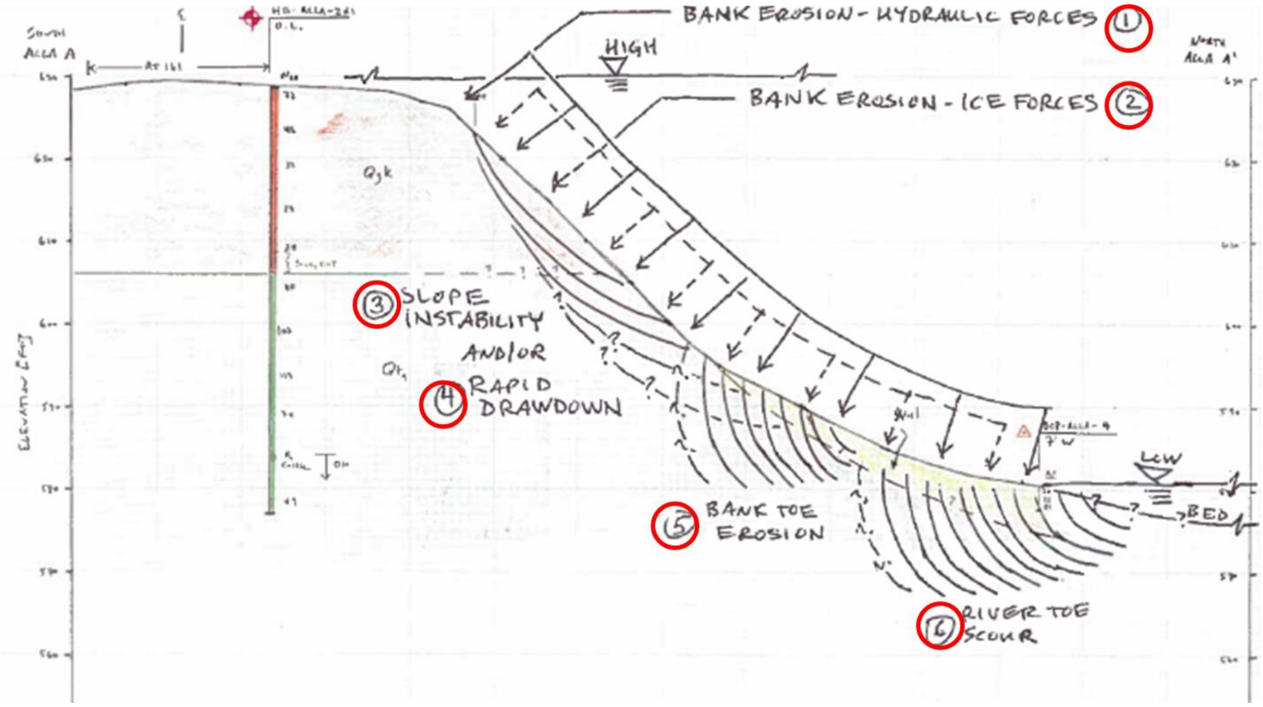

Figure 7-1: Conceptual Slope Erosion Processes

7.2 Hydraulic Modeling

Accounting for the findings from the site investigations and fluvial geomorphology conditions in the reaches pertaining to the unstable slopes, hydraulic analyses were performed to assess river flows at the sites and calculate hydraulic parameters corresponding to design flows (i.e., velocity, depth, width, etc.). Hydraulic forces are derived from shear stress of the water moving past the slope during either floods or elevated river levels resulting from ice jams. A detailed discussion of pertinent geology, geomorphology, hydrology and hydraulics evaluations is provided in Golder's technical memoranda dated March 12, 2019 and September 15, 2017 included herein as Appendices H and I, respectively. The following discussion provides a brief summary of the hydraulics evaluations.

As discussed in Appendix H, an estimated peak discharge of the St. John River for the 100-year recurrence interval was determined to be 133,000 cubic feet per second (cfs) at the Allagash site and 156,000 cfs at St. Francis site. One dimensional (1D) and two dimensional (2D) models were used to evaluate flow conditions at both sites. The 1D model was set up as a steady-flow model using the US Army Corps of Engineers Hydrologic Engineering Center River Analysis System[15] (HEC-RAS). Additionally, a layer of ice thickness was taken into account in the HEC-RAS models through the 'ice cover' tool option. An ice cover thickness of 3 ft for the banks and 2.5 ft for the channel was selected for both sites using guidance from the FEMA FIS[16]. In addition to the 1D models two-dimensional (2D) models were created to analyze the proposed conditions for each site. As discussed

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[15] US Army Corps of Engineers (2016). "Hydrologic Engineering Center River Analysis System (HEC-RAS)", Version 5.0, February 2016.

[16] FEMA (2003). "*Town of Allagash, Maine, Aroostook County, Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS)"*, Number 230440V000A, Revised April 2, 2003.

in Appendix I, the 2D models were developed using TUFLOW[17], a hydrodynamic numerical model, in order to resolve hydraulic conditions at a more granular scale throughout the project areas and to better represent the anticipated complex flow dynamics. 2D models report results for each cell within the grid, allowing for review of hydraulic conditions laterally as well as longitudinally within and between section locations. The following summarize the models:

- The modelling extents for the Allagash reach covers 1.9 miles and the St. Francis reach covers 1.7 miles. The two modeled reach extents were selected to encompass the proposed channel modifications and anticipated area of influence.
- The models utilized a combination of light detection and ranging (LiDAR) and conventional survey data. The LiDAR survey data was collected in 2009 through a FEMA project[18]. Conventional survey data was collected in 2016 by Maine DOT which included three river cross-sections taken at each site; one cross-section at the slope failure location and two cross-sections directly downstream. The LiDAR data was obtained during the high flow season of the spring freshet and as such did not capture much of the channel bathymetry. The conventional survey data was used to fill in the channel bathymetry.
- A Manning's n-value of 0.027 was selected for the main and side channels and an overbank value of 0.040 was selected for the floodplain. These roughness values were determined from aerial, site visit photographs, and values used in the FEMA flood study.
- Models were analyzed for the 2- through 100-year annual exceedance probability event of 58,000 through 133,000 cfs for the Allagash site and 68,000 through 156,000 cfs for the St. Francis site.

A summary of hydraulic modeling parameters for the 100-year recurrence interval event determined with HEC-RAS (1D) and TUFLOW (2D) is shown in Table 7-1. The results of the two models compared well, and TUFLOW results were used for subsequent analyses. Baseline velocity modeling results for non-ice flow conditions from the TUFLOW model are shown on Figures 15 and 16 for Allagash and St. Francis, respectively. A complete presentation of TUFLOW modeling results is presented in Appendix I.

Table 7-1: Summary of Hydraulic Parameters from HEC-RAS (1D) and TUFLOW (2D) Models

Site	Model	Water Surface Elevation (ft NAVD 88)	Maximum Channel Depth (ft)	Channel Velocity (ft per second)
Allagash	1D HEC-RAS (with ice)	605.49	29.62	3.89
	1D HEC-RAS	594.8	18.9	6.9
	2D TUFLOW	595.9	16.8	7.5
St. Francis	1D HEC-RAS (with ice)	554.34	33.81	5.41
	1D HEC-RAS	541.7	21.1	9.2
	2D TUFLOW	542.6	22.3	10.4

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[17] MBT WBM (2016). "TUFLOW", Build 2016-03.

[18] FEMA. 2009. Fort Kent LiDAR Survey.

7.3 Ice Conditions

Site history information coupled with conditions observed from our field investigations and our interpreted slope erosion processes strongly suggest that slope erosion from ice attack is a significant contributor to the unstable conditions at both sites. Ice forces acting along the slope are caused from accumulated ice masses coming into contact with the bank. Ice cover can also freeze to material on the slope and “pluck” it out as it begins to move downstream. To assess the history of ice jams and flooding in the region Golder reviewed information listed on the CRREL Ice Jam Database[19], data from stream gauges at Dickey and Allagash, and a videotape of the April 2014 flood on Facebook. Summaries and presentations of the information reviewed is presented in Appendix J. This information was compared to the results of the hydraulic modeling for ice conditions discussed in Section 7.2.

The data reviewed indicates the St. John River is susceptible to ice jam formations caused by river ice blockage near islands located within the waterway. Hunnewell Island, located roughly 2.5 miles downstream of the St. Francis site, is a frequently documented location for the formation of ice jams in this stretch of the river. Ice jams forming in this area are often reported to be 10 to 15 miles in length with shear walls along the river banks up to 12 ft tall. Ice thicknesses on the river can commonly exceed 2 ft. An ice thickness of 28 inches (2.3 ft) was reportedly measured on the river near the Allagash site during the 2014 ice jam and flood. Much of the information contained in the CRREL data base includes eye witness reports from local residents or officials. This information indicates that flooding from ice jams to elevation 552 ft at St. Francis is a common occurrence. The results from Golder’s hydraulic modeling for a 100-year event with ice indicate a flood elevation of 554 ft, which is in close agreement. Photographs in Appendix J (Figures J.2.4, J.2.5 and J.2.6) show conditions at the St. Francis site prior to, during and after an ice jam and flooding occurring in April 2014. A video of ice flow conditions taken by a local resident during the April 2014 ice jam/flood indicates ice levels at about elevation 559-560 ft at the St. Francis site, i.e., near the slope crest (El. 562 ft)). References to reported flood levels at the Allagash site were not found in the database, however, ice jam levels at the Allagash/Dickey town line were reported at elevation 625 ft which roughly 3 ft below the slope crest at the Allagash site.

Table 7-2 summarizes our conclusions about ice conditions based on the findings from the ice jam database, video of historic ice movements on the St, John River, and the results of the hydraulic modeling.

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[19] Cold Regions Research and Engineering Laboratory - Ice Engineering Group, (2016). "Ice Jam Database, Bulletins & Surveys," US Army Corps of Engineers, Hanover, NH. http://rsgisias.crrel.usace.army.mil/apex/f?p=273:1

Table 7-2: Water Surfaces With and Without Ice – Modeling vs Empirical Reports

Item	Allagash[1]	St. Francis
Slope Height	48 ft	37 ft
Crest of Slope El	628 ft	562 ft
Toe of Slope El	580 ft	525 - 530 ft
Q_{100} Water Surface El (no ice) - hydraulic modeling	596 ft	543 ft
Distance from Slope Crest to Q_{100} Water Surface (no ice) - hydraulic modeling	32 ft	19 ft
Distance from Toe of Slope to Q_{100} Water Surface (no ice) - hydraulic modeling	16 ft	18 ft
Q_{100} Water Surface El (with ice) - hydraulic modeling	606 ft	554 ft
Distance from Slope Crest to Q_{100} Water Surface (with ice) - hydraulic modeling	22 ft	8 ft
Distance from Toe of Slope to Q_{100} Water Surface (with ice) - hydraulic modeling	26 ft	29 ft
Q_{100} Water Surface El (with ice) - empirical reports	625 ft	562 ft
Distance from Slope Crest to Q_{100} Water Surface (with ice) - empirical reports	3 ft	0 ft
Distance from Toe of Slope to Q_{100} Water Surface (with ice) - empirical reports	45 ft	37 ft

7.4 Scour

Scour analyses were completed for existing conditions using the hydraulic parameters obtained from the TUFLOW modeling of both sites. The estimated scour is associated with no ice cover and corresponds to the 100-year recurrence interval. Scour was assessed through use of two different methods. The first of these methods is the United States Bureau of Reclamation's (USBR's) multiple regime calculation methods[20]. (USBR 1984). Estimates of subsurface ground conditions to support scour calculations were based on investigations completed by Golder. The second scour calculation method is the Maynord method, presented by the Federal Highway Administration in its HEC-23 publication[21]. Scour calculations summaries are provided in Attachment L, and the results for scour based on the regime equations are presented in Table 7-3.

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[20] U.S. Department of the Interior, Bureau of Reclamation (USBR). 1984. "Computing Degradation and Local Scour, Technical Guideline for Bureau of Reclamation." Denver, CO.

[21] FHWA. 2009. "Hydraulic Engineering Circular (HEC) No. 23: Bridge Scour and Stream Instability Countermeasures", Lagasse, P.F. et al., Federal Highway Administration, Third Edition, September 2009.

Table 7-3: Estimated Scour Depths

Method	100-Year Bend Scour Depths (ft Below Thalweg)	
	Allagash	St. Francis
FHWA Method	5.7	13.1
USBR Method	6.6	6.5
Average Scour Depth	6.2	9.8
Approximate Thalweg Elevation	577	520
Average Scour Elevation	571	510
Approximate Toe of Slope Elevation	580	525
Average Scour Depth Below Toe of Slope	11	15

7.5 Mitigation Options

It is evident that forces from both hydraulics and ice has caused scour along the slopes at both of the project sites. Stabilization methods must provide resistance to slope erosion and protection from toe scour. Resistance to slope erosion can include combinations of riprap armor (with or without cable reinforcement), wall systems, vegetation, and timber cribs. Toe protection can include riprap extended below the scour depth, mounded toes, bendway weirs, spur dikes, and small dams. Bendway weirs are low level rock dikes, which are submerged at all times, angled upstream to the flow in a waterway. These structures alter a river's secondary currents in a manner which controls excessive channel scour and reduces riverbank erosion on the outside banks.

Based on the site investigations, geomorphic assessments, hydraulic modeling, ice dam history research and slope stability analyses, mechanisms causing the slope instability were identified and a detailed analysis of stabilization options for both sites was completed. Sixteen stabilization options were identified as summarized below in Table 7-4. Advantages, disadvantages, construction issues and cost considerations were evaluated and discussed for the stabilization options during a coachpoint meeting on December 5, 2016. At the meeting MaineDOT recommended that design proceed with a similar solution for both sites incorporating large sized riprap on full-height regraded slopes and a series of bendway weir riprap structures extending out into the river bed along the toe of the unstable slopes. These mitigation concepts incorporate Options 1b, 3a and 4 as presented in Table 7-4.

Table 7-4: Slope Stabilization Alternatives

#	Option	Description
1a	Uniform Rip Rap	Rip rap rock slope armor reinforcement of uniform size
1b	Variable Rip Rap Sizes	Larger rip rap rock slope armor reinforcement to the 100yr flood level (w/ ice) and smaller rip rap above
2	Rip Rap with Launch Stone	Rip rap rock slope armor reinforcement with additional rip rap loosely piled at the toe. As scour and slope erosion occurs, the rip rap at the toe of slope should fall and fill the eroded portions of the slope.
3a	Rip Rap Slope with Buried Rip Rap Upper Slope	Rip rap armored slope with grubbings and vegetation over the upper portion of the slope (above 100yr water level w/ ice)
3b	Rip Rap Slope with Vegetated Upper Slope	Rip rap armored slope to the 100yr water level w/ ice and vegetated slope above
4	Bendway Weirs	Submerged rock weirs (dikes) angled upstream
5	Spur Dikes	Obstruction placed into flow channel to temporarily hold ice and delay ice jams
6	Peaked Stone Toe or Floodplain Bench Construction	Build a bench of rock out over colluvial slope to buttress slope and redirect scour from current toe of slope
7	Toe Scour Protection System	Rip rap rock slope armor reinforcement with ring net/ spiral rope cover anchored with soil nails
8	Steepened Slope with Soil Nails and Anchored Wire Mesh	Steepened soil slope covered with tensioned wire mesh and soil nail anchors
9	Soldier Pile and Lagging Wall (or Sheetpile Wall)	Install a full height retaining wall
10	Soldier Pile and Lagging Wall with Rip Rap Slope	Install a partial height vertical retaining wall at the upper portion of the slope with a rip rap reinforced slope below
11	Soldier Pile and Lagging Wall with Rip Rap Slope, Ice Spikes, and Bendway Weirs	Install a partial height vertical retaining wall with a rip rap reinforced slope above, ice spikes attached to the top of wall and bendway weirs extending outwards from the base of wall
12	Ice Booms	Seasonal or Permanent (Sink/Float) netting placed upstream to contain ice movement and allows ice to clear downstream
13	Stone Filled Timber Cribs	Placed into flow channel to temporarily hold ice and delay ice jams
14	Road Relocation	Realigning the roadway to provide more clearance from the river banks
15	Weirs or Small Dams	Install weirs or small dams within the river channel to stabilize ice sheets or hold brash ice
16	Dredging	Excavate soil in stream bed

7.6 Riprap

Riprap for slope stabilization was evaluated using design guidance for sizing rock to be placed for slope erosion protection. The NCHRP study, Report 568[22], evaluated numerous procedures for sizing revetment riprap, and recommends using the method developed by Maynord (1989, 1990) published by the U.S. Army Corps of Engineers (USACE) as Engineering Manual No. 1110-2-1601 (EM-1601) (USACE 1991). The procedure uses both velocity, depth and slope angle as its primary design parameters. To account for ice the FHWA[21] recommends increasing the factor of safety from a typical value of 1.1 for no ice up to 2.0 for conditions with ice. Following this methodology, it is estimated that a D_{50} (particle size for which 50% is finer by weight) of 1.05 ft (13 inches) and 2.49 ft (30 inches) is required for riprap at 2H:1V slopes at the Allagash and St. Francis sites, respectively, to resist water forces with ice. Full calculations can be found in Appendix M.

The EM-1601 states that riprap thickness should not be less than the diameter of the D_{100} or less than 1.5 times the diameter of the D_{50}, whichever results in greater thickness. This results in a minimum riprap thickness of approximately 2.0 ft and 3.75 ft for the Allagash and St. Francis sites, respectively, for 2H:1V slopes.

Research by the USACE/Cold Regions Research and Engineering Laboratory[23] (CRREL) based on model tests at a scale of 10:1 concluded that the D_{100} rock size required to avoid damage should be based on ice thickness. The results of these tests indicate that to avoid damage by ice shoving the D_{100} rock size should be twice the ice thickness for 3H:1V slopes and about three times the ice thickness for 1.5H:1V slopes. As discussed in Section 7.3, ice thicknesses up to about 2 ft and 2.3 ft have been reported at the St. Francis and Allagash area, respectively. According to the CRREL criteria, a D_{100} rock size for a 2H:1V slope would need to be about 5 ft and 5.8 ft at St. Francis and Allagash, respectively, to avoid slope damage. Use of smaller D_{100} rock sizes resulted in increasing probabilities of damage based on the ratio of rock size to ice thickness from the model testing. Additional model testing research by Sodhi and Donnelly[24] indicates that damage to riprap slopes occurs when the ice thickness is greater than the D_{50} rock size. The amount of damage is a function of the slope angle, the angle of ice movement relative to the slope, and the ratio of ice thickness to D_{50}.

7.7 Slope Stability

Global stability analyses were conducted for multiple slope sections at both sites. All analyses were performed using the 2D limit equilibrium SLIDE[25] model. Soil parameters selected for the analyses were determined based on the findings from the field investigations and laboratory testing. Four cross-sections were selected for each site to assess representative variations in interpreted soil stratigraphy, soil parameters and slope geometry. Slope sections were analyzed with circular and non-circular potential failure surfaces for existing conditions (to calibrate soil parameters) and three different loading conditions for the alternative slope geometries evaluated:

1) Rapid drawdown (due to a sudden drop from a Q_{100} water level due to an ice jam release). A minimum required factor of safety (FS) = 1.1 was established for design.

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[22] NCHRP. 2006. "Riprap Design Criteria, Recommended Specification, and Quality Control", NCHRP Report 568, Lagasse, et al, 2009.

[23] CRREL. 1996. "Ice Action on Riprap, Small Scale Tests", Sodhi, Devinder S., Borland, Sharon L., and Stanley, Jesse M., CRREL Report 96-12, US Army Corps of Engineers, Cold Regions Research & Engineering Laboratory, September 1996.

[24] Sodhi, Devinder S, and Donnelly, Christopher J. 1999. "Ice Effects on Riprap: Model Tests", Cold Regions Engineering, Putting Research into Practice, Proceedings of the Tenth International Conference, Lincoln, New Hampshire, American Society of Civil Engineers, August 16-19, 1999.

[25] Rocscience. 2018. "SLIDE – 2D Limit Equilibrium Slope Stability Analysis", Version 2018 8.018, Rocscience, Inc., Toronto, Ontario, Canada, build date September 28, 2018.

2) Seismic loads. A minimum required FS = 1.0 was established for design.

3) Steady state water pressures based on Q_2 water levels for post-construction conditions. A minimum required FS = 1.3 was established for design.

The stabilized slope section for all analyses assumed that Extra Heavy Riprap (with rock sizes larger than MaineDOT's Heavy Riprap specification 703.28) would be placed to the Q_{100} water surface elevation (with ice) determined from hydraulic modeling as shown on Table 7-2 (i.e., El 606 ft for Allagash and El 554 ft for St. Francis). Above these levels the preliminary design included a reduced thickness of riprap meeting the MaineDOT Heavy Riprap specification to provide erosion resistance against ice attack from extreme events with water/ice levels approaching the top of the slopes. Typical 2H:1V initial slope cross-sections that were analyzed for Allagash and St. Francis are shown on Figures 17 and 18, respectively.

Preliminary stability analyses were conducted for varying riprap layer thicknesses, varying riprap toe configurations, varying grading plans, and final slope angles of 1.5H:1V, 1.75H:1V and 2H:1V. The results of these analyses indicated that satisfactory FS's could be achieved for the three loading conditions considered with slopes at 1.75H:1V or flatter with riprap layer thicknesses less than that required for erosion protection (i.e., 5 ft thick as discussed in Section 8.5). A complete set of stability analyses was evaluated during preliminary design for all slope cross-sections for 2H:1V slopes with a 5 ft thick riprap layer. Pursuant to the results from preliminary project cost estimates, the final design slopes were steepened to 1.75H:1V. A discussion of stability analyses results for final design is presented in Section 8.7. Calculations supporting the stability analyses are included in Appendix M.

7.8 Preliminary Grading Plans

Preliminary grading plans for slope stabilization were made for 2H:1V slopes at both sites. Top of slope minimum setbacks from edge of pavement were established by MaineDOT in accordance with the criteria shown on Figure 19. Grading plans were developed to balance cut and fills assuming much of the excavated materials in crest and toe areas would be reused as fill below the riprap layer in mid-slope areas. Preliminary bendway weir layouts included nine weirs at Allagash and seven weirs at St. Francis as shown on the preliminary grading plans on Figures 20 and 21, respectively. To reduce riprap quantities and project costs, the design slopes were steepened to 1.75H:1V, typically by pulling the toe of the new slope back to the south (closer to Route 161) as shown on Figure 22. This grading change moved the toe of new slopes between 2 and 19 ft south of the locations based on 2H:1V slopes. This modification resulted in an imbalance of cut and fill quantities (cut excess) that was concluded to be an acceptable consequence of reducing riprap costs. Bendway weir sections and configurations were also revised to reduce riprap quantities.

8.0 DESIGN RECOMMENDATIONS

The design recommendations discussed herein are an extension and refinement of the basis of design evaluations discussed in Section 7 for the slope stabilization options selected by MaineDOT, and reflect the design presented in the final PDR-PIC plan set dated December 13, 2018. The findings from the evaluations indicate that velocities of the St. John River are higher at the St. Francis site than the Allagash site under Q_{100} flow conditions; however, erosion from ice attack, particularly during an ice jam release, likely represents the worst-case design conditions for sizing riprap armor, and the interpreted greater ice thickness at Allagash represents a more severe condition for design of riprap armor. Protection of the toe of riprap slopes against scour will be provided by a series of nine riprap bendway weir structures placed at each site. Bendway weir design details are discussed in Section 8.5.

8.1 Selected Stabilization Options

The slope stabilization work is planned to be similar at the St. Francis and Allagash sites and in general agreement with the stabilization Options 1b, 3a and 4 listed on Table 7-4. The final slopes will include riprap armored slopes at 1.75H:1V with a toe keyed into the river bed sediments for stability. A 5 foot thick layer of large sized riprap as described in Section 8.4 is planned to be placed from the base of the regraded slopes to the Q_{100} water level (with ice) determined from the hydraulic modeling (i.e., El 606 ft for Allagash and El 554 ft for St. Francis). A 4 ft thick layer of Heavy Riprap with rock sizes meeting MaineDOT 703.28 is planned to extend from the Q_{100} level to the crest of slopes at both sites to protect against ice attack from extreme events. A series of bendway weirs consisting of submerged low level rock dikes angled upstream to the direction of flow, will be placed at each site to prevent toe scour. The design includes reduced length bendway weirs that were extended upstream and downstream of the primary unstable slope areas to provide a transition for adjacent untreated slope areas.

8.2 Limits of Work

Slope erosion rates estimated from 2010 and 2016 MaineDOT survey data indicate the Allagash and St. Francis slopes are retreating horizontally towards Rt 161 at average rates of about 0.8 and 1.3 ft/ year, respectively. Communications with local residents suggest erosion rates could be higher. Considering these erosion rates and corresponding projected lateral retreat distances over time relative to a minimum 18 foot setback criteria from road centerline to the crest of the riverbank slope, project limits were compared for a 25 year and 50 year design life as shown on Figures 23 and 24. The 25 year period assumed a lateral retreat of about 20 ft and 28 ft at Allagash and St. Francis, respectively. Accounting for property acquisition issues, drainage features and culvert outfalls that would need to be included with the work, and cost considerations, a project limit of required slope stabilization was established for a 25 year erosion period. Transition zones ranging from about 130 ft to 220 ft were added to the upstream and downstream ends of the stabilized slope areas between the full riprap slope sections and the adjacent unprotected slopes. The resulting project lengths are about 1,300 ft at St. Francis and a 1,100 ft at Allagash.

8.3 Hydraulic Design Criteria

Hydraulic parameters selected for design were based on the TUFLOW model results presented in Appendix I and are summarized in Table 8-1. The hydraulic modeling data was augmented by the empirical reports of ice surfaces during the development of ice jams. Ice surfaces at each site used for design are also shown on Table 8-1 and assume the development of ice jams resulting in rapid river rise upstream of the ice jam.

Table 8-1: Hydraulic Parameters Used for Design

Item	Allagash	St. Francis
Q_{100} Velocity (water only)	7.5 fps	10.0 fps
Q_{100} Velocity (with ice)	3.9 fps	5.4 fps
Q_{100} WSE (no ice)	El 596	El 543
Q_{100} WSE (with ice)	El 606	El 554
Q_{100} Water Depth	17 ft	22 ft
Q_{100} Ice Surface (empirical reports)	El 625	El 562

8.4 Bendway Weir Design

Protection against toe bank erosion and channel scour migration (i.e., erosion processes Nos 5 and 6, respectively, shown on Figure 7-1) will be provided with a series of bendway weir structures connected to the riprap toe key and extending varied lengths into the river. The bendway weirs have three primary performance characteristics:

1) The combined placement of several bendway weirs (intended to perform as a group) will move the thalweg (i.e., the highest velocity flow-line where it may be located along the toe of the bank) off the slope toe such that it will generally follow along the tips of the structures.

2) The orientation of each weir structure assumes that as flows pass over the structure (regardless of approach angle) the departure angle is perpendicular to the longitudinal centerline of the structure. Structures are typically oriented slightly upstream relative to the shoreline to direct flows away from the slope.

3) The structures can encourage deposition of sediments (up to the top of the structures) in and around where they are placed and thereby act as local grade controls for newly deposited and existing native sediments along the toe of the slope.

The basis of design and preliminary design details for the bendway weirs are discussed in technical memoranda presented in Appendices K and L, respectively. Preliminary design work considered hydrology, 2D hydraulic modeling, and geomorphic performance (supported by design expertise and experience and modeling results) to support the development of preliminary bendway weir layouts. Continued project discussions and technical review made some adjustments to the structure layouts (following with the intended function and basis of design concepts) and supported development of bendway weir designs and layouts for the PDR-PIC plans. The resulting design package has a total of nine weir structures with site-specific spacing, structures dimensions, and configurations planned at each site. The preliminary layout of the weir structures relative to the proposed 1.75H:1V riprap slope grading plans are shown on Figures 25 and 26. Weir structures extend varying distances out into the St. John River ranging from about 30 ft to 90 ft at Allagash and about 50 ft to 100 ft at St. Francis. The weir design intends for the structures to be generally low to the bed elevation (top of weir maintained 2 ft above the bed recognizing the bed varies) and extending 4 ft (Allagash) to 6 ft (St. Francis) below the bed. The rock structures forming the weirs are mostly buried below the bed grades within the scour and erosion zone and only become “activated” when and where scour and erosion occurs that could threaten the slope.

The design includes an inverted trapezoid shape for the weir cross-section (i.e. wider at top than at bottom) in order to minimize excavation (i.e. typical trapezoidal shape that is wider at bottom than top would have require excavation to achieve full bottom width and then also require backfill with native to establish finished grades), plans for out-sloping structure geometry on up- and downstream edges that allows for practical excavation slope below water or in wet subgrade conditions (i.e. same excavation slope used as finished grade for installing rock materials), and assumes rock materials installed along up- and downstream edges of structure will “launch” into scour and erosion as it occurs in the future. The weirs will have a core section of riprap with a crest width of about 14 ft and a thickness of about 6 ft at Allagash. At St. Francis higher flow velocities require the weirs to be about 20 ft wide and 8 ft thick. The bendway weir riprap will be material sized to resist erosion from hydraulic flow and includes a minimum D_{50} of 9 inches (corresponding to MaineDOT 703.26 Plain Riprap) at Allagash and 24 inches (MaineDOT 703.28 Heavy Riprap) at St. Francis. Proposed bendway weir plan, profile and sections are shown on Sheets 5 through 10 of the final PDR-PIC drawings included in Appendix N. Specifications for the construction of the bendway weirs will be developed as a Special Provision during final design.

Long term performance (and maintenance) considerations for the weir structures include the following:

1) The structures are assumed and expected to take abuse and wear-and-tear from river flows, in fact this is the intended function of the structures, namely to move the wear-and-tear away from the toe of the bank and focus it on the installed bendway weirs. As such we expect scour and erosion to focus initially on the tips and along the downstream edge of the structures, and we expect that rock materials will shift or “launch” into scoured areas which may result in general changes in the installed structure(s) section, length and elevations. This typically occurs starting at the ends of the structures and moves back along the structure towards the bank.

2) Changes to the structures are expected and the proposed design configurations account for some loss of length and change in the installed rock materials. The expected changes in the length or configuration of the structure can be observed as rock materials launch into scoured areas during regular monitoring (either regular annual monitoring, and after large flood events).

3) The need for addressing or maintaining observed changes is a function of the resulting change in performance of the structures at the site-scale (i.e. not necessarily on single structures). Performance can be reviewed by assessing whether the structures are functioning as intended (refer to the design basis summary in Appendix L), and in particular by observing and confirming the flow-line resulting from the in-place structures as seen in the field (e.g. if there is enough reduction in length then the result will be a flow line that lands between that structure and the next downstream structure, such that erosion and scour is observed or would be expected to occur at or near the toe of the bank).

4) Generally, maintenance of installed structures is expected to be infrequent and would be limited to adding rock materials to restore the section, length, and elevation, or to address changes that result in targeted eroded areas. The expected frequency of maintenance based on Golder’s experience with similar projects is on a decadal scale, and only on an as-needed basis.

8.5 Riprap Size and Layer Thickness

As discussed in Section 7.6, design criteria for riprap rock size was evaluated considering criteria recommended by the USACE (EM-1601) based on river flow velocity and slope angle with adjustments for ice recommended by FHWA, and criteria based on CRREL scale model tests of ice action on riprap slopes where the ratio of rock size to ice thickness governed damage effects. To satisfy criteria recommended by the CRREL research, D_{100} rock sizes for 1.75H:1V slopes would need to be about 6.2 ft and 5.4 ft for Allagash and St. Francis, respectively. Based on MaineDOT’s discussions with local contractors in the project areas, D_{100} rock sizes at this scale are not locally available and the cost to transport larger rock from outside the region is not economically feasible. Accounting for the limitations of locally available maximum rock size, the EM-1601/FHWA criteria, and the observations of performance of existing riprap slopes on the St. John River in the area as described in Section 3.1 and Appendix B, we recommend the riprap design criteria presented in Table 8-2. Since the rock size is larger than the standard MaineDOT Heavy Riprap, a special provision will be prepared for Extra Heavy Riprap.

A typical slope cross section for the stabilized slope at each site is shown on Sheet 4 of the final PDR-PIC plans in Appendix N and includes a 5 ft thick layer of Extra Heavy Riprap located from the toe of the slope up to the 100 year water level (Q_{100}) elevation with ice for the St. John River at each site determined from hydraulic modeling. The Extra Heavy Riprap will be a Special Provision material, well-graded with a minimum D_{100} of 48 inches and a minimum D_{50} of 33 inches. Gradation and rock quality criteria for the Extra Heavy Riprap will be developed during final design for the Special Provision. Above the Q_{100} (with ice) elevation the slope will be covered with a 4 ft thick layer of Heavy Riprap (MaineDOT 703.28) overlain by a 1 ft layer of vegetative grubbing materials. A 1 ft layer of a granular cushion material overlying a filter geotextile will be placed under all slope riprap.

Table 8-2: Riprap Size Design Criteria

Site	Slope Angle	Channel Velocity	Rock Size Per EM-1601 with FS= 1.1 (no Ice) Per FHWA		Rock Size Per EM-1601 with FS= 2.0 (with Ice) Per FHWA		Recommended Design				
							Riprap Slope			Bendway Weirs	
		TUFLOW 2D (fps)	Min D_{50} (in)	Min Layer Thickness (>1,5 D_{50}) (in)	Min D_{50} (in)	Min Layer Thickness (>1,5 D_{50}) (in)	Min D_{50} (in)	Min D_{100} (in)	Layer Thickness (in)	Min D_{50} (in)	Min D_{100} (in)
Allagash	1.75H:1V	7.5	8	11	14	21	33	48	60	9	12
St. Francis	1.75H:1V	10.0	18	27	33	49	33	48	60	24	36

8.6 Slope Cross-Sections and Grades

The final slopes will include riprap armored slopes at 1.75H:1V with a toe keyed into the river bed sediments for stability. Plan views of the slope stabilization features and bendway weir layouts are shown on Sheets 7 through 10 of the final PDR-PIC plans included in Appendix N. Isopach maps showing the amounts and locations of cut and fill grading are shown on Figures 27 and 28. A typical slope cross section for the stabilized slope at each site is shown on Sheet 4 of the final PDR-PIC plans in Appendix N and includes a 5 ft thick layer of Extra Heavy Riprap located from the toe of the slope up to the Q_{100} water elevation with ice for the St. John River at each site determined from hydraulic modeling. The Extra Heavy Riprap will be a Special Provision material meeting the criteria discussed in Section 8.5. Above the Q_{100} (with ice) elevation the slope will be covered with a 4 ft thick layer of heavy riprap (MaineDOT 703.28) overlain by a 1 ft layer of vegetative grubbing materials. A 1 ft layer of a granular cushion material overlying a filter geotextile will be placed under all slope riprap. Due to the very large size of the Extra Heavy Riprap and the requisite strength needed for the filter geotextile, a Special Provision will be developed during final design for the geotextile.

Under riprap fill material between the existing native soils and the riprap armor layer will be comprised of compacted structural fill placed in horizontal lifts on benched excavations made into the native soil subgrade. The under riprap fill should consist of material meeting the requirements of Granular Borrow, Material for Underwater Backfill (MaineDOT 703.19), and should be compacted to at least 95 percent of its maximum dry density in accordance with AASHTO T-99. Quarry spalls from the riprap quarry source may also be suitable for use as under riprap fill, and acceptable gradation and quality requirements for quarry spalls should be assessed during final design. On-site native materials excavated from the slopes and at bendway weir locations during subgrade preparation will include a range of gradations and plasticity and will need to be classified for suitable reuse placement and application at specific “low risk” site areas Native glacial outwash and glacial till materials with water contents above the optimum water content at the time of excavation are considered unsuitable for reuse. Native glaciolacustrine silty clays (present only at St. Francis) are not suitable for reuse at any site area.

8.7 Slope Stability

Global stability analyses for final design were completed for four representative cross-sections at each site located as shown on Figures 27 and 28. Each section included the design cut and fill thicknesses for 1.75H:1V design slopes reflected in the isopach maps shown on Figures 27 and 28 for the final grading plans incorporating the design riprap slope profiles shown on Sheet 4 of the final PDR-PIC plans included in Appendix N. Typical SLIDE profiles for Allagash and St. Francis slopes are shown on Figures 29 and 30 showing stratigraphy, soil parameters and water level assumptions used in the analyses. A summary of calculated FS's for the eight cross-sections and two loading conditions analyzed is shown on Table 4 at the end of this report. The results indicate FS's ranging between 1.25 and 1.40 for the rapid drawdown loading condition (versus a target minimum FS of 1.1) and FS's ranging between 1.30 and 1.43 (versus a 1.30 for the steady state seepage/post-construction loading conditions. Calculations for the stability analyses for all cases analyzed are presented in Appendix M.

8.8 Culvert Downspouts and Stone Ditches

Three existing culverts at Allagash and two at St. Francis drain roadside ditches towards the river. These culverts will all be replaced as part of this work but will continue to drain onto the face of the slope. At Allagash drainage from the three culverts has all caused significant erosion which has been repaired in the past by dumping heavy riprap over the edge although due to the slope height the riprap did not extend to the bottom of the slope. At St. Francis similar erosion has occurred, with a short channel having been constructed at some point on the west end to convey water from the culvert outlet to the slope face and has subsequently eroded.

As shown on Sheet 3 in Appendix N, part of the proposed work at each culvert location includes a 2 ft wide downspout in the face of the slope. The proposed replacement culverts will remain in their existing locations and the culvert will be extended as needed to reach the new downspouts. These downspouts are slightly inset to form a defined channel down the slope as well as to offer limited protection to the culvert outlet during extreme flood events. The slope riprap already exceeds the size needed for the flow from the culverts however the riprap located in the downspouts will be chinked with quarry spalls to help define the channel. Additionally, a second layer of contrasting color geotextile, Special Provision (Geotextile for Downspout) will be included below the typical black geotextile used elsewhere. This contrasting color helps during future inspections of the slope since if it is visible the primary geotextile has been compromised and erosion of fines below the riprap is possible.

The eroded channel on the west end of the St. Francis site at Sta 4+70 will be backfilled up to the elevation of the culvert outlet and a new stone lined ditch will be installed at a 2% slope to direct water towards the riprap slope. The downspout in this location is slightly wider at 3 ft.

9.0 ESTIMATED MATERIAL QUANTITIES

Material quantities for the stabilization project were estimated for each site by the design team based in part on the design criteria presented herein and the PDR-PIC plans in Appendix N. A summary of material quantities and estimated costs is included in the PDR. The estimated riprap quantities include 24,600 cubic yards (cy) of Extra Heavy Riprap, 9,700 cy of Heavy Riprap, and 1,925 cy of Plain Riprap.

10.0 CONSTRUCTION AND MAINTENANCE CONSIDERATIONS

10.1 Construction

Requirements for stabilization in place are driven by the need to resist high erosion forces generated by the river at the toe of the slopes and by ice blocks that can attack nearly the full height of the slopes. The proposed riprap and bendway weir design is a reliable and effective stabilization option; however, construction will be challenging and will need to account for the following:

Access to Base of Slopes

- Access to the base of slopes at both sites is required for construction equipment for subgrade excavations, bendway weir construction and bottom-up riprap slope construction. Temporary roads to the base of the slopes will be required for the excavation equipment, removal of excavated material and delivery of riprap and under-riprap fill materials.
- Temporary road access may be available at St. Francis during low flow river conditions via a downstream boat ramp. Mobilization to the project site would be required along dry riverbed materials along the base of slopes between the ramp and the project site. This access would likely be available only during low flow conditions in the river. Temporary access to the property along the base of slopes between the ramp and the project site would need to be secured, and the stability of the riverbed materials to support construction equipment would need to be assessed.
- If access via the boat ramp at St. Francis is not available, a temporary road will likely need to be installed diagonally cross-slope. The roadway would likely need to be constructed mostly with fill due to the steep existing slopes. Road stability and impacts on selected upper slope areas with stable vegetative growth intended to remain will need to be considered.
- At Allagash, access along the river bed via upstream toe of slope sections may be feasible under low flow river conditions; however, a temporary roadway installed diagonally cross-slope will likely be required. Considering the steep existing slopes the temporary roadway will likely need to be constructed mostly with fill. Temporary access road stability and impacts on upper slope areas with stable vegetative growth intended to remain will need to be considered.
- At Allagash a temporary fill platform at the base of the slope will be required for equipment to operate in the dry.

Low Flow River Level Conditions Required for Segments of Work

- Low flow river conditions will facilitate, and in some cases be required, for construction of bendway weirs, the riprap toe key at the base of slopes, the lower portions of the riprap slopes and placement of geotextiles in the dry.
- During low flow levels we expect much of the toe of slope work at the St. Francis site can be performed in the dry. At Allagash the low flow river levels will always be above toe of slope grades.
- Typical low flow levels occur from July to October at both sites, however, temporary rises in river levels up to roughly 3 to 5 ft due to periods of high or prolonged rainfall events during these periods is not uncommon.

Riprap Toe Key at Base of Slope Excavations

- Excavations for the riprap toe key and placement of geotextile, aggregate cushion and Extra Heavy Riprap at the base of the slopes should be performed in the dry. Cofferdams may not be required for this work at St. Francis depending on river levels during construction, but we expect cofferdams will be required for this work at Allagash.
- Toe of slope excavations should be performed in segments of limited length and duration prior to toe key riprap placement to maintain global slope stability. Preliminary criteria includes limiting such toe of slope excavations to 75 ft in length and for no more than 48 hours before backfilling with toe key riprap.

Construction phase stability analyses may be warranted during PS&E to confirm this criteria and/or identify selected site areas where it applies, i.e., where the excavations are in close proximity to the toe of the existing slope.

Bendway Weir In-River Excavations

- Construction of bendway weir structures can be constructed in the wet. Cofferdams will be required at each site to preclude the occurrence of flowing water at the bendway weir excavation areas; however, the subgrade areas inside the cofferdams do not need to be dewatered to construct the bendway weirs. The weir design is an inverted trapezoid shape (i.e., wider at top than at bottom) in order to minimize excavation quantities and allow for practical excavation slope angles below water or in wet subgrade conditions, and assumes rock materials installed along up- and downstream edges of structures will “launch” into scour and erosion as it occurs in the future.

Material Delivery to Slopes and Stockpiles

- Temporary access roads to base of slopes will be required for delivery of riprap for bendway weirs and riprap and under riprap fill for lower slope construction at minimum. Material delivery and placement to upper slope areas could conceivably be provided via stable upper slope access roads or with cranes set back sufficient distance from the crest of the slope to maintain slope stability.

- Stockpiling of riprap, under-riprap fill, aggregate cushion material and excavated soils should not be allowed within the slope crest areas shown on the plans.

Benching, Slope Subgrade Preparation and Material Reuse

- All stabilized slope subgrade areas should be stripped of vegetation, excavated to the required subgrade, and benched with excavated steps in accordance with MaineDOT Specifications. Bench widths should be sufficient to allow the required compaction of the overlying fill materials. Bench heights will vary depending on the subgrade slope angle and localized stability requirements.

- Materials excavated within the area of regraded stabilized slopes will be more predominant at the base and upper portions of the existing slopes, but nonetheless are expected to include a mix of all of the native soil deposits discussed in Section 5.0 including: alluvium, colluvium, glacial outwash, glacial steam deposits, glacial till and lacustrine silty clay (at St. Francis only). Representative grain size distributions for these materials are shown on Figures 11 and 12. The lacustrine silty clays are not suitable for reuse for any of the new construction and should be removed from the site. The suitability for reuse of the other excavated native soils materials will depend on the amount of fines present and the in-situ moisture content, and will need to be assessed based on conditions encountered during construction. More detailed criteria for acceptance can be developed during PS&E.

- Seepage encountered during subgrade preparation and benching will need to be collected and discharged to the base of the slope areas in a controlled manner. As discussed in Section 5 stabilized groundwater levels measured at Allagash were about 45 ft below the top of the slope and are not expected to present seepage concerns on the slope face during construction. However, at St. Francis a perched water level was encountered about 20 ft below the top of the slope above the lacustrine silty clay layer. We expect seepage at this level will be encountered during construction and will need to be properly collected and discharged to the base of the slope within drainage downspouts.

Construction Observations

Key aspects of the construction warranting monitoring and observation by qualified geotechnical personnel include:

- Quarry operations producing the Extra Heavy Riprap
- Extra Heavy Riprap gradations and rock quality
- Riprap toe key excavations
- Bendway weir construction
- Subgrade benching and geotextile placement
- Reuse of excavated materials
- Placement and compaction of under riprap fill
- Disturbance of stable vegetation at crest and upper slope areas

10.2 Long Term Maintenance

The long-term performance of the riprap slopes will primarily be governed by the occurrence of ice jams and the related erosion from accumulated ice during rapid flows following an ice jam break. Damaging ice erosion is expected to be infrequent, but unpredictable, and it is possible for large ice formations to develop that could erode portions of the slope during an ice jam break event. The slopes should be inspected after any ice jam break event that could impact the slopes. Routine annual monitoring is recommended to confirm the stability of the slopes and drainage structures.

The long-term performance of bendway weirs should be regularly monitored (annually and after large flood events), and they are not expected to require frequent maintenance. The structures are expected to take abuse and wear-and-tear from river flows; this is the intended function of the weirs, namely to move erosive forces from the toe of the slope and focus them on the installed structures (instead of the toe of the slope). Scour and erosion are expected to occur initially at and around the tips and along the downstream edges of the structures, and the rock materials are expected to shift or “launch” into scoured areas which may result in general changes in the installed structure(s) section, length and elevations. The progression of erosion typically starts at the weir tips and moves back along the structure toward the slope. Changes to the structure with time are expected and the proposed design accounts for some loss of length and change in configuration. Maintenance of the structures is not required after every occurrence of observed change at one or more structures. The need for maintenance is a function of the resulting change in performance of the structures at the site-scale, to meet the original intended design intent; performance can be reviewed by assessing whether the structures are functioning as intended, and in particular whether the river flow-line resulting from the structures is allowing erosion and/or scour to approach the toe of the slope. Maintenance is expected to be infrequent and typically limited to adding rock materials to restore the structure design dimensions (for example restore structure section, length, or elevation), or to address changes that result in targeted eroded areas. Maintenance should be needed only on an as-needed basis and is expected to be on a decadal frequency scale.

The risks of ongoing scour, erosion and threats to public safety are considered higher for the St. Francis site than the Allagash site. While the 2010 to 2016 survey data indicates erosion rates are similar at both sites, the St.

Francis site has current slope failure headscarps at the edge of pavement in some areas, the slope faces have much larger unvegetated areas with exposed soils (i.e., more easily erodible), and the river water velocities are higher.

11.0 CLOSING AND LIMITATIONS

This report was prepared for the exclusive use of MaineDOT for specific application to the proposed mitigation design for the two Route 161 slopes in St. Francis and Allagash, Maine in accordance with generally accepted soil and foundation geotechnical engineering and geologic practices exercised in this geographical area and under similar time and financial constraints. Golder makes no other warranty, either express or implied. In the event that any changes in the nature, design or location of the proposed project are planned, Golder should be notified to review the appropriateness of our conclusions and recommendations, and to modify the recommendations as appropriate to reflect the changes in design. In addition, Golder should review the final plans and specifications to evaluate compliance with these recommendations.

Our analyses, and recommendations are based, in part, on information obtained from the referenced subsurface explorations and geologic mapping completed at the discrete locations described in the report. Readers of this report should make their own interpretation of the results of the subsurface investigations, geologic mapping and laboratory testing. Variations in the nature and extent of subsurface conditions between explorations should be expected. Golder should be notified if conditions encountered during construction vary from those described in this report so that we may re-evaluate, and if necessary, revise the recommendations made in this report.

The professional services provided by Golder for this project include only the geotechnical and geologic aspects of the surface and subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this report and have not been investigated or addressed.

TABLES

Table 1: Dynamic Cone Penetrometer (DCP) Testing Results
Geotechnical and Hydrotechnical Slope Stabilization Evaluation
State Route 161 Unstable Slopes Adjacent to the St. John River
Allagash and St. Francis, Maine
WIN 17236.00

Exploration ID	Station[(1)] (ft.)	Offset (ft.)	Blows	Penetration (mm)	DCP Penetration Index (mm/blow)	Cumulative Penetration (ft)	Calculated SPT N Value[(2)]	Average Calculated SPT N Value[(3)]
DCP-ALLA-1	9+59	17.17 RT	5	215	43	0.7	14.5	20
			5	101	20	1.0	21.1	
			5	70	14	1.3	25.3	
DCP-ALLA-1b	9+59	17.17 RT	5	187	37	0.6	15.6	17
			5	141	28	1.1	17.9	
			5	80	16	1.3	23.7	27
			5	82	16	1.6	23.4	
			5	42	8	1.7	32.5	
			5	57	11	1.9	28.0	
			5	63	13	2.1	26.6	23
			5	94	19	2.4	21.8	
			5	104	21	2.8	20.8	
DCP-ALLA-2	10+90	109.39 RT	5	232	46	0.8	14.0	16
			5	140	28	1.2	18.0	
			5	117	23	1.6	19.6	31
			5	35	7	1.7	35.5	
			5	40	8	1.9	33.3	
			5	36	7	2.0	35.1	
			5	46	9	2.1	31.1	33
			5	33	7	2.2	36.6	
			5	46	9	2.4	31.1	
DCP-ALLA-3	7+20	90.08 RT	5	218	44	0.7	14.4	28
			5	38	8	0.8	34.1	
			5	36	7	1.0	35.1	
			5	64	13	1.2	26.4	25
			5	121	24	1.6	19.3	
			5	62	12	1.8	26.8	
			5	65	13	2.0	26.2	
			5	54	11	2.2	28.7	28
			5	32	6	2.3	37.1	
			5	78	16	2.5	24.0	
			5	89	18	2.8	22.4	
DCP-ALLA-4	4+65	94.74 RT	5	156	31	0.5	17.0	20
			5	83	17	0.8	23.2	
			5	100	20	1.1	21.2	22
			5	115	23	1.5	19.8	
			5	74	15	1.7	24.6	
			5	85	17	2.0	23.0	
			5	93	19	2.3	22.0	27
			5	56	11	2.5	28.2	
			5	47	9	2.7	30.7	
			5	63	13	2.9	26.6	
DCP-STFR-1	12+09	10.96 RT	5	128	26	0.4	18.8	24
			5	71	14	0.7	25.1	
			5	59	12	0.8	27.5	
			5	69	14	1.1	25.4	

Table 1: Dynamic Cone Penetrometer (DCP) Testing Results
Geotechnical and Hydrotechnical Slope Stabilization Evaluation
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Exploration ID	Station(1) (ft.)	Offset (ft.)	Blows	Penetration (mm)	DCP Penetration Index (mm/blow)	Cumulative Penetration (ft)	Calculated SPT N Value(2)	Average Calculated SPT N Value(3)
DCP-STFR-2	12+17	116.62 RT	5	228	46	0.7	14.1	17
			5	134	27	1.2	18.3	
			5	126	25	1.6	18.9	
DCP-STFR-3	10+33	105.98 RT	5	139	28	0.5	18.0	20
			5	105	21	0.8	20.7	
			5	90	18	1.1	22.3	
			5	92	18	1.4	22.1	23
			5	79	16	1.7	23.8	
			5	82	16	1.9	23.4	
DCP-STFR-4	9+13	94.68 RT	5	120	24	0.4	19.4	23
			5	55	11	0.6	28.4	
			5	73	15	0.8	24.7	
			5	102	20	1.1	21.0	
			5	97	19	1.5	21.5	21
			5	106	21	1.8	20.6	
			5	93	19	2.1	22.0	
DCP-STFR-5	9+13	51.88 RT	5	111	22	0.4	20.1	22
			5	106	21	0.7	20.6	
			5	76	15	1.0	24.3	
			5	75	15	1.2	24.4	25
			5	70	14	1.4	25.3	
			5	82	16	1.7	23.4	
			5	64	13	1.9	26.4	
DCP-STFR-6	8+75	66.59 RT	5	261	52	0.9	13.2	13
			5	162	32	1.4	16.7	20
			5	114	23	1.8	19.9	
			5	90	18	2.1	22.3	
DCP-STFR-7	4+70	78.8 RT	5	126	25	0.4	18.9	24
			5	52	10	0.6	29.2	
			5	70	14	0.8	25.3	
			5	94	19	1.1	21.8	28
			5	67	13	1.3	25.8	
			5	55	11	1.5	28.4	
			5	51	10	1.7	29.5	
			5	48	10	1.8	30.4	
			5	50	10	2.0	29.8	
			5	52	10	2.2	29.2	

Notes:

1) Location of DCP locations were surveyed by MaineDOT in October 2016 and are shown on Figures 7 & 8.

2) DCP Penetration Index correlated to SPT N-value using Figure 11 in the MinnesotaDOT User Guide to the Dynamic Cone Penetrometer (1996). This value was then converted from the SPT mm/blow value to N-value by dividing 305mm(1ft) by the SPT mm/blow value.

3) The average calculated SPT N value is an average of the calculated SPT N values over approximately 1 ft of penetration.

Prepared By:	LLM
Checked By:	JRS
Reviewed By:	JDL

Table 2: Test Boring Summary
Geotechnical and Hydrotechnical Slope Stabilization Evaluation
State Route 161 Unstable Slopes Adjacent to the St. John River
Allagash and St. Francis, Maine
WIN 17236.00

Test Boring Designation[1,2,3]	As-Drilled Locations[4]		Existing Ground Surface Elevation[4] (feet)	Boring Depth[5] (feet)	Stratigraphy Thicknesses[6]						Completion Date
	Station (ft.)	Offset (ft.)			Roadway/ Fill	Upper Glaciofluvial Deposit	Glaciolacustrine Deposit	Lower Glaciofluvial Deposit	Ablation Till	Basal Till	
HB-ALLA-101	5+86	7.00 RT	627.5	57.0	6.0	12.0	Not Identified	Not Identified	39.0	Not Identified	7/23/2014
HB-ALLA-201	4+60	7.40 RT	628.91	52.0	5.0	17.5	Not Present	Not Present	29.5	Not Present	9/20/2016
HB-ALLA-202	7+17	8.12 RT	627.87	82.0	5.0	38.0	Not Present	Not Present	18.0	21.0	9/21/2016
HB-ALLA-203	9+59	17.17 RT	626.73	52.0	Not Present	28.3	Not Present	Not Present	23.7	Not Present	9/21/2016
HB-ALLA-204	9+33	16.47 LT	627.26	41.0	Not Present	29.0	Not Present	Not Present	12.0	Not Present	9/21/2016
HB-STFR-101	7+19	10.1 RT	526.3	36.0	2.0	11.0	Not Identified	Not Identified	23.0	Not Identified	7/24/2014
HB-STFR-201	4+61	5.79 RT	559.75	61.0	5.0	10.0	11.4	32.6	2.0	Not Present	9/22/2016
HB-STFR-202	9+04	13.17 LT	563.57	71.0	5.0	17.0	23.0	8.0	11.0	7.0	9/28/2016
HB-STFR-203	12+09	10.96 RT	562.86	72.0	5.0	21.0	4.0	Not Present	6.0	36.0	9/28/2016
HB-STFR-204	10+43	8.16 RT	564.01	50.0	5.5	19.5	11.7	Not Present	13.3	Not Present	9/22/2016

Notes:

1. Test boring locations are shown in Figures 7 and 8.
2. Borings HB-STFR-101 and HB-ALLA-101 were performed by MaineDOT. Golder was not onsite during driling and did not observe or log the borings.
3. Borings HB-STFR-201 to HB-STFR-204 and HB-ALLA-201 to HB-ALLA-204 were perfomed by New England Boring Contractors and MaineDOT and were observed and logged by Golder.
4. As-drilled locations and elevations from MaineDOT survey data dated October 2016.
5. Depth below ground surface.
6. Stratigraphic units shown as "Not Present" were not encountered in the boring. Units shown as "Not Identified" may be present in the boring but were not sampled or logged.
7. Boring logs presented in Appendix E.

Prepared By: LLM
Checked By: JRS
Reviewed By: MSP

Table 3: Soil Laboratory Testing Results
Geotechnical and Hydrotechnical Slope Stabilization Evaluation
State Route 161 Unstable Slopes Adjacent to the St. John River
Allagash and St. Francis, Maine
WIN 17236.00

Boring Information				Sample Information						Laboratory Testing Results and Classification								
																Classification		
Test Boring Designation[1]	Station (feet)	Offset (feet)	Elevation[2] (feet)	Sample Number	Pen./Rec. (in.)	Sample Depth Below Ground Surface (ft)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-Uncorrected	N_{60}	Liquid Limit @ 25 Blows (T 89), %	Plastic Limit (T 90), %	Plaxticity Index (T 90), %	Specific Gravity, Corrected to 20°C (T 100)	Water Content (T 265), %	Fines Content (T 27, T 11), %	USCS[3,4]	AASHTO[3,4]	Frost
HB-ALLA-101	5+86	7.00 RT	627.50	1D	24 / 17	5.0 - 6.0	12/11/8/7	19	27					3.8	13.1	SM	A-1-b	
				1DA		6.0 - 7.0							2.76	22.4	57.2	CL-ML	A-4	
				2D	24 / 19	10.0 - 12.0	10/10/10/12	20	29					6.7	17.6	SM	A-1-b	
				3D	24 / 14	14.0 - 16.0	6/7/6/7	13	19					16.1	17.9	SM	A-2-4	
				4D	24 / 14	19.0 - 21.0	36/22/20/22	52	75					10.0	15.3	GM	A-1-b	
				5D	24 / 15	24.0 - 26.0	15/21/25/22	46	66					10.8	15.1	SM	A-1-b	
				6D	24 / 16	29.0 - 31.0	21/15/15/16	30	43					8.7	14.4	GM	A-1-a	
				7D	24 / 17	34.0 - 36.0	15/17/22/22	39	56					8.1	12.3	GM	A-1-a	
				8D	24 / 16	39.0 - 41.0	20/21/21/23	42	61					12.0	14.7	SM	A-1-b	
				9D	24 / 15	44.0 - 46.0	25/16/19/21	35	51					9.2	13.6	SM	A-1-a	
				10D	24 / 13	49.0 - 51.0	16/16/16/16	32	46					9.8	16.8	GC	A-1-b	
				11D	24 / 18	55.0 - 57.0	13/13/20/19	33	48					11.7	11.6	GW-GM	A-1-a	
HB-ALLA-201	4+60	7.40 RT	628.91	1D	24 / 16	1.0 - 3.0	7/23/26/29	49	77									
				2D	24 / 21	5.0 - 7.0	15/14/15/16	29	46									
				3D	24 / 21	9.0 - 11.0	13/11/10/8	21	33					9.7	9.9	SW-SM	A-1-a	0
				4D	24 / 13	14.0 - 16.0	10/7/10/8	17	27									
				5DA	24 / 17	19.0 - 21.0	7/7/6/6	13	20				2.62	24.1	95.4	CL	A-4	IV
				6D	24 / 14	24.0 - 26.0	25/26/25/25	51	80	21	18	3	2.60	21.3	98.1	ML	A-4	IV
				7D	24 / 14	29.0 - 31.0	29/31/37/31	68	107									
				8D	24 / 15	34.0 - 36.0	24/34/42/28	76	119					7.8	12.3	GW-GM	A-1-a	0
				9D	24 / 14	39.0 - 41.0	19/23/24/26	47	74									
				MD	6 / 0	44.0 - 44.5	70/6"											
				10D	24 / 14	50.0 - 52.0	21/17/14/16	31	49									
HB-ALLA-202	7+17	8.12 RT	627.87	1D	24 / 14.5	1.0 - 3.0	8/13/15/23	28	27									
				2D	24 / 13	5.0 - 7.0	12/18/17/24	35	33									
				3D	24 / 11	10.0 - 12.0	12/12/9/12	21	20					13.8	14.4	SM	A-1-b	II
				4D	24 / 11	15.0 - 17.0	11/19/39/15	58	55									
				5D	24 / 11	20.0 - 22.0	17/22/28/23	50	47					5.6	6.9	GW-GM	A-1-a	0
				6D		25.0 - 27.0	20/23/25/21	55	52									
				7D	24 / 11	30.0 - 32.0	14/21/19/15	40	38					20.8	9.7	GW-GM	A-1-a	0
				8D	24 / 9.5	35.0 - 37.0	15/21/15/11	36	34									
				9D	24 / 11	40.0 - 42.0	17/15/16/17	31	29					17.3	16.5	SM	A-2-4	II
				10D	24 / 9	45.0 - 47.0	22/43/32/30	75	71									
				11D	24 / 13	50.0 - 52.0	35/24/26/36	50	47				2.67	10.4	15.5	SC-SM	A-1-b	II
				12DB	24 / 13	55.0 - 57.0	25/40/40/35	80	76				2.70	11.6	46.9	SC-SM	A-4	IV
				13D	24 / 15	60.0 - 62.0	32/38/27/28	65	62									
				14D	13.5 / 10	65.0 - 66.1	39/50/50/1.5"	R				NP	2.65	15.7	77.7	ML	A-4	IV
				15D	3 / 3	70.0 - 70.3	50/3"	R										
				16D	3 / 3	75.0 - 75.3	50/3"	R										
				17D	4 / 2	80.0 - 80.3	55/4"	R										
HB-ALLA-203	9+59	17.17 RT	626.73	1D	24 / 16	0.0 - 2.0	2/2/7/7	9	14									
				2D	24 / 16	5.0 - 7.0	2/5/7/11	12	19				2.66	8.6	20.7	SC-SM	A-1-b	II
				3D	24 / 18	10.0 - 12.0	14/24/23/35	47	74									
				4D	24 / 20	14.0 - 16.0	8/8/13/20	21	33									
				5D	24 / 12	19.0 - 21.0	10/11/11/9	22	35					9.5	11.6	SW-SM	A-1-a	0
				6D	24 / 15	24.0 - 26.0	14/14/11/11	25	39									
				7D	24 / 17	29.0 - 31.0	12/13/20/24	33	52									
				8D	24 / 12	34.0 - 36.0	22/35/31/30	66	104									
				9D	24 / 13	39.0 - 41.0	11/22/20/20	42	66				2.65	10.1	18.5	SC-SM	A-1-b	II
				10D	24 / 17	44.0 - 46.0	14/17/17/15	34	53									
HB-ALLA-204	9+33	16.47 LT	627.26	1D	24 / 16	0.0 - 2.0	7/11/11/10	22	35									
				2D	24 / 14	5.0 - 7.0	13/9/13/14	22	35					4.6	10.8	SW-SM	A-1-b	0
				3D	24 / 18	10.0 - 12.0	15/16/25/25	41	64									
				4D	24 / 17	14.0 - 16.0	10/16/21/22	37	58									
				5D	24 / 13	19.0 - 21.0	18/11/9/8	20	31					10.5	6.7	SW-SM	A-1-a	0
				6D	24 / 15	24.0 - 26.0	15/18/29/23	47	74									
				7D	24 / 16	29.0 - 31.0	9/10/14/12	24	38									
				8D	24 / 18	34.0 - 36.0	18/21/31/48	52	82				2.71	7.6	41.8	SC-SM	A-4	III
				9D	24 / 14	39.0 - 41.0	11/22/30/66	52	82									

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Boring Information				Sample Information						Laboratory Testing Results and Classification									
																Classification		
Test Boring Designation[1]	Station (feet)	Offset (feet)	Elevation[2] (feet)	Sample Number	Pen./Rec. (in.)	Sample Depth Below Ground Surface (ft)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-Uncorrected	N_{60}	Liquid Limit @ 25 Blows (T 89), %	Plastic Limit (T 90), %	Plaxticity Index (T 90), %	Specific Gravity, Corrected to 20°C (T 100)	Water Content (T 265), %	Fines Content (T 27, T 11), %	USCS[3,4]	AASHTO[3,4]	Frost
HB-STFR-101	7+19	10.10 RT	526.3	1D	24 / 18	5.0 - 7.0	10/11/15/12	26	38					3.8	8.3	SW-SM	A-1-b	
				2D	24 / 19	10.0 - 12.0	15/26/27/22	53	77					9.0	10.1	SW-SM	A-1-b	
				3D	24 / 18	14.0 - 16.0	21/22/19/14	41	59					11.0	10.0	GW-GM	A-1-a	
				4D	24 / 17	19.0 - 21.0	11/15/17/23	32	46					10.6	22.1	SM	A-2-4	
				5D	24 / 16	24.0 - 26.0	16/15/12/15	27	39					11.3	9.4	SW-SM	A-1-b	
				6D	24 / 16	29.0 - 31.0	13/10/11/13	21	30					11.8	10.1	SW-SM	A-1-a	
				7D	24 / 15	34.0 - 36.0	8/9/9/11	18	26					13.2	7.1	SW-SM	A-1-a	
HB-STFR-201	4+61	5.79 RT	559.75	1D	24 / 20	1.0 - 3.0	6/6/4/5	10	16									
				2D	24 / 17	5.0 - 7.0	2/3/5/16	8	13					8.9	15.5	SM	A-2-4	II
				3D	24 / 16	10.0 - 12.0	10/22/21/60	43	68									
				4D	24 / 20	15.0 - 17.0	5/10/8/01	18	28				2.67	16.7	99.2	CL	A-4	IV
				5D	24 / 18	19.0 - 21.0	8/8/11/9	19	30									
				6D	24 / 20	24.0 - 26.0	7/5/3/4	8	13									
				V1														
				7D	24 / 15	29.0 - 31.0	10/11/11/13	22	35									
				8D	24 / 16	34.0 - 36.0	10/12/14/17	26	41					13.3	10.3	SW-SM	A-1-a	0
				9D	24 / 13	39.0 - 41.0	11/13/12/10	25	39									
				10D	24 / 14	44.0 - 46.0	11/13/15/13	28	44									
				11D	24 / 15	49.0 - 51.0	12/13/14/17	27	42									
				12D	24 / 12	54.0 - 56.0	14/18/13/18	21	33									
				13D	24 / 17	59.0 - 61.0	14/16/15/18	31	49					11.8	7.0	SW-SM	A-1-a	0
HB-STFR-202	9+04	13.17 LT	563.57	1D	24 / 17	0.0 - 2.0	15/16/11/10	27	42									
				2D	24 / 18	5.0 - 7.0	10/15/14/15	29	46					1.9	9.4	SW-SM	A-1-a	0
				3D	24 / 19	10.0 - 12.0	11/39/32/27	71	112									
				4D	24 / 14	14.0 - 16.0	13/12/9/12	21	33									
				5D	24 / 1	19.0 - 21.0	22/32/30/27	62	97									
				V1/6D	24 / 19	24.0 - 26.0	5/8/7/9	15	24	21	19	2	2.69	18.9	95.0	ML	A-4	IV
				7D	24 / 20	29.0 - 31.0	9/8/10/11	18	28									
				8D	24 / 20	34.0 - 36.0	7/10/10/11	20	31				2.66	20.4	98.9	ML	A-4	IV
				9D	24 / 21	39.0 - 41.0	5/6/7/11	13	20									
				10D	24 / 13	45.0 - 47.0	8/15/16/14	31	39					10.8	9.8	SW-SM	A-1-a	0
				11D	24 / 11	49.0 - 51.0	9/9/9/10	18	28									
				12D	24 / 12	54.0 - 56.0	6/7/9/13/	16	25									
				13D	24 / 14	59.0 - 61.0	6/13/16/12	29	46				2.69	8.9	35.8	SC-SM	A-2-4	III
				14D	12 / 12	64.0 - 65.0	65/56	R										
				15D	24 / 14	69.0 - 71.0	23/29/35/43	64	101					7.5	35.4	SM	A-2-4	II
HB-STFR-203	12+09	10.96 RT	562.86	1D	24 / 16	0.0 - 2.0	9/19/17/16	36	34									
				2D	24 / 16	5.0 - 7.0	7/13/21/23	34	32					1.9	12.5	SM	A-1-b	II
				3D	24 / 20	10.0 - 12.0	18/15/10/12	25	24									
				4D	24 / 9.5	15.0 - 17.0	11/19/21/19	40	38				2.65	6.0	12.2	SC-SM	A-1-b	II
				5D	24 / 3	20.0 - 22.0	16/14/15/20	29	28									
				6DB	24 / 15	25.0 - 27.0	14/9/4/9	13	12	23	22	1	2.62	21.7	95.7	ML	A-4	IV
				7D	24 / 11	30.0 - 32.0	19/19/19/16	36	34				2.70	9.3	32.0	SC-SM	A-2-4	III
				8D	7 / 6	35.0 - 27.0	34/(50/1")	R										
				9D	24 / 16	40.0 - 42.0	20/31/31/42	62	59									
				10D	24 / 19	45.0 - 47.0	26/38/44/54	82	78				2.71	8.2	44.7	SC-SM	A-4	III
				11D	24 / 19	50.0 - 52.0	31/31/42/46	73	69									
				12D	24 / 14	55.0 - 56.5	24/42/53	R						6.9	43.8	SM	A-4	III
				13D	6 / 5	60.0 - 60.5	53	R										
				14D	3 / 3	65.0 - 65.3	50	R										
				15D	4 / 4	70.0 - 70.3	50/4"	R										
HB-STFR-204	10+43	8.16 RT	564.01	1D	24 / 11	1.0 - 3.0	14/42/22/8	64	61									
				2D	24 / 17	5.0 - 7.0	20/21/20/22	41	39									
				3D	24 / 20	10.0 - 12.0	21/27/32/32	59	56									
				4D	24 / 12	15.0 - 17.0	12/20/53/20	73	69				2.68	8.6	11.2	SW-SC	A-1-a	0
				5D	24 / 1	19.0 - 21.0	21/36/19/17	55	52									
				6D	24 / 16	25.0 - 27.0	7/8/9/11	17	16				2.64	20.5	32.9	SC-SM	A-2-4	III
				7DB	24 / 20	27.0 - 29.0	10/7/8/12	15	14	26	20	6	2.76	25.6	96.9	CL-ML	A-4	IV
				8D	24 / 23	30.0 - 32.0	6/10/11/13	21	20									
				MV1	24 / 24	32.0 - 34.0	9/15/16/20	31	29	26	23	3	2.76	14.6	99.6	ML	A-4	IV
				9D	20 / 11	40.0 - 41.7	13/16/16/(50/4")	32	30				2.65	8.0	35.1	SC-SM	A-2-4	III
				10D	24 / 11	45.0 - 47.0	20/27/24/21	51	48					8.7	40.3	SM	A-4	III

Notes:
1. Test boring locations are shown in Figures 7 and 8
2. As-drilled elevations are derived from MaineDOT survey data dated October 2016 and based on NAVD88.
3. AASHTO and USCS symbols assigned based on interpretation of laboratory test results.
4. Complete laboratory test results for soil testing are provided in Appendix F.

Prepared By:	LLM
Checked By:	JRS
Reviewed By:	MSP

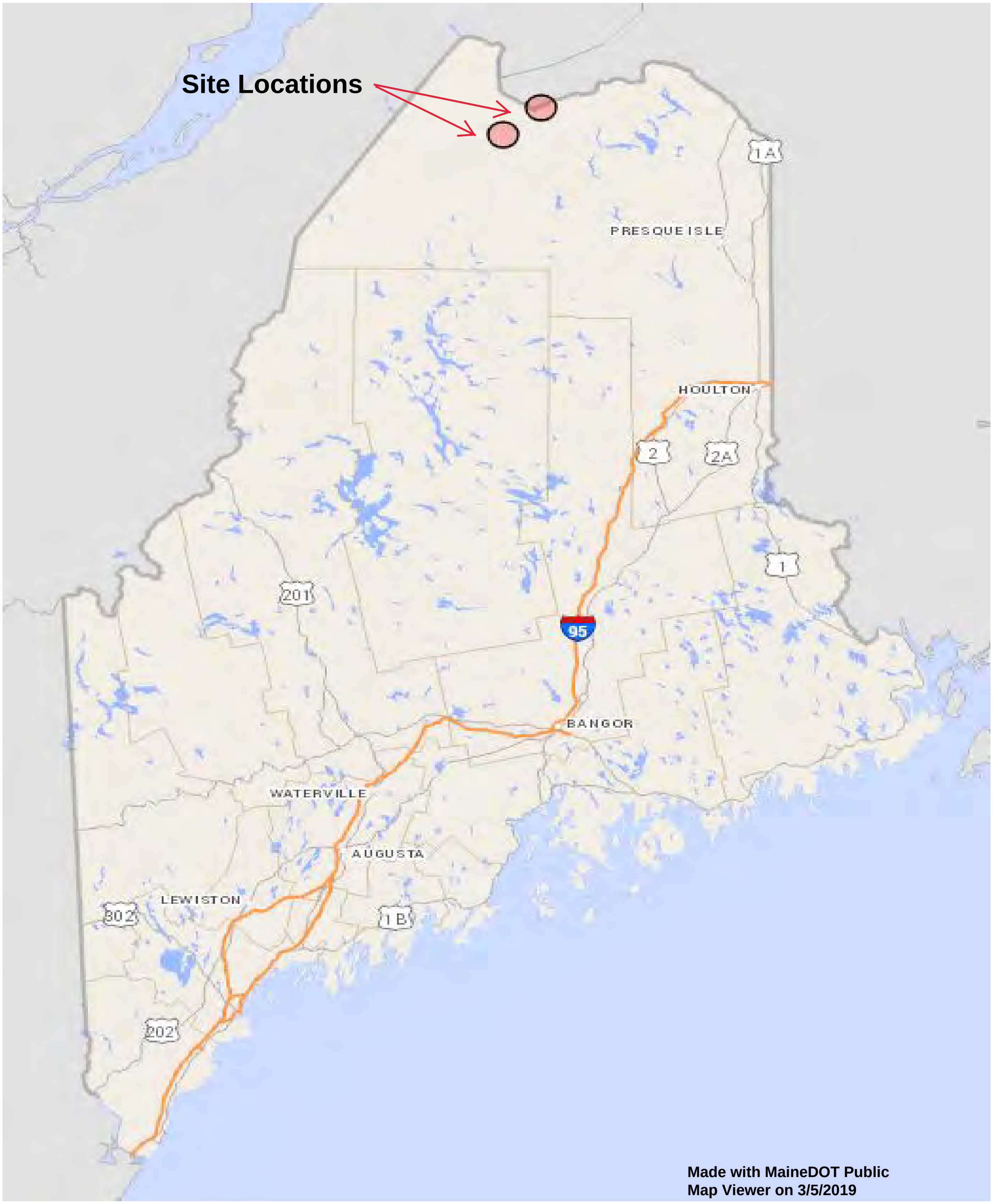
Table 4: Slope Stability Analysis Summary
Geotechnical and Hydrotechnical Slope Stabilization Evaluation
State Route 161 Unstable Slopes Adjacent to the St. John River
Allagash and St. Francis, Maine
WIN 17236.00

Site	Slide Figure No.[1]	Section[2]	Station[3]	GW Case[4]	FS[5]
Allagash	AL-1	2	107+88	Rapid Drawdown	1.29
	AL-2			Steady State	1.34
	AL-3	5	109+38	Rapid Drawdown	1.30
	AL-4			Steady State	1.33
	AL-5	9	111+38	Rapid Drawdown	1.29
	AL-6			Steady State	1.33
	AL-7	11	112+38	Rapid Drawdown	1.30
	AL-8			Steady State	1.30
St. Francis	SF-1	2	5+78	Rapid Drawdown	1.30
	SF-2			Steady State	1.30
	SF-3	8	8+78	Rapid Drawdown	1.40
	SF-4			Steady State	1.40
	SF-5	13	11+28	Rapid Drawdown	1.26
	SF-6			Steady State	1.34
	SF-7	17	13+78	Rapid Drawdown	1.25
	SF-8			Steady State	1.43

Notes:
1. Slope stability calculations are presented in Appendix M.
2. Slide figures are presented in Appendix M.
3. Stability section locations are shown on Figures 7 and 8.
4. GW Case = Assumed groundwater condition.
5. FS = Calculated Factor of Safety for the slip surface shown on the slide figure.

Prepared By: SKB
Checked By: CJS
Reviewed By: MSP

FIGURES



Made with MaineDOT Public
Map Viewer on 3/5/2019

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MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

YYYY-MM-DD	**2019-03-05**
DESIGNED	**CJS**
PREPARED	**CJS**
REVIEWED	**MSP**
APPROVED	**MSP**

TITLE
Site Location (State Level)

PROJECT NO.	PHASE	FIGURE
165-9907		1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

1 in

0

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STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT

GOLDER

YYYY-MM-DD	**2019-03-04**
DESIGNED	**CJS**
PREPARED	**CJS**
REVIEWED	**MSP**
APPROVED	**MSP**

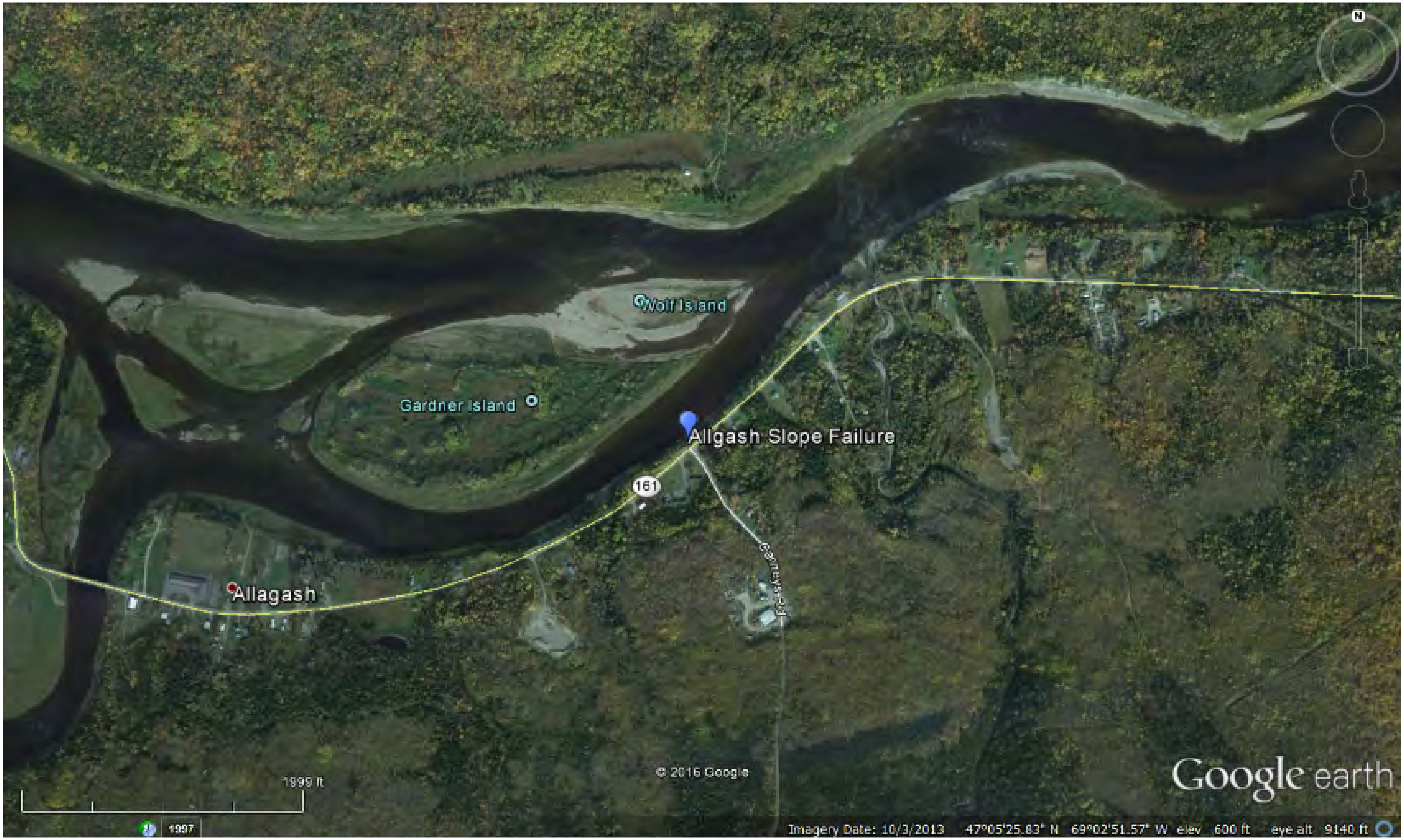
TITLE

Site Locations

PROJECT NO. 165-9907

PHASE

FIGURE 2



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PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT

GOLDER

YYYY-MM-DD	**2019-03-08**
DESIGNED	**CKS**
PREPARED	**SKB**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE

Allagash Site Location

PROJECT NO.	PHASE	FIGURE
165-9907		3

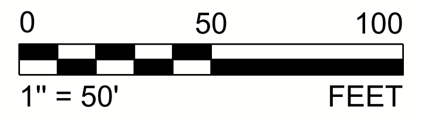
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

1 in

0

REFERENCE(S)

1. BASE MAP PROVIDED BY MAINEDOT ELECTRONIC FILE TITLED "ALLAGASH ALIGNMENT 1723600.DGN" DATED 10/27/2016.



A	2019-03-15	DESCRIPTION	CJS	MPB	JDL	MSP
REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED

SEAL

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AUGUSTA, MAINE 04333-0016

CONSULTANT
GOLDER

Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

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STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST. FRANCIS, MAINE WIN 17236.00

TITLE
ALLAGASH PLAN VIEW

PROJECT NO.	REV.	of	FIGURE
165-9907	----		4

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GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
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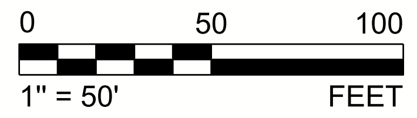
YYYY-MM-DD	**2019-03-08**
DESIGNED	**CKS**
PREPARED	**SKB**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE
St. Francis Site Location

PROJECT NO.	PHASE	FIGURE
165-9907		5

REFERENCE(S)

1. BASE MAP PROVIDED BY MAINEDOT ELECTRONIC FILE TITLED "ALLAGASH ALIGNMENT 1723600.DGN" DATED 10/27/2016.



A	2019-03-15	DESCRIPTION	CJS	MPB	JDL	MSP
REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED

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CONSULTANT

GOLDER

Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

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STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST. FRANCIS, MAINE WIN 17236.00

TITLE
ST. FRANCIS PLAN VIEW

PROJECT NO.	REV.	of	FIGURE
165-9907	----		6

LEGEND

○	HB-ALLA-203	TEST BORING LOCATION
△	DCP-ALLA-2	DYNAMIC CONE PENETROMETER (DCP) TEST LOCATION
⊞	ALLA-STAFF	STAFF GAUGE LOCATION

REFERENCE(S)

1. BASE MAP PROVIDED BY MAINEDOT ELECTRONIC FILE TITLED "ALLAGASH ALIGNMENT 1723600.DGN" DATED 10/27/2016.

0 50 100
1" = 50' FEET

A	2019-03-15	DESCRIPTION	CJS	MPB	JDL	MSP
REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED

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CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

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GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILITY EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST. FRANCIS, MAINE WIN 17236.00

TITLE
ALLAGASH - EXPLORATION LOCATIONS

PROJECT NO. 165-9907
REV. ----
of
FIGURE 7

Path: \\manchester\cadd\MaineDOT\Allagash River\99_PROJECTS\1659907_AllagashSlopeStabilization\SlopeRepair\02_PRODUCTION\DWG\001_Allagash\ | File Name: 1659907_001_011.dwg | Last Edited By: mboisvert Date: 2019-03-15 Time:3:56:10 PM | Printed By: mboisvert Date: 2019-03-28 Time:2:25:05 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
0
1 in

LEGEND

○ HB-STFR-203	TEST BORING LOCATION
△ DCP-STFR-2	DYNAMIC CONE PENETROMETER (DCP) TEST LOCATION
⊞ STFR-STAFF	STAFF GAUGE LOCATION
● CL-STFR-1	CLAY OUTCROP LOCATION (2016)
⊛ SEEP-STFR-1	OBSERVED SEEP LOCATION (2016)

REFERENCE(S)

1. BASE MAP PROVIDED BY MAINEDOT ELECTRONIC FILE TITLED "ALLAGASH ALIGNMENT 1723600.DGN" DATED 10/27/2016.

0 30 60
1" = 30' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2019-03-15	DESCRIPTION	CJS	MPB	JDL	MSP

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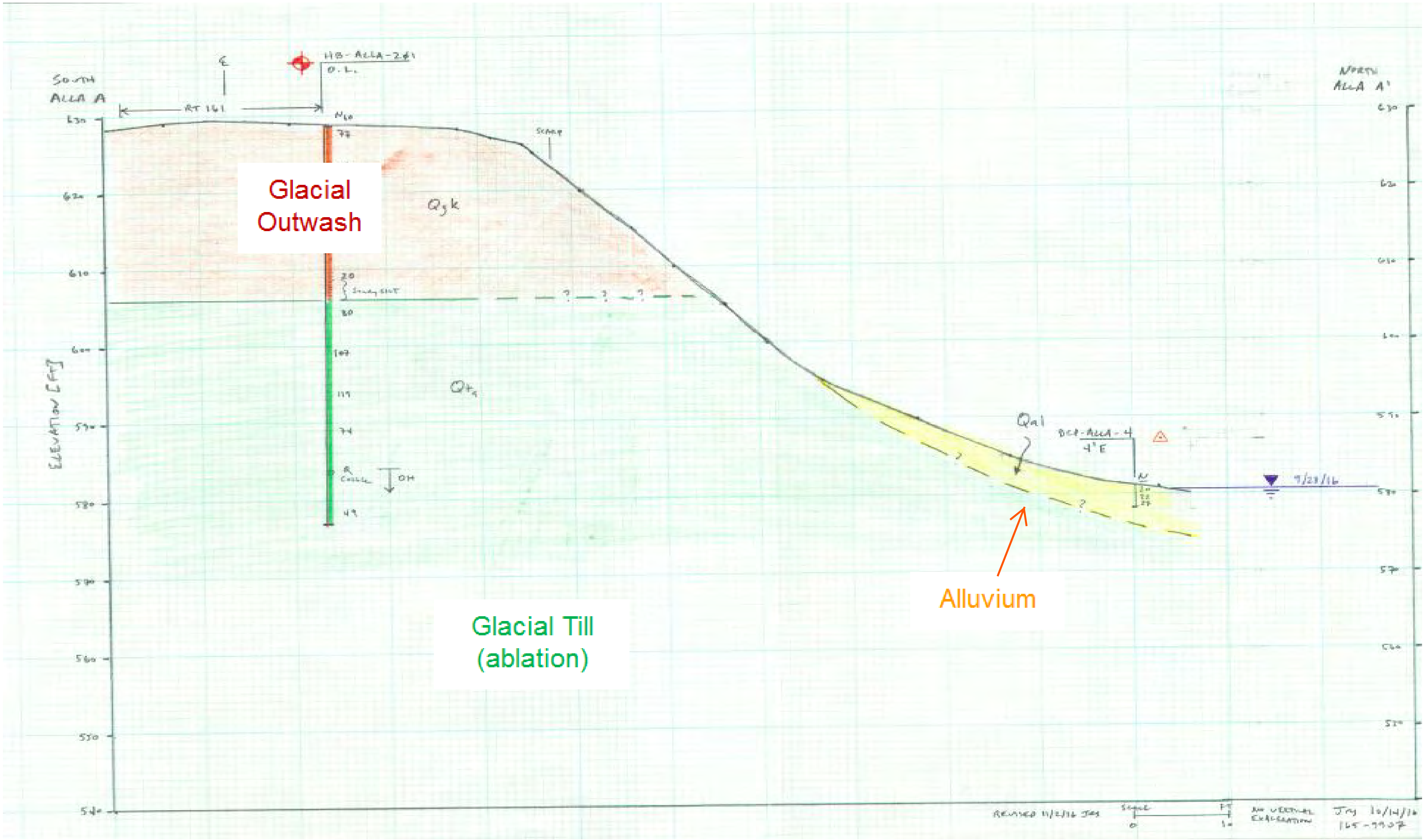
AUGUSTA, MAINE 04333-0016

CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILITY EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST. FRANCIS, MAINE WIN 17236.00

TITLE
ST. FRANCIS - EXPLORATION LOCATIONS

PROJECT NO. 165-9907
REV. ----
of
FIGURE 8



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STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
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CONSULTANT

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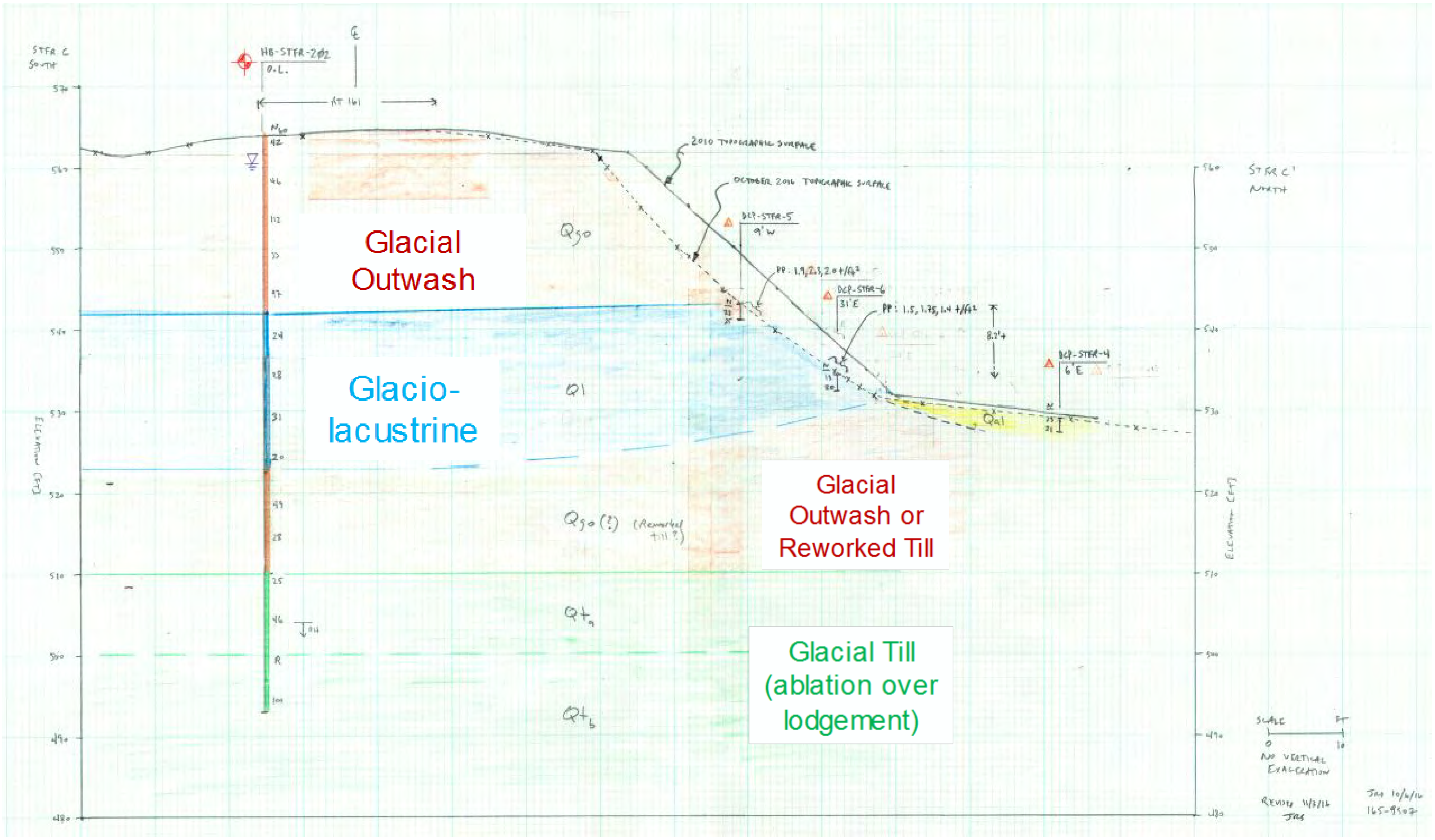
DESIGNED	**CJS**
PREPARED	**CJS**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE

Allagash Subsurface Profile A-A'

PROJECT NO.	PHASE	FIGURE
165-9907		9



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GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
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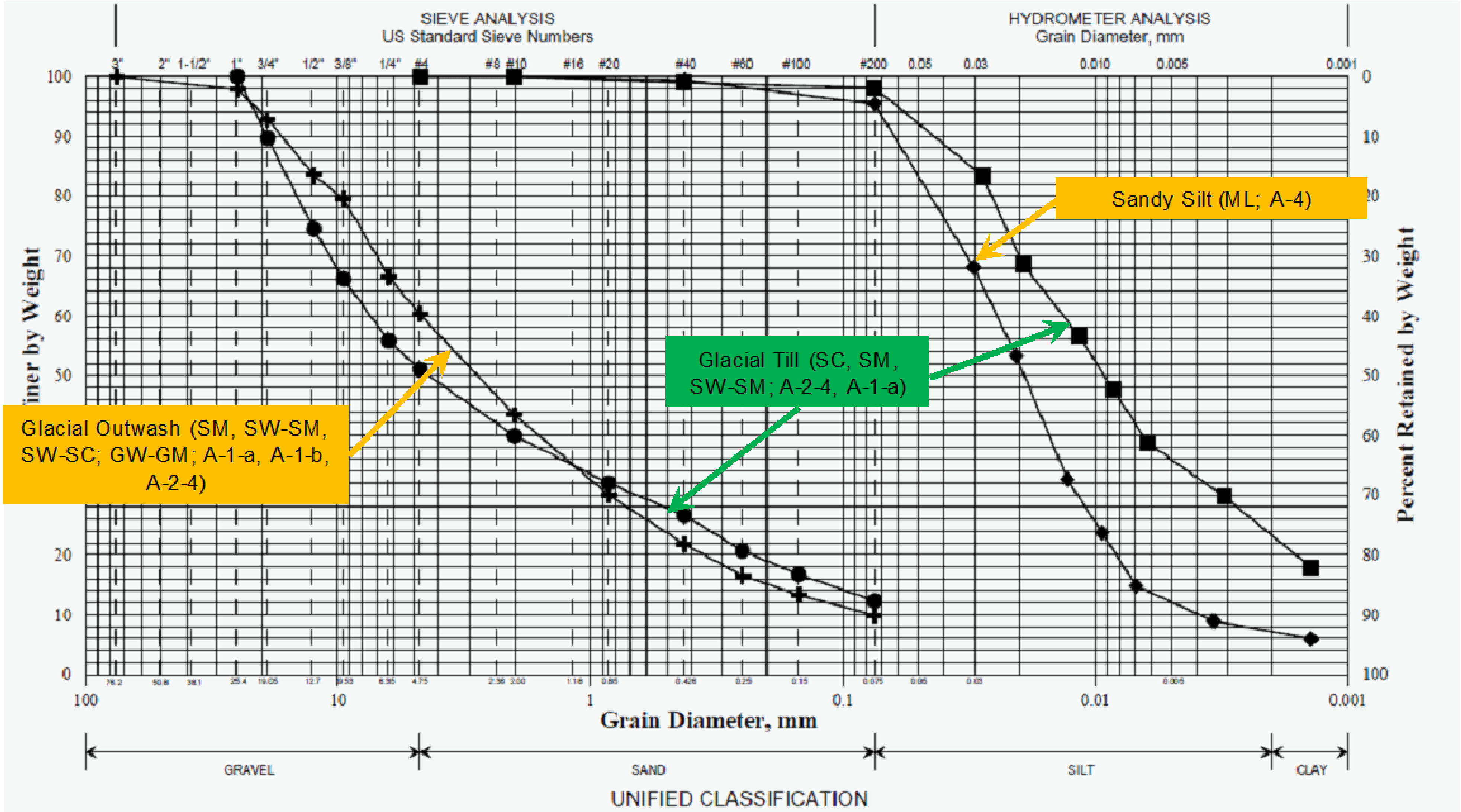
YYYY-MM-DD	**2019-03-04**
DESIGNED	**CJS**
PREPARED	**CJS**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE

St. Francis Subsurface Profile C-C'

PROJECT NO.	PHASE	FIGURE
165-9907		**10**



Sandy Silt (ML; A-4)

Glacial Till (SC, SM, SW-SM; A-2-4, A-1-a)

Glacial Outwash (SM, SW-SM, SW-SC; GW-GM; A-1-a, A-1-b, A-2-4)

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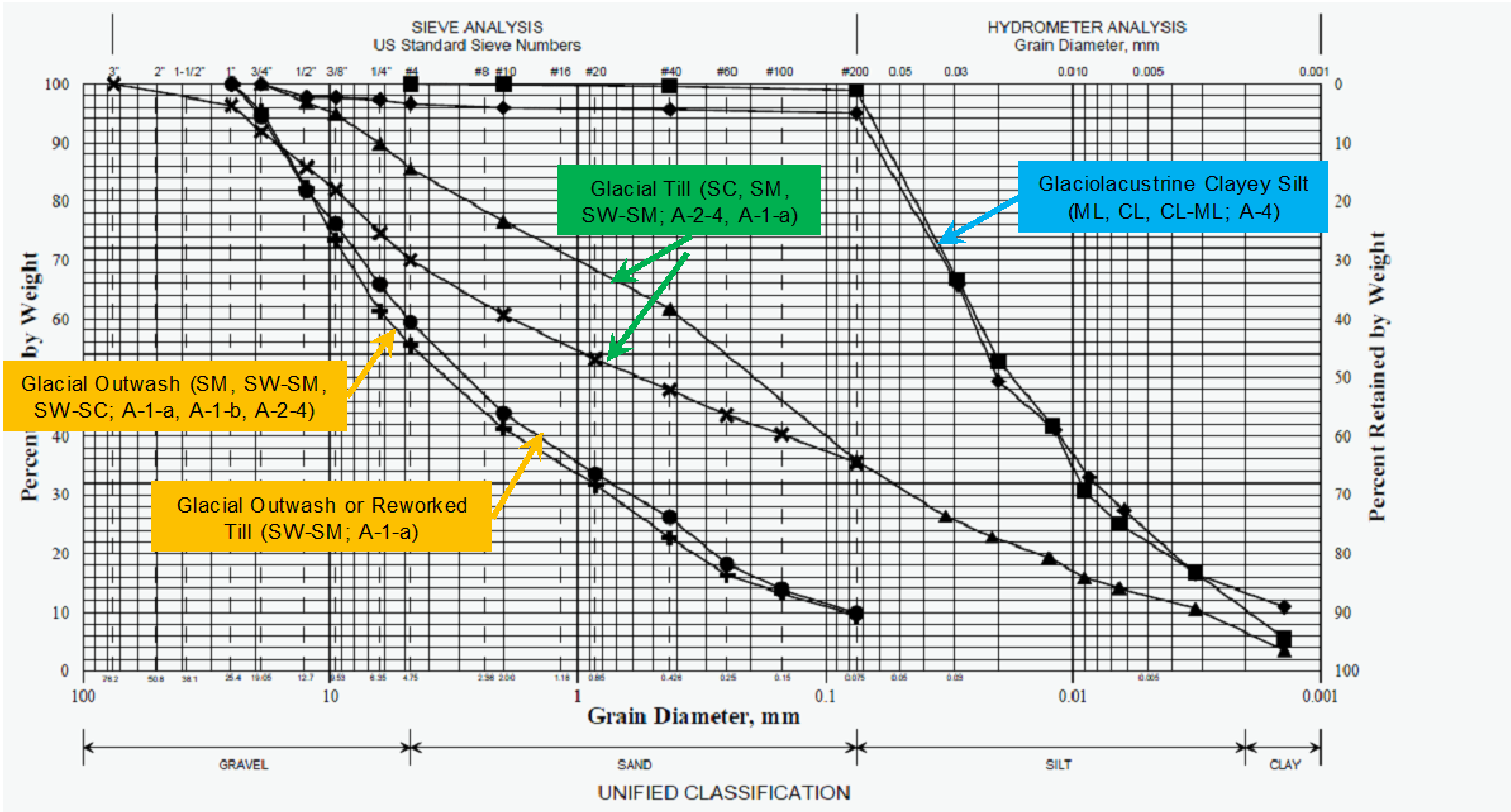
YYYY-MM-DD	**2019-03-04**
DESIGNED	**CJS**
PREPARED	**CJS**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE

Allagash - Typical Grain Size Curves

PROJECT NO. 165-9907
PHASE
FIGURE 11



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AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

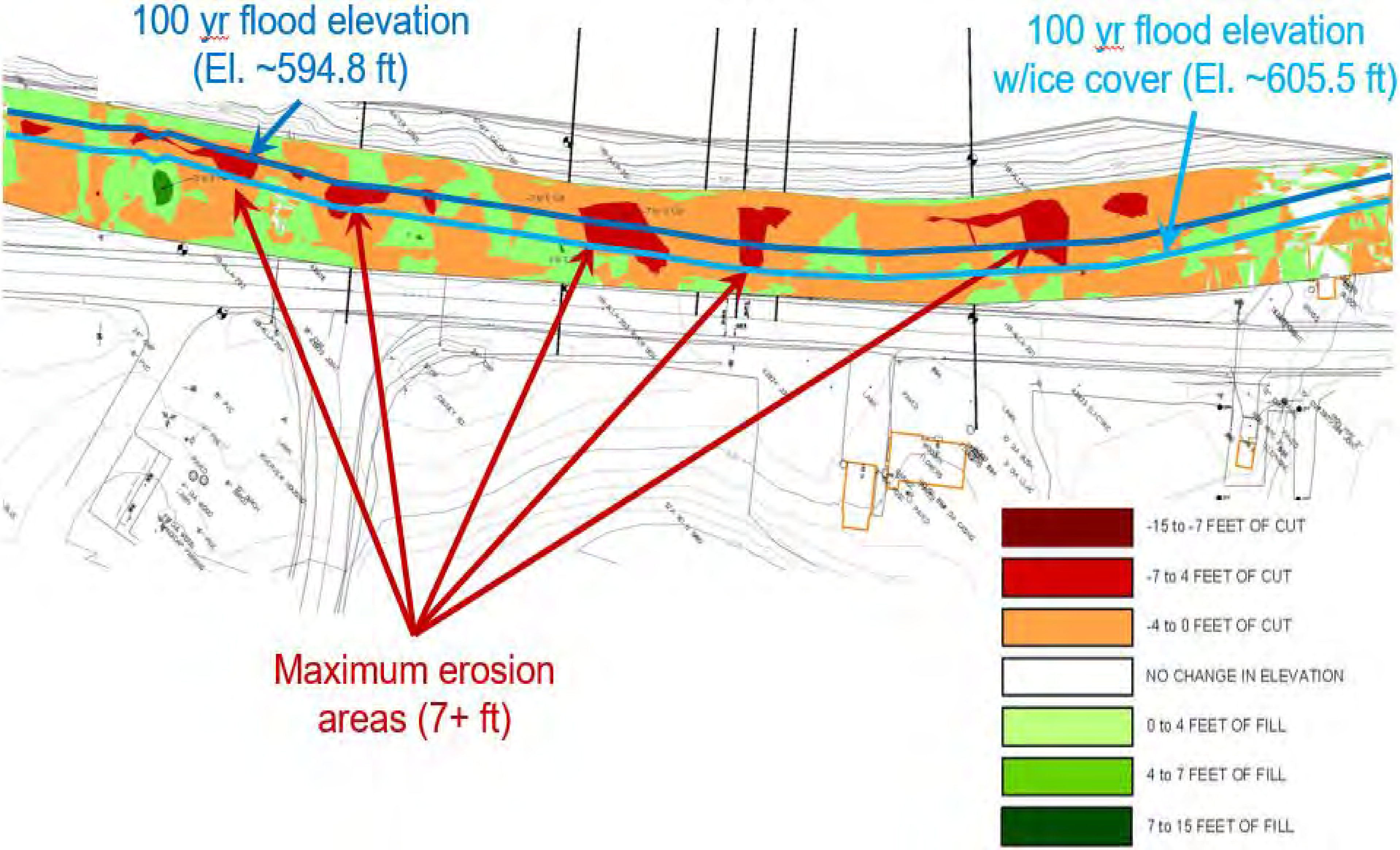
CONSULTANT

GOLDER

YYYY-MM-DD	**2019-03-04**
DESIGNED	**CJS**
PREPARED	**CJS**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE
St. Francis - Typical Grain Size Curves

PROJECT NO.	PHASE	FIGURE
165-9907		12



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16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

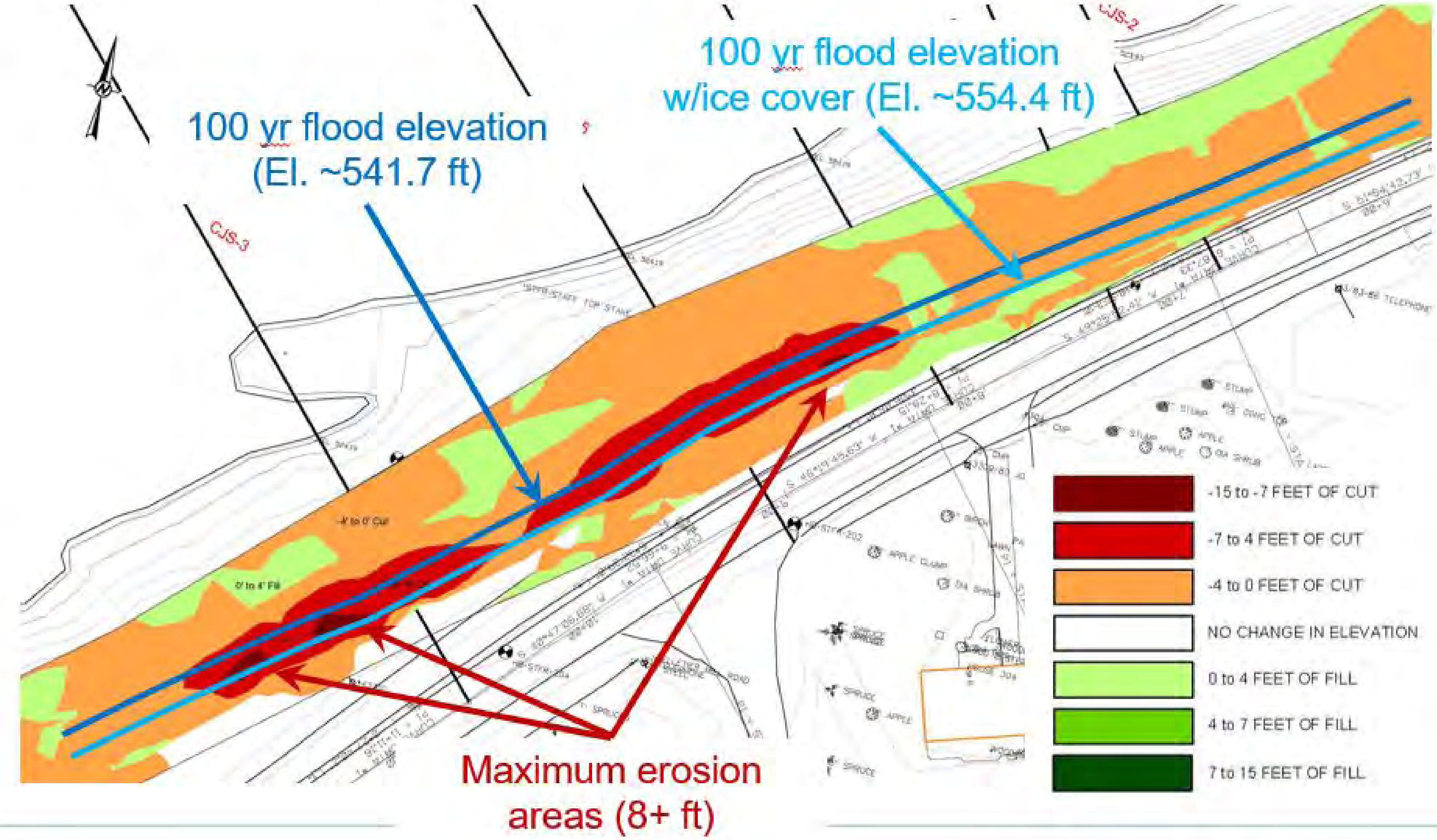
PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

YYYY-MM-DD	**2019-03-04**
DESIGNED	**CJS**
PREPARED	**CJS**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE
Allagash-Plan View of Measured Erosion 2010-2016

PROJECT NO.	PHASE	FIGURE
165-9907		**13**



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MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

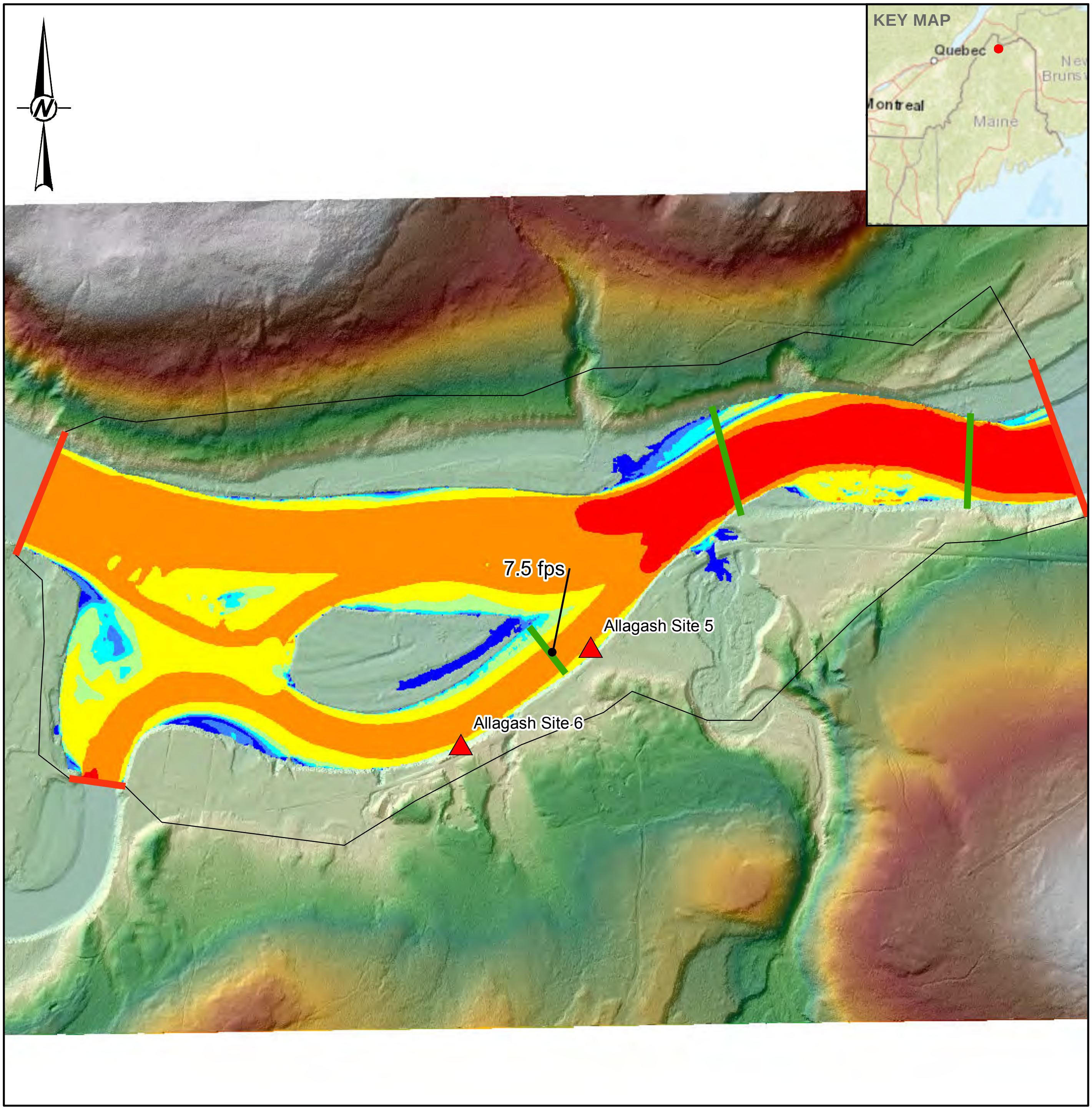
PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

YYYY-MM-DD	**2019-03-04**
DESIGNED	**CJS**
PREPARED	**SKB**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE
St. Francis - Plan View of Measured
Erosion 2010-2016

PROJECT NO.	PHASE	FIGURE
165-9907		**14**



LEGEND

🟥 Boundary Condition
🟩 Surveyed cross-sections
☐ Model Domain

Velocity (fps)

🟦 0.00 to 0.20
🟦 0.20 to 0.50
🟦 0.50 to 1.00
🟩 1.00 to 2.00
🟨 2.00 to 5.00
🟧 5.00 to 10.00
🟥 10.00 to 20.00

0 400 800 1,600
Feet

REFERENCE(S)
1. HYDRAULIC MODEL SETUP AND RESULTS IS FROM GOLDER BASED ON TUFLOW.
2. DIGITAL ELEVATION MODEL (DEM) IS FROM 2009 FEDERAL EMERGENCY MANAGEMENT AGENCY TOPOGRAPHIC LIDAR: FORT KENT, MAINE.
3. SUPPLEMENTAL BATHYMETRY IS BASED ON FROM MAINE DEPARTMENT OF TRANSPORTATION SURVEY OF THREE CROSS-SECTION, 10/2016.
4. COORDINATE SYSTEM: NAD 1983 MAINE 2000 CENTRAL ZONE FOOT US
5. SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, USGS, INTERMAP, IPC, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI (THAILAND), TOMTOM, 2013

CLIENT
MAINE DOT

PROJECT
EVALUATION AND STABILIZATION OF UNSTABLE SLOPES
STATE ROUTE 161, ST. FRANCIS AND ALLAGASH, MAINE

TITLE
2D MODELING RESULTS - VELOCITY
100-YEAR EVENT (NO ICE)
ALLAGASH SITE

CONSULTANT

GOLDER

YYYY-MM-DD	2019-03-12
DESIGNED	SJS
PREPARED	SJS
REVIEWED	AQK
APPROVED	AQK

PROJECT NO.	PHASE	REV.	FIGURE
1659907	004	0	**15**

PATH: G:\MaineDOT\Allagash\99_PROJECTS\1659907_Allagash\02_PRODUCTION\MXD\FIGURES\Rev0\1659907_004_TUFLOW_Allagash.mxd

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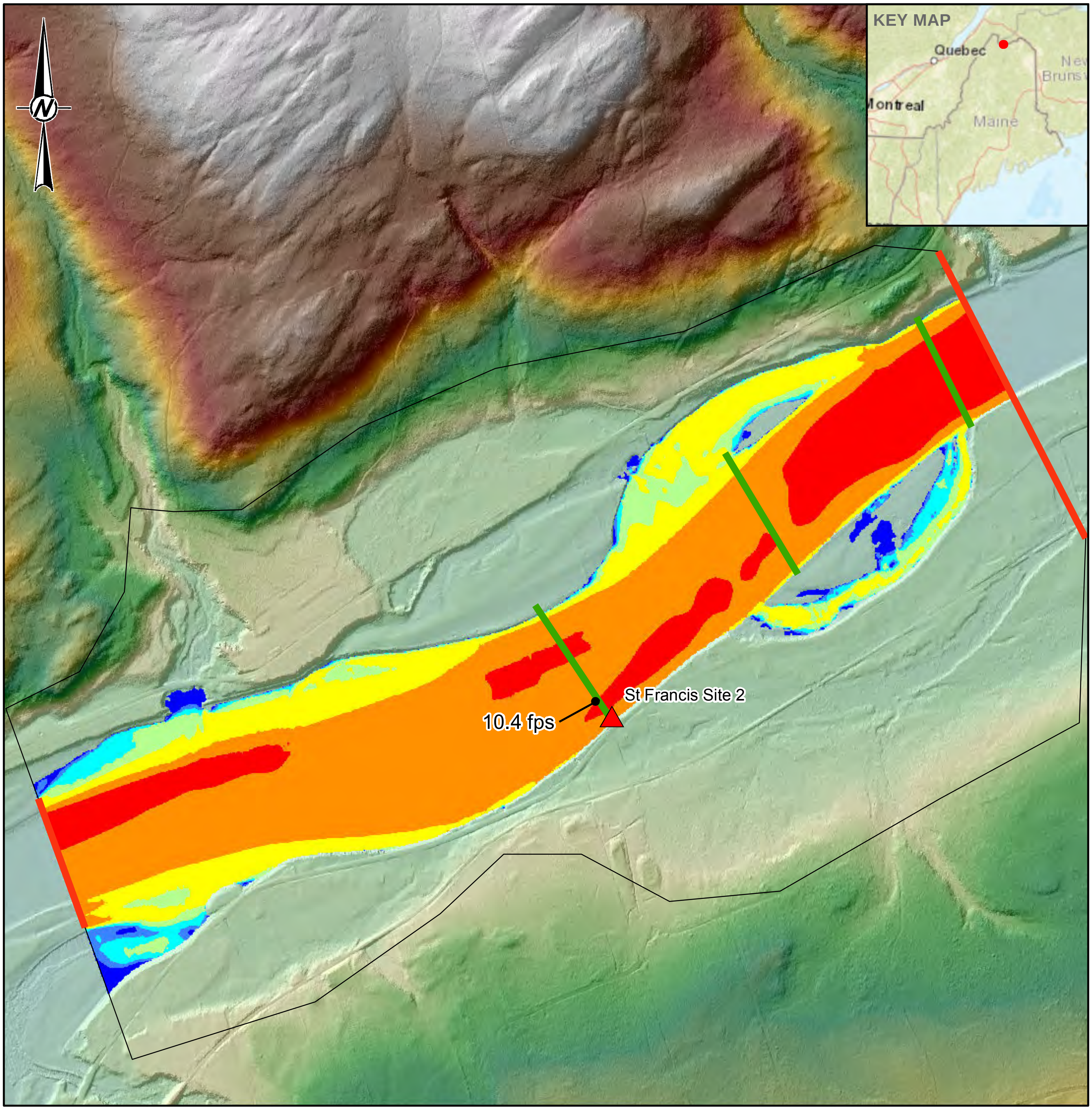


LEGEND

🟥 Boundary Condition
🟩 Surveyed cross-sections
☐ Model Domain

Velocity (fps)

🟦 0.00 to 0.20
🟦 0.20 to 0.50
🟦 0.50 to 1.00
🟩 1.00 to 2.00
🟨 2.00 to 5.00
🟧 5.00 to 10.00
🟥 10.00 to 20.00

0 375 750 1,500
Feet

REFERENCE(S)
1. HYDRAULIC MODEL SETUP AND RESULTS IS FROM GOLDER BASED ON TUFLOW.
2. DIGITAL ELEVATION MODEL (DEM) IS FROM 2009 FEDERAL EMERGENCY MANAGEMENT AGENCY TOPOGRAPHIC LIDAR: FORT KENT, MAINE.
3. SUPPLEMENTAL BATHYMETRY IS BASED ON FROM MAINE DEPARTMENT OF TRANSPORTATION SURVEY OF THREE CROSS-SECTION, 10/2016.
4. COORDINATE SYSTEM: NAD 1983 MAINE 2000 CENTRAL ZONE FOOT US
5. SERVICE LAYER CREDITS: SOURCES: ESRI, DELORME, NAVTEQ, USGS, INTERMAP, IPC, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI (THAILAND), TOMTOM, 2013

CLIENT
MAINE DOT

PROJECT
EVALUATION AND STABILIZATION OF UNSTABLE SLOPES
STATE ROUTE 161, ST. FRANCIS AND ALLAGASH, MAINE

TITLE
2D MODELING RESULTS - VELOCITY
100-YEAR EVENT (NO ICE)
ST FRANCES SITE

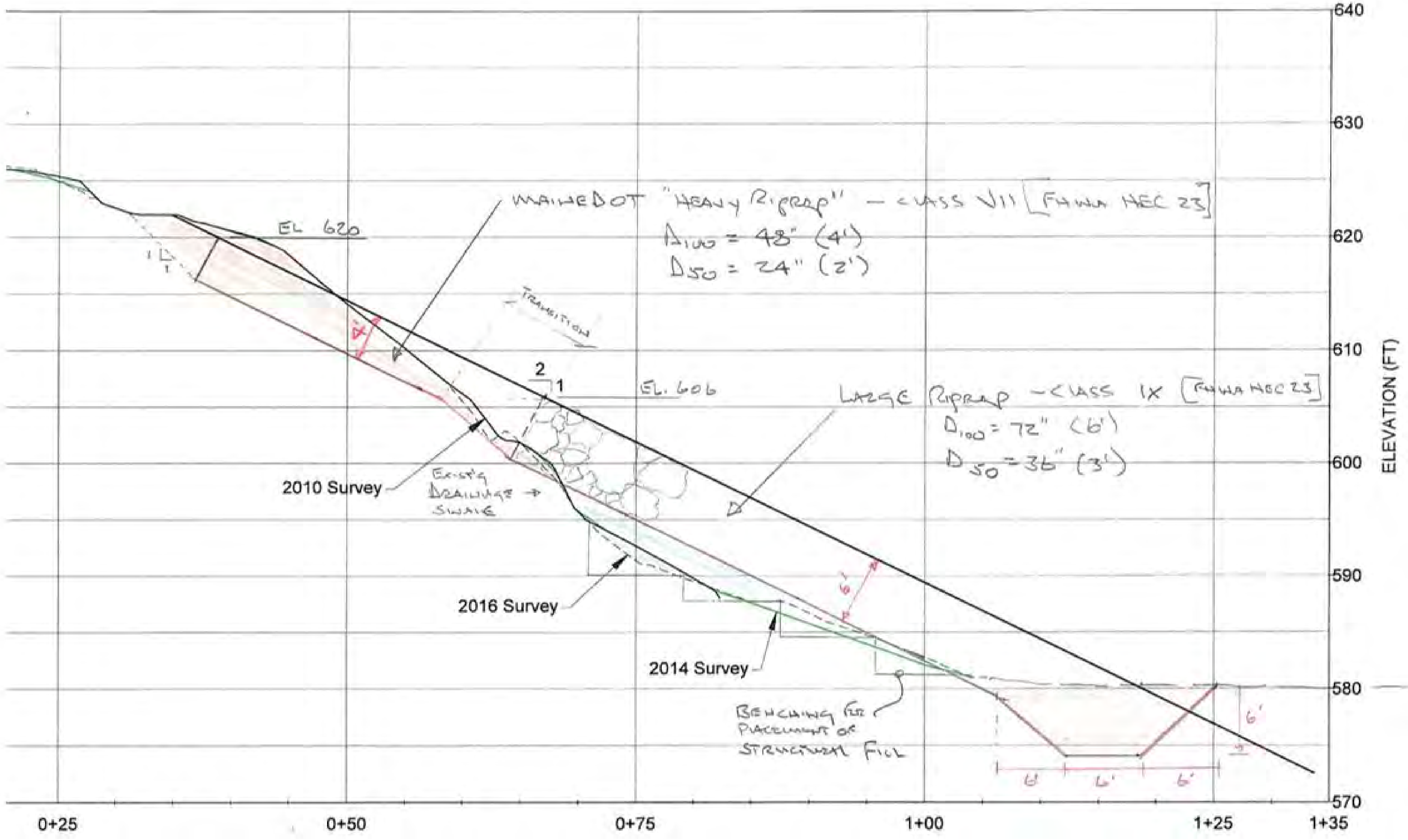
CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-12
DESIGNED	SJS
PREPARED	SJS
REVIEWED	AQK
APPROVED	AQK

PROJECT NO.	PHASE	REV.	FIGURE
1659907	004	0	**16**

PATH: G:\MaineDOT\Allagash\99_PROJECTS\1659907_Allagash\02_PRODUCTION\MXD\FIGURES\Rev0\1659907_001_TUFLOW_StFrancis.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

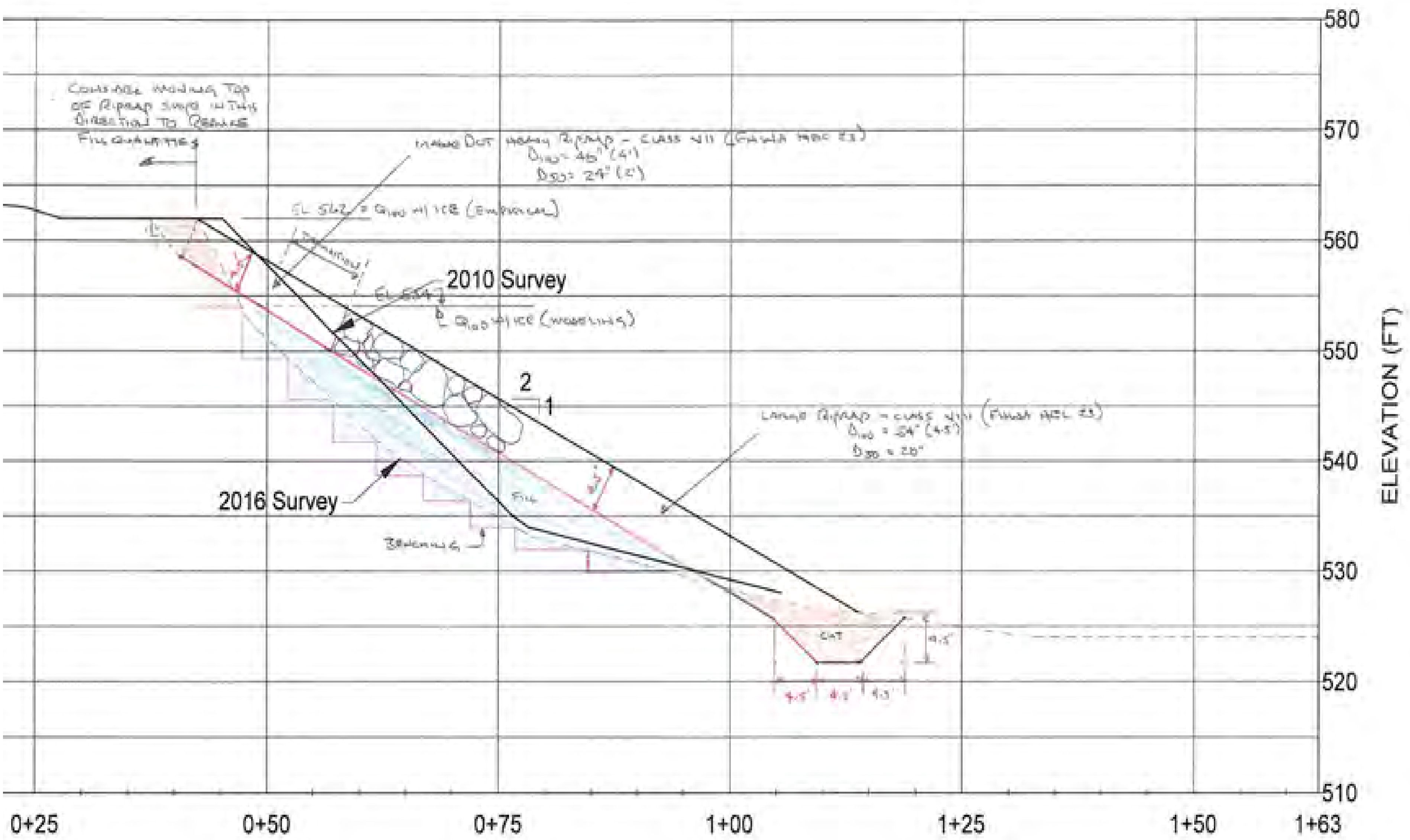
PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-04
DESIGNED	CJS
PREPARED	CJS
REVIEWED	JDL
APPROVED	MSP

TITLE
Preliminary Proposed 2H:1V Slope Cross-Section - Allagash

PROJECT NO.	PHASE	FIGURE
165-9907		17



CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

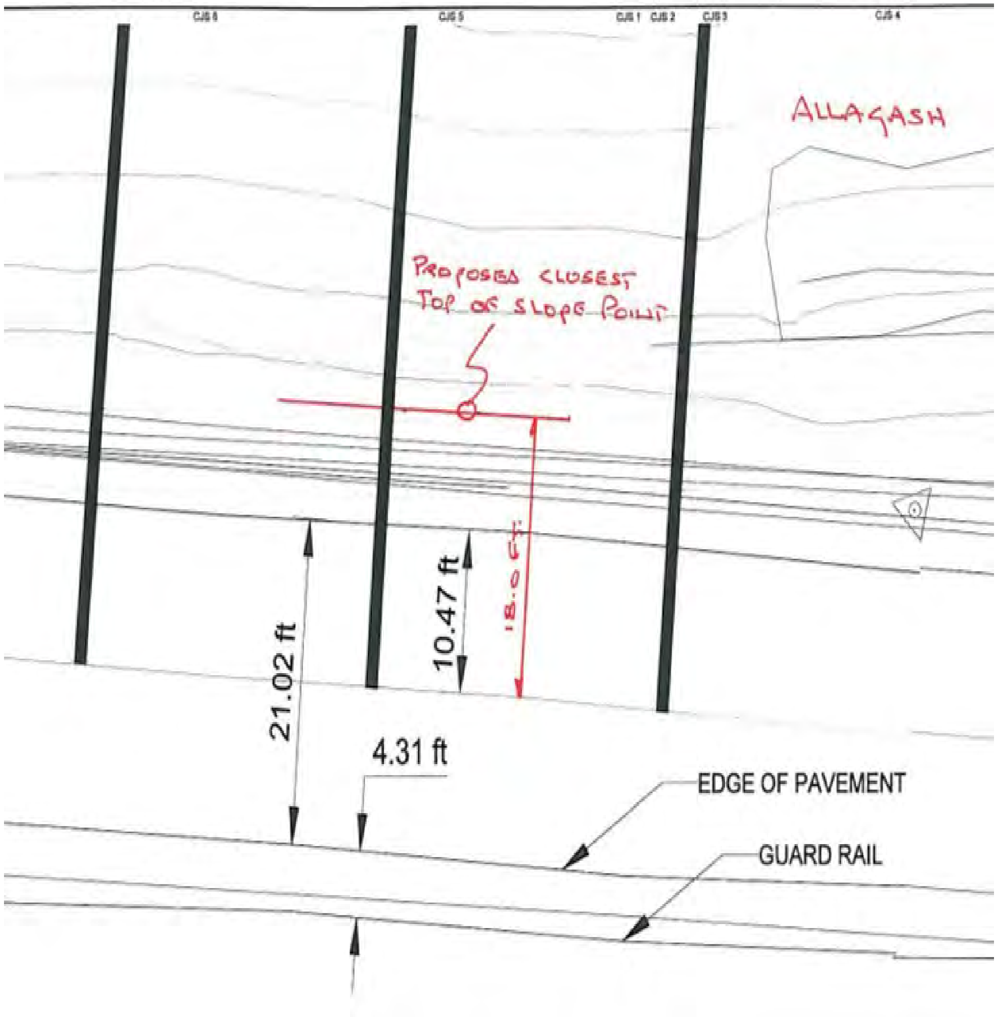
YYYY-MM-DD	**2019-03-04**
DESIGNED	**CJS**
PREPARED	**CJS**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE
Preliminary Proposed 2H:1V Slope Cross-Section - St. Francis

PROJECT NO. 165-9907
PHASE
FIGURE **18**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

Allagash



St. Francis

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT

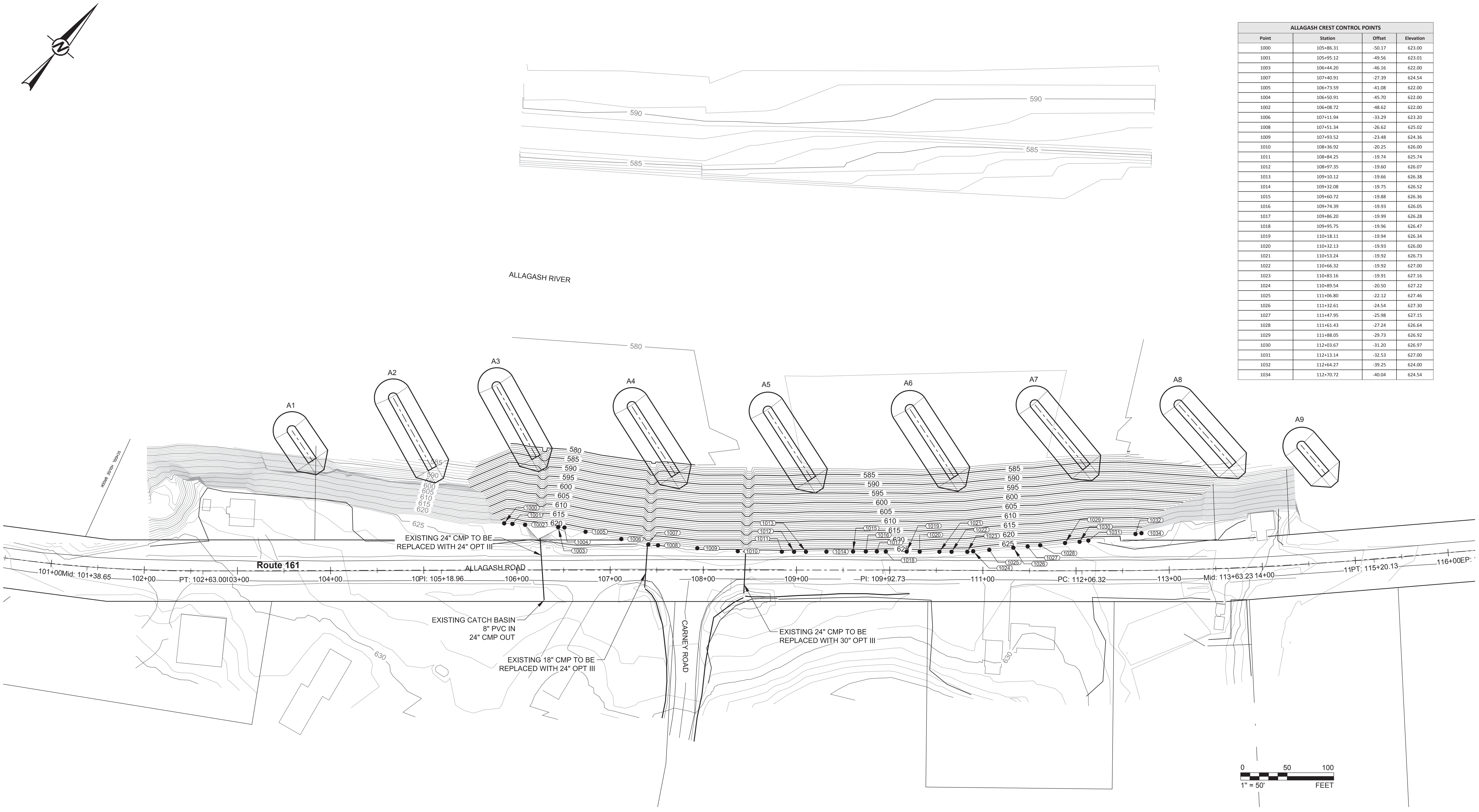
GOLDER

YYYY-MM-DD	**2019-03-10**
DESIGNED	**CJS**
PREPARED	**SKB**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE

Top of Slope Criteria

PROJECT NO. 165-9907
PHASE
FIGURE **19**



EXISTING 24" CMP TO BE
REPLACED WITH 24" OPT III

EXISTING CATCH BASIN
8" PVC IN
24" CMP OUT

EXISTING 18" CMP TO BE
REPLACED WITH 24" OPT III

EXISTING 24" CMP TO BE
REPLACED WITH 30" OPT III

ALLAGASH CREST CONTROL POINTS			
Point	**Station**	**Offset**	**Elevation**
1000	105+86.31	-50.17	623.00
1001	105+95.12	-49.56	623.01
1003	106+44.20	-46.16	622.00
1007	107+40.91	-27.39	624.54
1005	106+73.59	-41.08	622.00
1004	106+50.91	-45.70	622.00
1002	106+08.72	-48.62	622.00
1006	107+11.94	-33.29	623.20
1008	107+51.34	-26.62	625.02
1009	107+93.52	-23.48	624.36
1010	108+36.92	-20.25	626.00
1011	108+84.25	-19.74	625.74
1012	108+97.35	-19.60	626.07
1013	109+10.12	-19.66	626.38
1014	109+32.08	-19.75	626.52
1015	109+60.72	-19.88	626.36
1016	109+74.39	-19.93	626.05
1017	109+86.20	-19.99	626.28
1018	109+95.75	-19.96	626.47
1019	110+18.11	-19.94	626.34
1020	110+32.13	-19.93	626.00
1021	110+53.24	-19.92	626.73
1022	110+66.32	-19.92	627.00
1023	110+83.16	-19.91	627.16
1024	110+89.54	-20.50	627.22
1025	111+06.80	-22.12	627.46
1026	111+32.61	-24.54	627.30
1027	111+47.95	-25.98	627.15
1028	111+61.43	-27.24	626.64
1029	111+88.05	-29.73	626.92
1030	112+03.67	-31.20	626.97
1031	112+13.14	-32.53	627.00
1032	112+64.27	-39.25	624.00
1034	112+70.72	-40.04	624.54

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT

GOLDER

YYYY-MM-DD	2019-03-11
DESIGNED	RWC
PREPARED	RWC/CJS
REVIEWED	JDL
APPROVED	MSP

TITLE

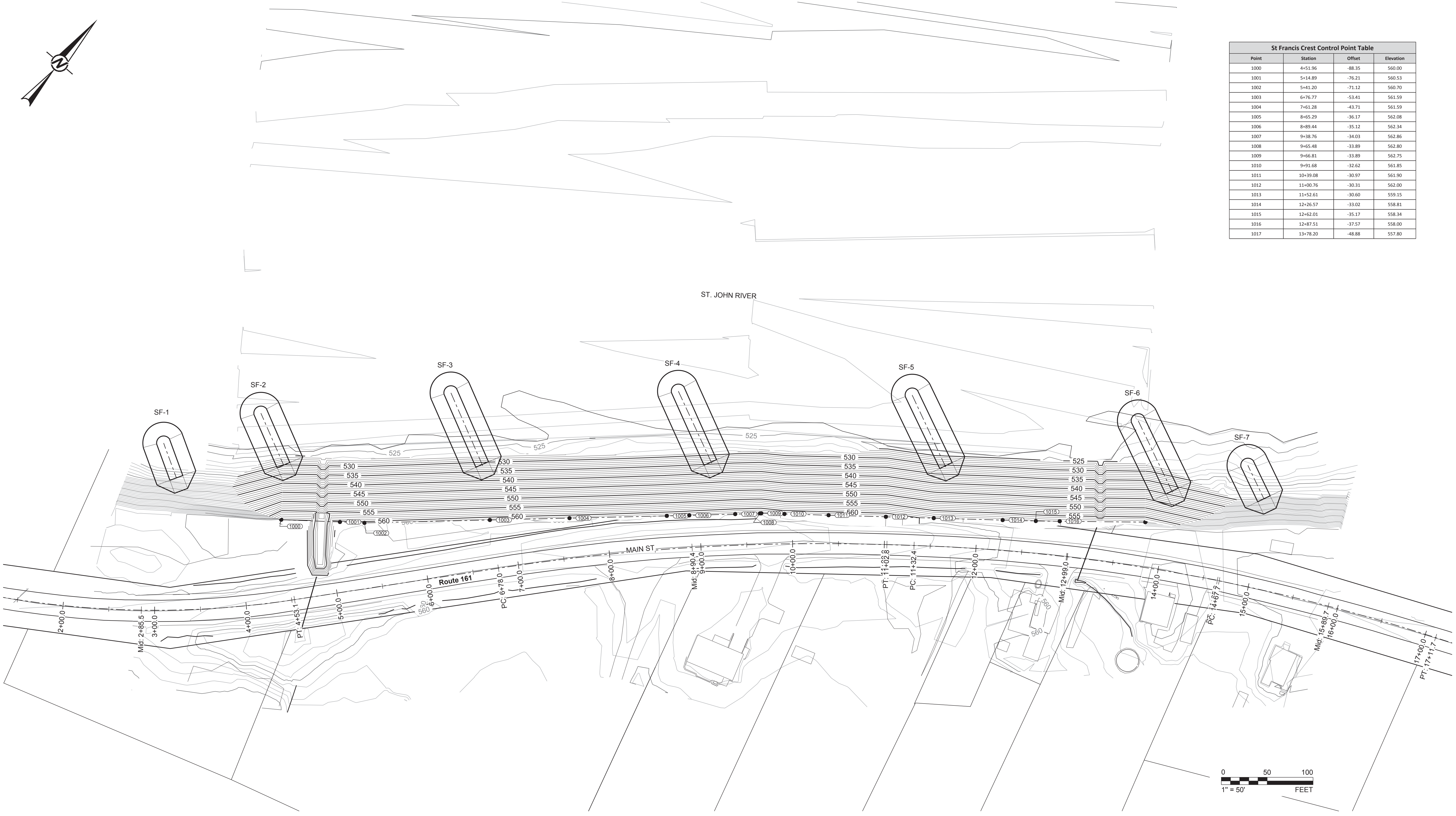
Preliminary Grading Plan - Allagash 2H:1V Slopes

PROJECT NO.
165-9907

PHASE

FIGURE
20

Path: \\manchester\cadd\MaineDOT\Allagash River\99_PROJECTS\1659907_AllagashSlopeStabilization\SlopeRepair\02_PRODUCTION\DWG\001_Allagash | File Name: 1659907_001_001.dwg | Last Edited By: rclark Date: 2018-03-09 Time:2:16:36 PM | Printed By: rclark Date: 2018-03-09 Time:4:42:07 PM



St Francis Crest Control Point Table			
Point	Station	Offset	Elevation
1000	4+51.96	-88.35	560.00
1001	5+14.89	-76.21	560.53
1002	5+41.20	-71.12	560.70
1003	6+76.77	-53.41	561.59
1004	7+61.28	-43.71	561.59
1005	8+65.29	-36.17	562.08
1006	8+89.44	-35.12	562.34
1007	9+38.76	-34.03	562.86
1008	9+65.48	-33.89	562.80
1009	9+66.81	-33.89	562.75
1010	9+91.68	-32.62	561.85
1011	10+39.08	-30.97	561.90
1012	11+00.76	-30.31	562.00
1013	11+52.61	-30.60	559.15
1014	12+26.57	-33.02	558.81
1015	12+62.01	-35.17	558.34
1016	12+87.51	-37.57	558.00
1017	13+78.20	-48.88	557.80

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MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

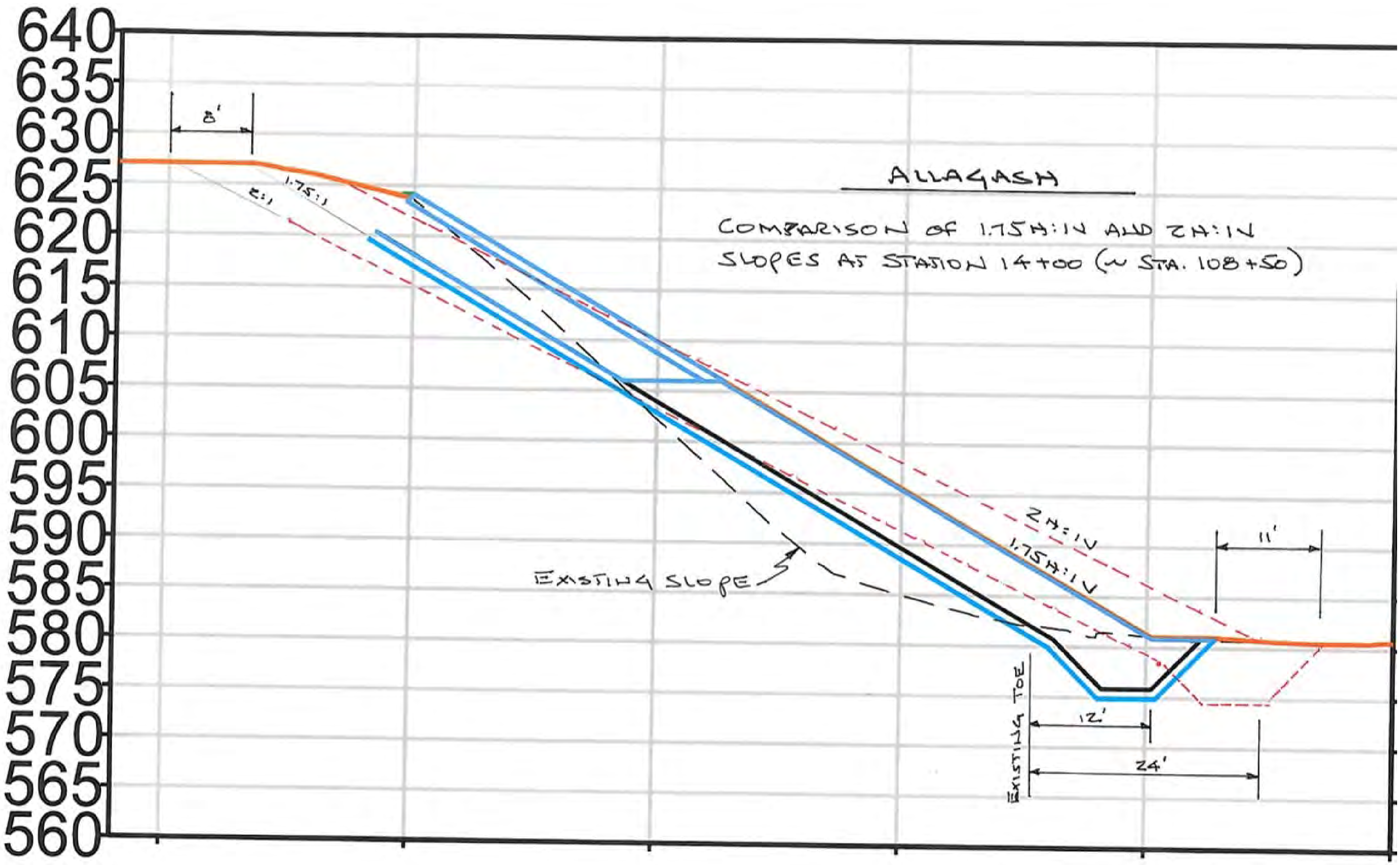
YYYY-MM-DD	2019-03-11
DESIGNED	RWC
PREPARED	RWC/CJS
REVIEWED	JDL
APPROVED	MSP

TITLE
Preliminary Grading Plan - St. Francis 2H:1V Slopes

PROJECT NO.
165-9907

PHASE

FIGURE
21



ALLAGASH

COMPARISON OF 1.75H:1V AND 2H:1V SLOPES AT STATION 14+00 (~ STA. 108+50)

MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT

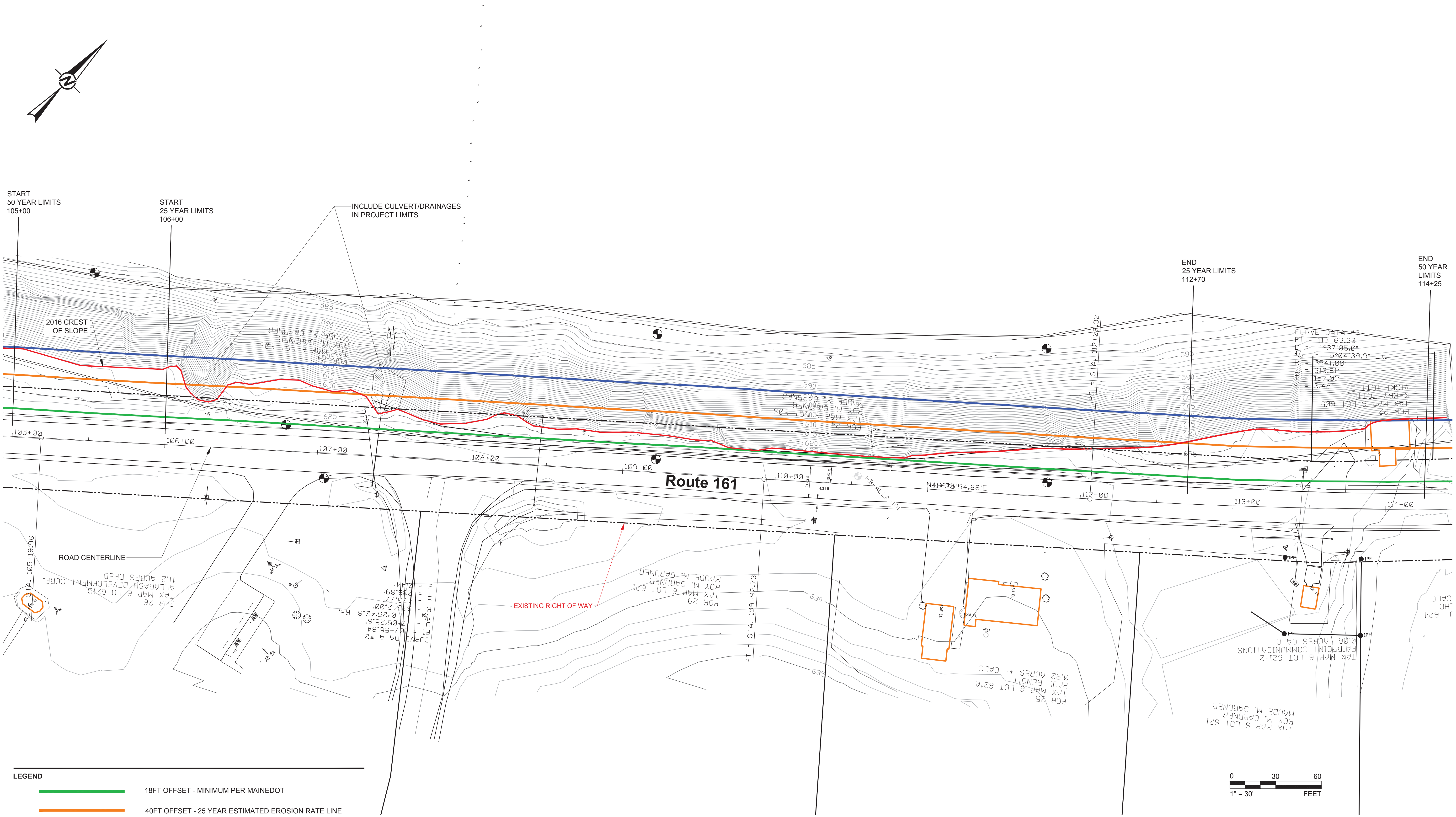
GOLDER

YYYY-MM-DD	**2019-03-10**
DESIGNED	**CJS**
PREPARED	**SKB**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE

Comparing 2:1 to 1.75:1 slopes (Allagash)

PROJECT NO.	PHASE	FIGURE
165-9907		22



LEGEND

🟩	18FT OFFSET - MINIMUM PER MAINEDOT
🟧	40FT OFFSET - 25 YEAR ESTIMATED EROSION RATE LINE
🟦	58FT OFFSET - 50 YEAR ESTIMATED EROSION RATE LINE
🟥	2016 CREST OF SLOPE

50 YEAR LIMITS: STA 105+00 TO 114+25, 925FT

25 YEAR LIMITS: STA 106+00 TO 12+70, 670FT

NOTE:
1) EROSION SETBACK BASED IN THE MAXIMUM ANNUAL EROSION RATE FOR A LIMITED (i.e. 2010-2016) DATASET.

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

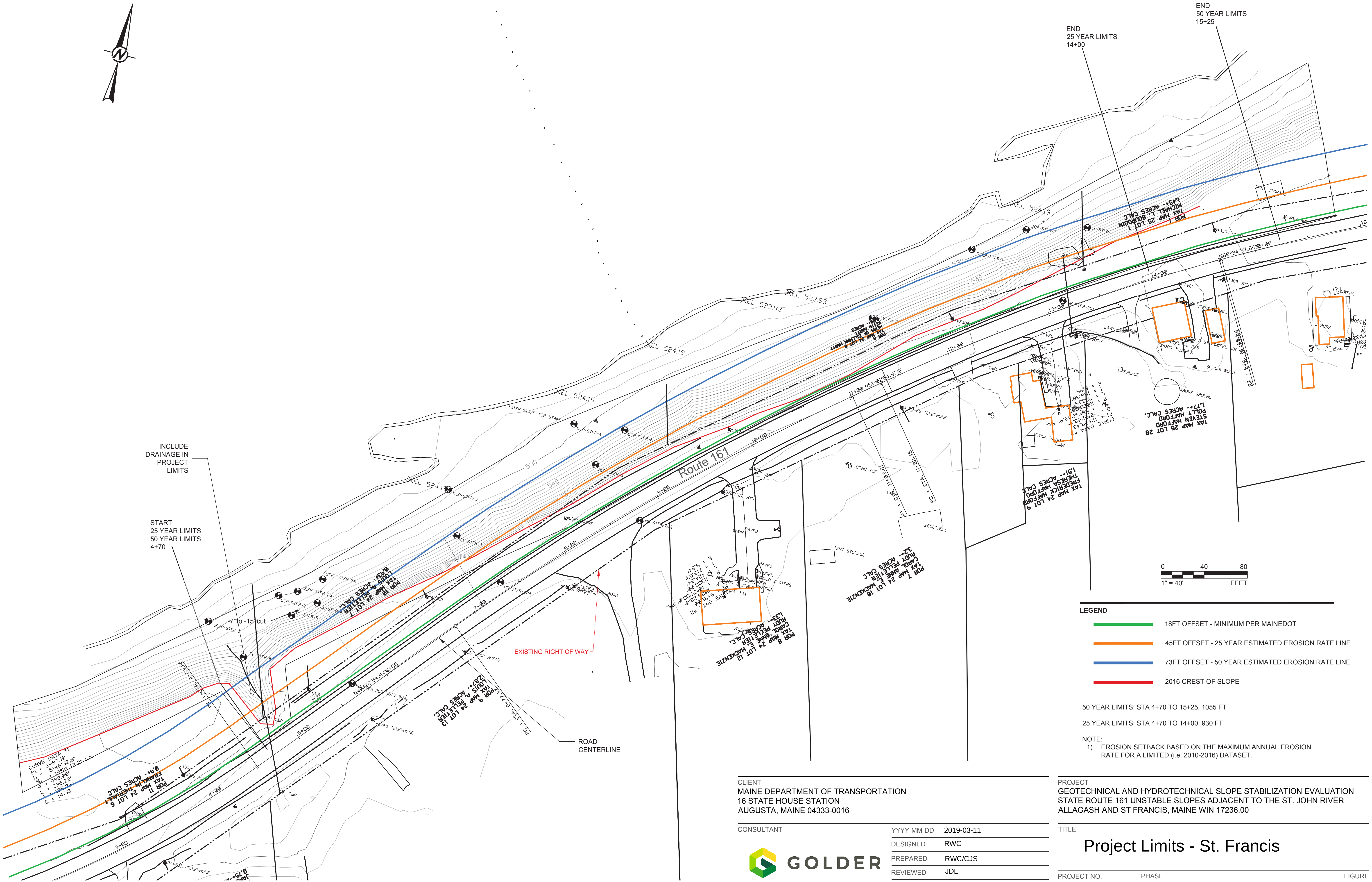
CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-11
DESIGNED	RWC
PREPARED	RWC/CJS
REVIEWED	JDL
APPROVED	MSP

TITLE
Project Limits - Allagash

PROJECT NO. 165-9907
PHASE
FIGURE 23

Path: \\manchester\cadd\Drawings\2016\1659907 MaineDOT - Allagash-St.Francis\St A_Allagash, ME\ | File Name: 1659907A006B.dwg



LEGEND

🟩	18FT OFFSET - MINIMUM PER MAINEDOT
🟧	45FT OFFSET - 25 YEAR ESTIMATED EROSION RATE LINE
🟦	73FT OFFSET - 50 YEAR ESTIMATED EROSION RATE LINE
🟥	2016 CREST OF SLOPE

50 YEAR LIMITS: STA 4+70 TO 15+25, 1055 FT

25 YEAR LIMITS: STA 4+70 TO 14+00, 930 FT

NOTE:
1) EROSION SETBACK BASED ON THE MAXIMUM ANNUAL EROSION RATE FOR A LIMITED (i.e. 2010-2016) DATASET.

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MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-11
DESIGNED	RWC
PREPARED	RWC/CJS
REVIEWED	JDL
APPROVED	MSP

TITLE
Project Limits - St. Francis

PROJECT NO. 165-9907
PHASE
FIGURE 24

Path: \\manchester\cadd\Drawings\2016\1659907 MaineDOT - Allagash-St Francis\St B_St. Francis, ME\ | File Name: 1659907B005B.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
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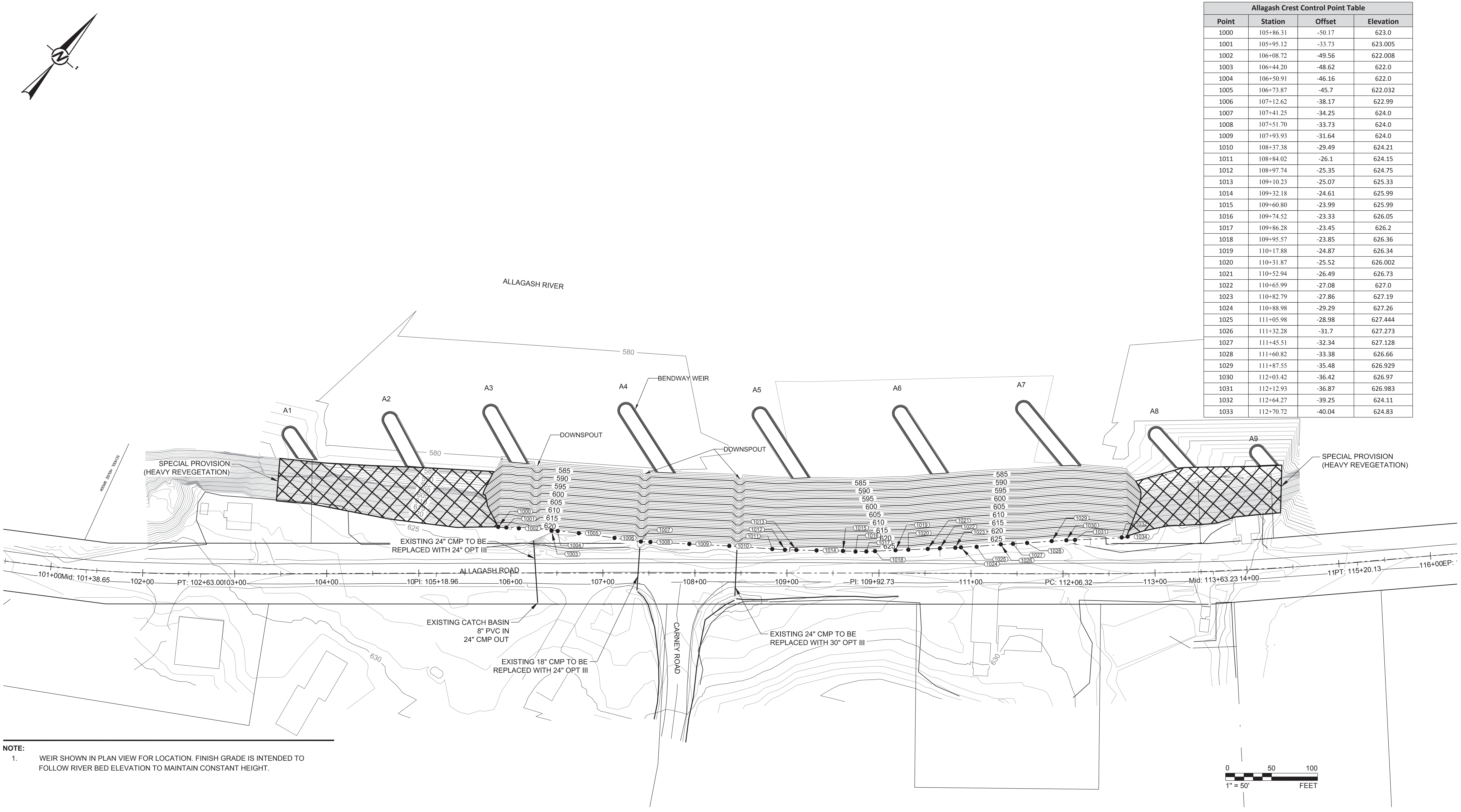

Allagash Crest Control Point Table			
Point	**Station**	**Offset**	**Elevation**
1000	105+86.31	-50.17	623.0
1001	105+95.12	-33.73	623.005
1002	106+08.72	-49.56	622.008
1003	106+44.20	-48.62	622.0
1004	106+50.91	-46.16	622.0
1005	106+73.87	-45.7	622.032
1006	107+12.62	-38.17	622.99
1007	107+41.25	-34.25	624.0
1008	107+51.70	-33.73	624.0
1009	107+93.93	-31.64	624.0
1010	108+37.38	-29.49	624.21
1011	108+84.02	-26.1	624.15
1012	108+97.74	-25.35	624.75
1013	109+10.23	-25.07	625.33
1014	109+32.18	-24.61	625.99
1015	109+60.80	-23.99	625.99
1016	109+74.52	-23.33	626.05
1017	109+86.28	-23.45	626.2
1018	109+95.57	-23.85	626.36
1019	110+17.88	-24.87	626.34
1020	110+31.87	-25.52	626.002
1021	110+52.94	-26.49	626.73
1022	110+65.99	-27.08	627.0
1023	110+82.79	-27.86	627.19
1024	110+88.98	-29.29	627.26
1025	111+05.98	-28.98	627.444
1026	111+32.28	-31.7	627.273
1027	111+45.51	-32.34	627.128
1028	111+60.82	-33.38	626.66
1029	111+87.55	-35.48	626.929
1030	112+03.42	-36.42	626.97
1031	112+12.93	-36.87	626.983
1032	112+64.27	-39.25	624.11
1033	112+70.72	-40.04	624.83

NOTE:

1. WEIR SHOWN IN PLAN VIEW FOR LOCATION. FINISH GRADE IS INTENDED TO FOLLOW RIVER BED ELEVATION TO MAINTAIN CONSTANT HEIGHT.

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16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

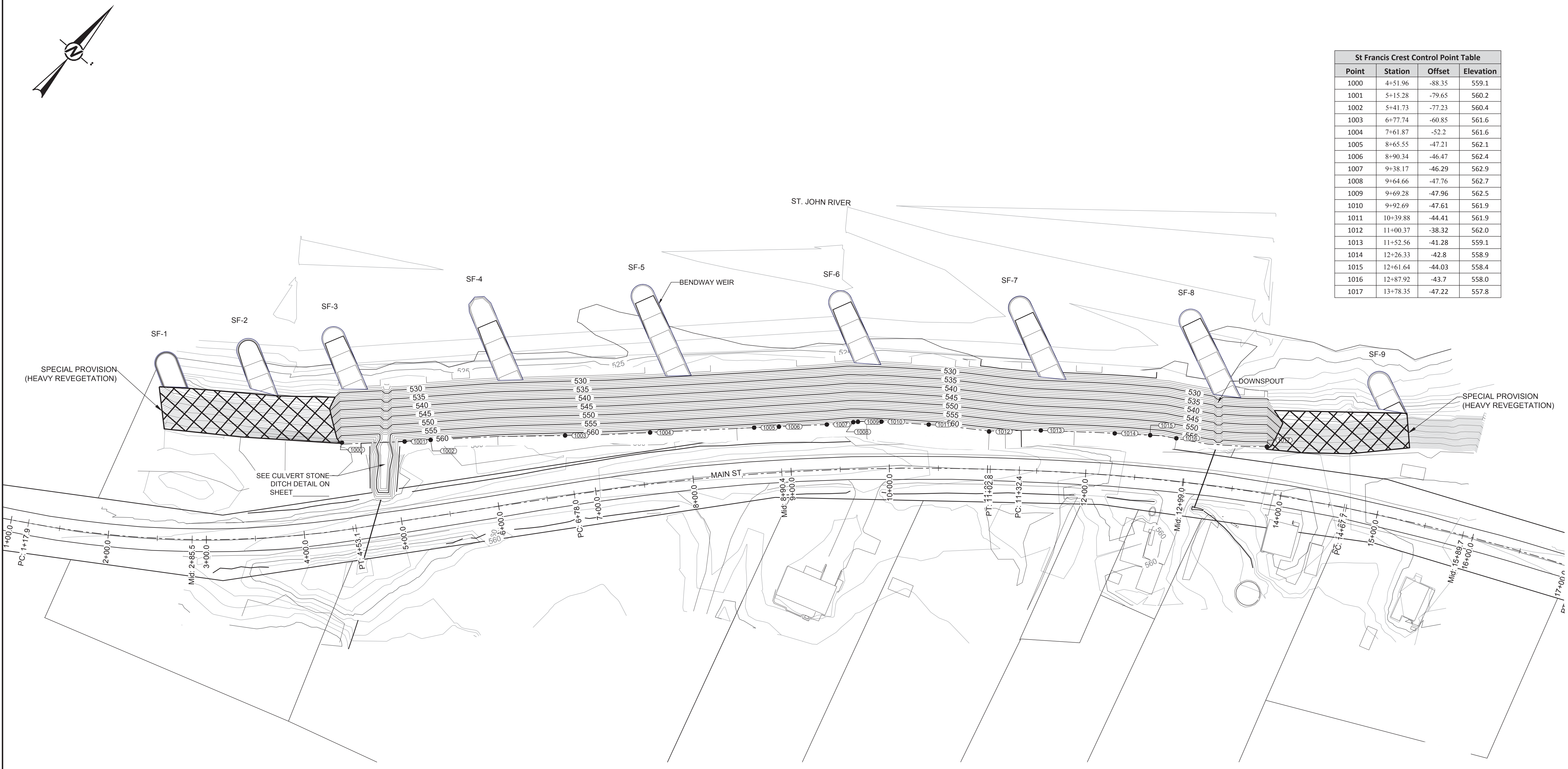
YYYY-MM-DD	2019-03-11
DESIGNED	SCS
PREPARED	RWC/CJS
REVIEWED	AQK
APPROVED	MSP

TITLE

Preliminary Bendway Weir Layout - Allagash

PROJECT NO.	PHASE	FIGURE
165-9907		25

Path: \\manchester\cadd\MaineDOT\Allagash River\99_PROJECTS\1659907_AllagashSlopeStabilization\SlopeRepair\02_PRODUCTION\DWG\001_Allagash\ | File Name: 1659907_001_001.dwg | Last Edited By: rclark Date: 2018-06-15 Time:3:48:25 PM | Printed By: rclark Date: 2018-06-18 Time:11:38:48 AM



St Francis Crest Control Point Table			
Point	**Station**	**Offset**	**Elevation**
1000	4+51.96	-88.35	559.1
1001	5+15.28	-79.65	560.2
1002	5+41.73	-77.23	560.4
1003	6+77.74	-60.85	561.6
1004	7+61.87	-52.2	561.6
1005	8+65.55	-47.21	562.1
1006	8+90.34	-46.47	562.4
1007	9+38.17	-46.29	562.9
1008	9+64.66	-47.76	562.7
1009	9+69.28	-47.96	562.5
1010	9+92.69	-47.61	561.9
1011	10+39.88	-44.41	561.9
1012	11+00.37	-38.32	562.0
1013	11+52.56	-41.28	559.1
1014	12+26.33	-42.8	558.9
1015	12+61.64	-44.03	558.4
1016	12+87.92	-43.7	558.0
1017	13+78.35	-47.22	557.8

NOTE:

1. WEIR SHOWN IN PLAN VIEW FOR LOCATION. FINISH GRADE IS INTENDED TO FOLLOW RIVER BED ELEVATION TO MAINTAIN CONSTANT HEIGHT.

0 50 100
1" = 50' FEET

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

YYYY-MM-DD	2019-03-11
DESIGNED	SCS
PREPARED	RWC/CJS
REVIEWED	AQK
APPROVED	MSP

TITLE
Preliminary Bendway Weir Layout - St. Francis

PROJECT NO. 165-9907
PHASE
FIGURE 26

REFERENCE(S)

1. BASE MAP PROVIDED BY MAINEDOT ELECTRONIC FILE TITLED "ALLAGASH ALIGNMENT 1723600.DGN" DATED 10/27/2016.

ELEVATION TABLE

NUMBER	MIN. EL.	MAX. EL.	AREA FT2	COLOR	VOLUME	C/F
1	-10.0	-7.0	927.47	🟥	22	CUT
2	-7.0	-4.0	10598.93	🟥	732	CUT
3	-4.0	0.0	15533.41	🟥	2705	CUT
4	0.0	3.0	11612.97	🟩	2914	FILL
5	3.0	6.0	10727.89	🟩	1664	FILL
6	6.0	11.0	9900.00	🟩	610	FILL

0 30 60
1" = 30' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2019-03-15	DESCRIPTION	CJS	MPB	JDL	MSP

SEAL

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILITY EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST. FRANCIS, MAINE WIN 17236.00

TITLE
GRADING ISOPACHS - ALLAGASH

PROJECT NO. 165-9907
REV. ----
of
FIGURE 27

REFERENCE(S)

1. BASE MAP PROVIDED BY MAINEDOT ELECTRONIC FILE TITLED "ALLAGASH ALIGNMENT 1723600.DGN" DATED 10/27/2016.

ELEVATION TABLE

NUMBER	MIN. EL.	MAX. EL.	AREA FT^2	COLOR	VOLUME	C/F
1	-10.0	-7.0	6550.39	🟥	119	CUT
2	-7.0	-4.0	7281.43	🟥	1096	CUT
3	-4.0	0.0	16279.76	🟥	3223	CUT
4	0.0	3.0	12651.52	🟩	3380	FILL
5	3.0	6.0	17605.64	🟩	1713	FILL
6	6.0	10.0	6393.87	🟩	239	FILL

0 30 60
1" = 30' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2019-03-15	DESCRIPTION	CJS	MPB	JDL	MSP

SEAL

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILITY EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST. FRANCIS, MAINE WIN 17236.00

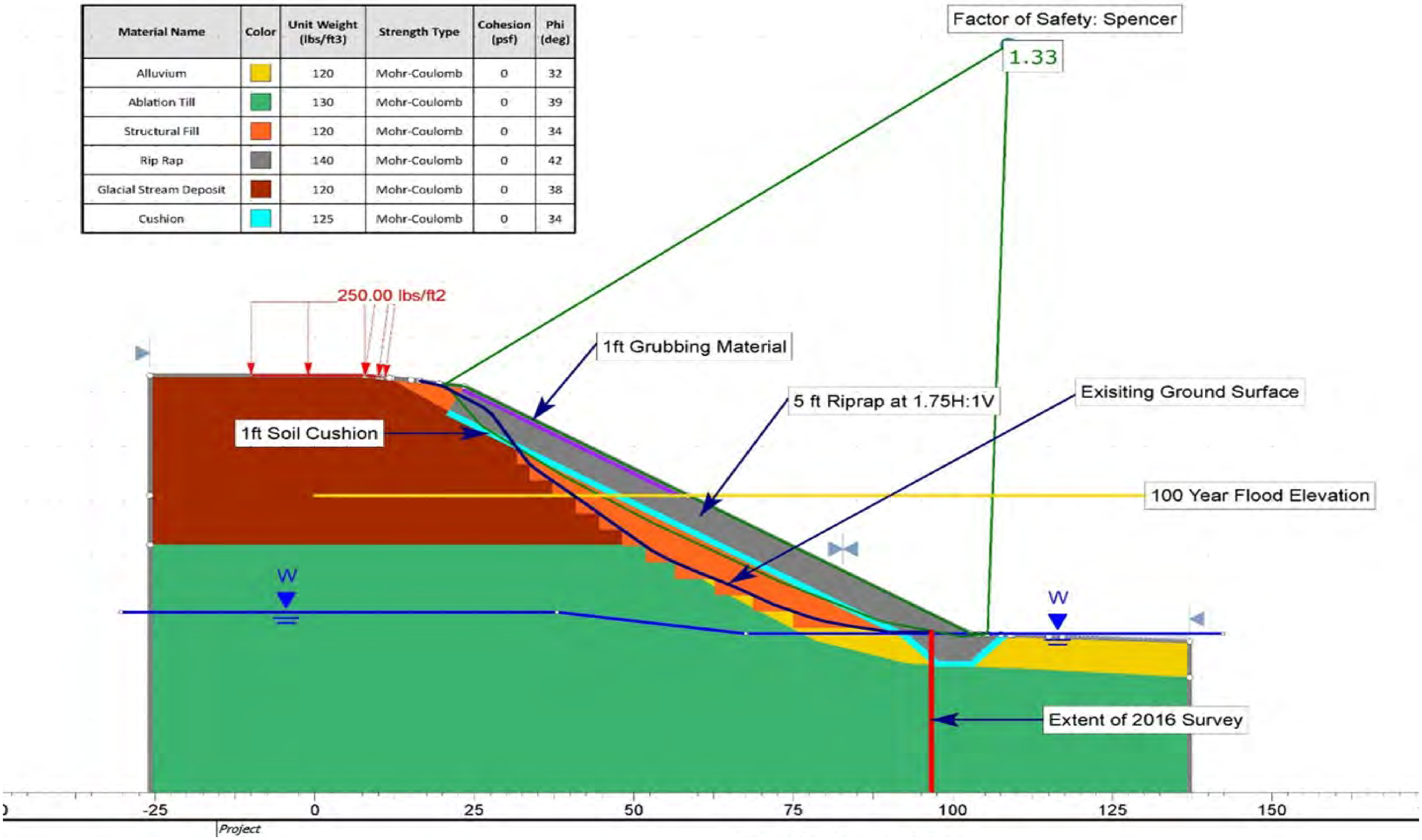
TITLE
GRADING ISOPACH - ST. FRANCIS

PROJECT NO. 165-9907
REV. ----
of
FIGURE 28

Path: \\manchester\cadd\MaineDOT\Allagash River\99_PROJECTS\1659907_AllagashSlopeStabilization\SlopeRepair\02_PRODUCTION\DWG\001_Allagash\ | File Name: 1659907_001_010.dwg | Last Edited By: mboisvert Date: 2019-03-15 Time:3:59:23 PM | Printed By: mboisvert Date: 2019-03-28 Time:3:09:29 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

0 1 in



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Alluvium	🟨	120	Mohr-Coulomb	0	32
Ablation Till	🟩	130	Mohr-Coulomb	0	39
Structural Fill	🟧	120	Mohr-Coulomb	0	34
Rip Rap	◼	140	Mohr-Coulomb	0	42
Glacial Stream Deposit	🟫	120	Mohr-Coulomb	0	38
Cushion	🟦	125	Mohr-Coulomb	0	34

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

CONSULTANT

GOLDER

YYYY-MM-DD	**2019-03-10**
DESIGNED	**CJS**
PREPARED	**SKB**
REVIEWED	**JDL**
APPROVED	**MSP**

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

TITLE

Typical SLIDE Profile - Allagash

PROJECT NO.	PHASE	FIGURE
165-9907		**29**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
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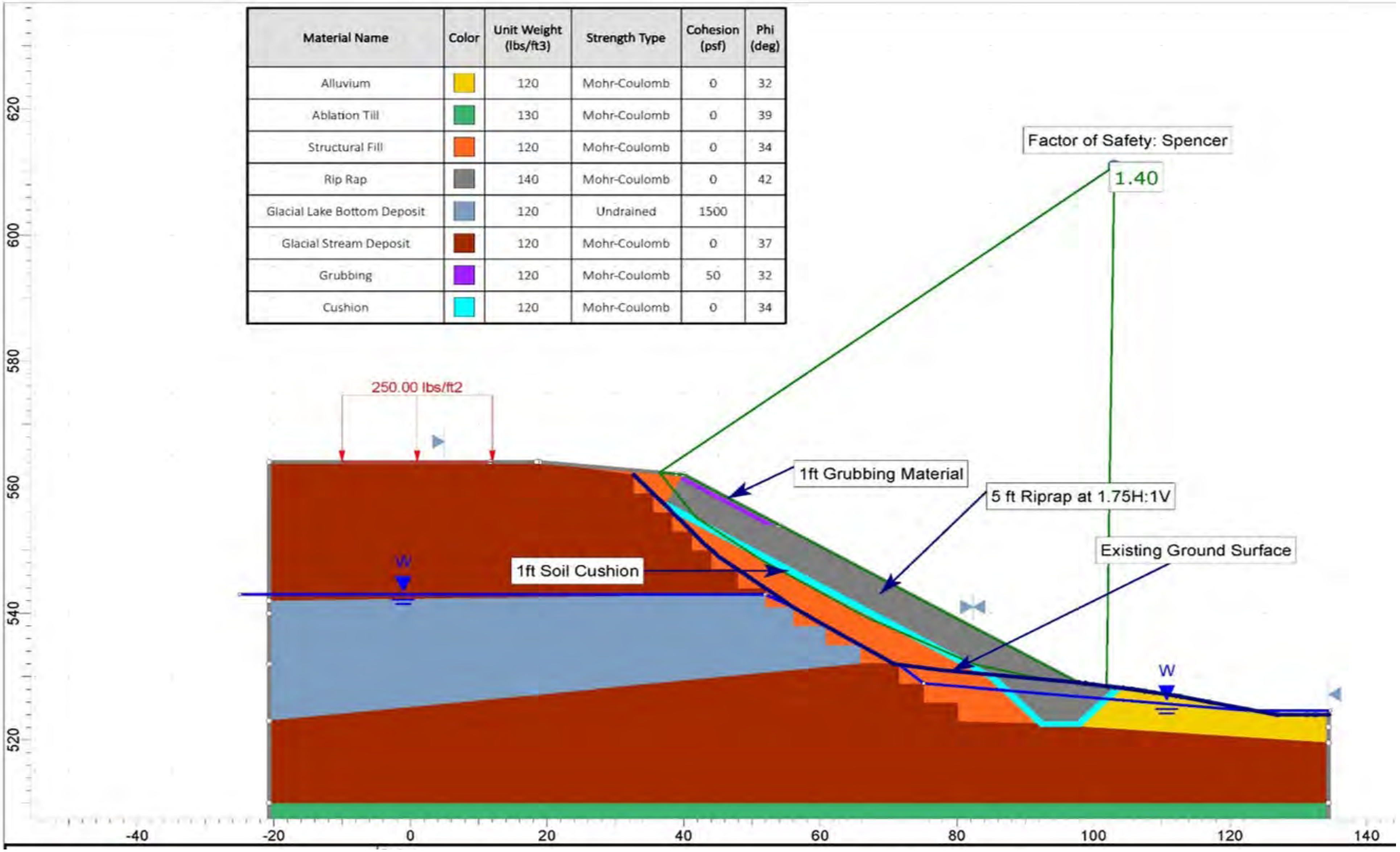


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Alluvium	🟨	120	Mohr-Coulomb	0	32
Ablation Till	🟩	130	Mohr-Coulomb	0	39
Structural Fill	🟧	120	Mohr-Coulomb	0	34
Rip Rap	⬛	140	Mohr-Coulomb	0	42
Glacial Lake Bottom Deposit	🟦	120	Undrained	1500	
Glacial Stream Deposit	🟫	120	Mohr-Coulomb	0	37
Grubbing	🟪	120	Mohr-Coulomb	50	32
Cushion	🟦	120	Mohr-Coulomb	0	34

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT
GOLDER

YYYY-MM-DD	**2019-03-10**
DESIGNED	**CJS**
PREPARED	**SKB**
REVIEWED	**JDL**
APPROVED	**MSP**

TITLE
Typical SLIDE Profile - St. Francis

PROJECT NO.
165-9907

PHASE

FIGURE
30

APPENDIX A

Site Photographs

APPENDIX A.1

Allagash Site Photos

Appendix A.1 - Allagash Site Photographs

PHOTO 1

Slope conditions looking upstream (2016)

PHOTO 2

Slope conditions looking upslope (2016)

PHOTO 3

Slope conditions looking downstream (2016)

Appendix A.1 - Allagash Site Photographs

PHOTO 4

East End Transition

(2016)

PHOTO 5

Midslope

(2018)

PHOTO 6

West End Transition

(2018)

APPENDIX A.2

St. Francis Site Photos

Appendix A.2 – St. Francis Site Photographs

PHOTO 1

Slope conditions looking south (2016)

PHOTO 2

Slope conditions looking northeast (2016)

PHOTO 3

Leaning trees looking northeast (2016)

Appendix A.2 – St. Francis Site Photographs

PHOTO 4

Mid-slope looking south

(2016)

PHOTO 5

Leaning trees looking south

(2016)

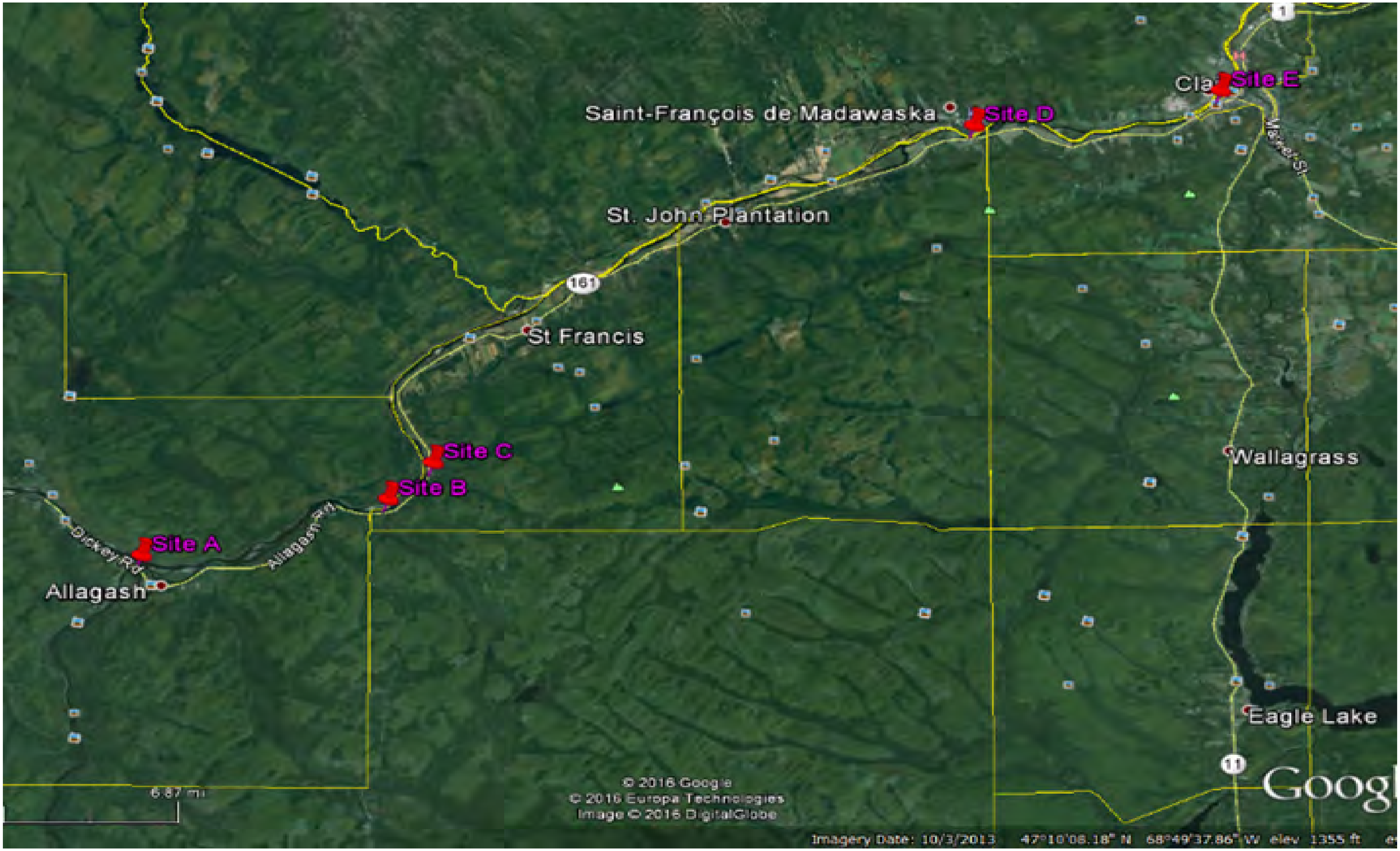
PHOTO 6

West end armored slope

(2016)

APPENDIX B

Existing Riprap Slopes in Project Area



CLIENT
MAINE DEPARTMENT OF TRANSPORTATION
16 STATE HOUSE STATION
AUGUSTA, MAINE 04333-0016

PROJECT
GEOTECHNICAL AND HYDROTECHNICAL SLOPE STABILIZATION EVALUATION
STATE ROUTE 161 UNSTABLE SLOPES ADJACENT TO THE ST. JOHN RIVER
ALLAGASH AND ST FRANCIS, MAINE WIN 17236.00

CONSULTANT

GOLDER

YYYY-MM-DD **2019-03-06**
DESIGNED **CJS**
PREPARED **SKB**
REVIEWED **JDL**
APPROVED **MSP**

TITLE

Nearby Riprap Slope Locations

PROJECT NO. 165-9907
PHASE
FIGURE **B.1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

Appendix B – Riprap Slope Photographs

SITE A – PHOTO A1

Description:

Existing rip rap slope placed between Rt. 161 and Allagash River, Allagash. Observations:

- Slope Height 20-25 ft (vertical)
- Slope Angle: ~35° (~1V:1.5H)
- Rip-Rap: Heavy, 3’x1’x1’ typical, and smaller (phyllite/slate/metagraywacke)

Photo Orientation:

View to east from N47° 05’ 21.89”/W069° 03’ 13.80” (intersection of Rt. 161 and Inn Road).

Photo Date:

9/27/2016

SITE A – PHOTO A2

Description:

View downslope showing rip-rap. Note alluvial sediments between slope toe and edge of river, and driftwood at toe.

Photo Orientation:

View to south at N47° 05’ 19.17”/W069° 03’ 03.88”.

Photo Date:

9/16/2016

Appendix B – Riprap Slope Photographs

SITE A – PHOTO A1

Description:

View to east showing rip-rap. Note horizontal grass covered crest of slope.

Photo Orientation:

View to east at N47° 05’ 19.28”/W069° 03’ 03.64”.

Photo Date:

9/27/2016

SITE B – PHOTO B1

Description:

Existing rip rap slope placed between Rt. 161 and St. John River, St. Francis. Observations:

- Slope Height 16.5 ft (vertical)
- Slope Angle: ~27° (~1V:2H)
- Rip-Rap: Heavy, up to 5’x3’x1’, most light 2’x1.5’x0.75’ and smaller (phyllite/slate/metagraywacke)
- Rip-Rap Thickness: 4’+

Photo Orientation:

View to west from N47° 06’ 29.92”/W068° 56’ 59.82”.

Photo Date:

9/27/2016

Appendix B – Riprap Slope Photographs

Site B – PHOTO B2

Description:

View of rip-rap slope. Note driftwood located within 5’ from crest of slope, and suspected light rip-rap that has migrated downslope.

Photo Orientation:

View to northwest from N47° 06’ 29.92”/W068° 56’ 59.82”.

Photo Date:

9/27/2016

Site B – PHOTO B3

Description:

View of rip-rap slope conditions.

Photo Orientation:

View to west from N47° 06’ 29.92”/W068° 56’ 59.82”.

Photo Date:

9/27/2016

Appendix B – Riprap Slope Photographs

<table>
<tr><td>

SITE C – PHOTO C1

Description:

Existing rip rap slope placed between Rt. 161 and St. John River, St. Francis. Observations:

- Slope Height 25-30 ft (vertical)
- Slope Angle: ~33° (~1V:1.5H)
- Rip-Rap: Heavy, up to 2.5'x2'x1', most light 1.5'x1'x0.75' and smaller (mostly metagraywacke)
- Rip-Rap Thickness: 4'+
- 100ft+ to from toe of slope to edge of river

Photo Orientation:

View to west from N47° 07' 15.11"/W068° 55' 51.21".

Photo Date:

9/27/2016

</td><td>

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<tr><td>

SITE C – PHOTO C2

Description:

Rip rap slope conditions. Estimated age of trees ~10 years. Note driftwood located at about midslope.

Photo Orientation:

View to west from N47° 07' 15.07"/W068° 55' 52.29".

Photo Date:

9/27/2016

</td><td>

</td></tr>
</table>

Appendix B – Riprap Slope Photographs

SITE C – PHOTO C3

Description:

Close up view of rip rap. Note less platy nature of this rip rap compared with Site A and B rip rap. Field book for scale.

Photo Orientation:

View to west from N47° 07’ 15.58”/W068° 55’ 51.52”.

Photo Date:

9/27/2016

SITE D – PHOTO D1

Description:

Existing rip rap slope placed between Rt. 161 and St. John River, St. John. Observations:

- Slope Height 35-40 ft (vertical)
- Slope Angle: ~27° (~1V:1.75H)
- Rip-Rap: Heavy, up to 3’x2’x1’, most light 1’x1’x0.5’ and smaller (phyllite/slate/metagraywacke)
- Rip-Rap Thickness: 3.5-4’
- Slope toe at river edge

Photo Orientation:

View to west from N47° 14’ 13.24”/W068° 42’ 19.02”.

Photo Date:

9/27/2016

Appendix B – Riprap Slope Photographs

SITE D – PHOTO D2

Description:

View downslope at east end. Note rip-rap blocks sitting just upstream of exposed bedrock at river edge.

Photo Orientation:

View to north from N47° 14’ 13.24”/W068° 42’ 19.02”.

Photo Date:

9/27/2016

SITE D – PHOTO D3

Description:

Disintegrated rip-rap block (slate/phyllite). Field book for scale.

Photo Orientation:

Upper end of slope at N47° 14’ 13.24”/W068° 42’ 19.02”.

Photo Date:

9/27/2016

Appendix B – Riprap Slope Photographs

SITE D – PHOTO D4

Description:

View of midslope conditions. Driftwood/ debris noted at midslope elevation.

Photo Orientation:

View to west from N47° 14’ 13.24”/W068° 42’ 19.02”.

Photo Date:

9/27/2016

SITE E – PHOTO E1

Description:

Existing rip rap slope placed at new Ft. Kent, ME - Clair, NB international bridge over St. John River. Observations:

- Slope Height ~15-20 ft (vertical)
- Slope Angle: ~27° (~1V:1.75H)
- Rip-Rap: Light, mostly 1.5’x1.5’x1’ and smaller (metalimestone)
- Rip-Rap Thickness: unknown
- Slope toe at river edge

Photo Orientation:

View to northeast from N47° 14’ 55.83”/W068° 36’ 08.29”.

Photo Date:

9/27/2016

Appendix B – Riprap Slope Photographs

SITE E – PHOTO E2

Description:

View to southwest of rip rap placed at northeast corner of southeast bridge abutment.

Photo Orientation:

View to southwest from N47° 14’ 55.83”/W068° 36’ 08.29.

Photo Date:

9/16/2016

SITE E – PHOTO E3

Description:

Close up of metalimestone rip rap blocks. Note general equigranular nature of rip rap blocks and coarseness of broken rock surfaces. Motel keys for scale.

Photo Orientation:

Crest of slope at N47° 14’ 55.83”/W068° 36’ 08.29.

Photo Date:

9/27/2016

APPENDIX C

Geologic Mapping

APPENDIX C.1

Allagash Geologic Mapping

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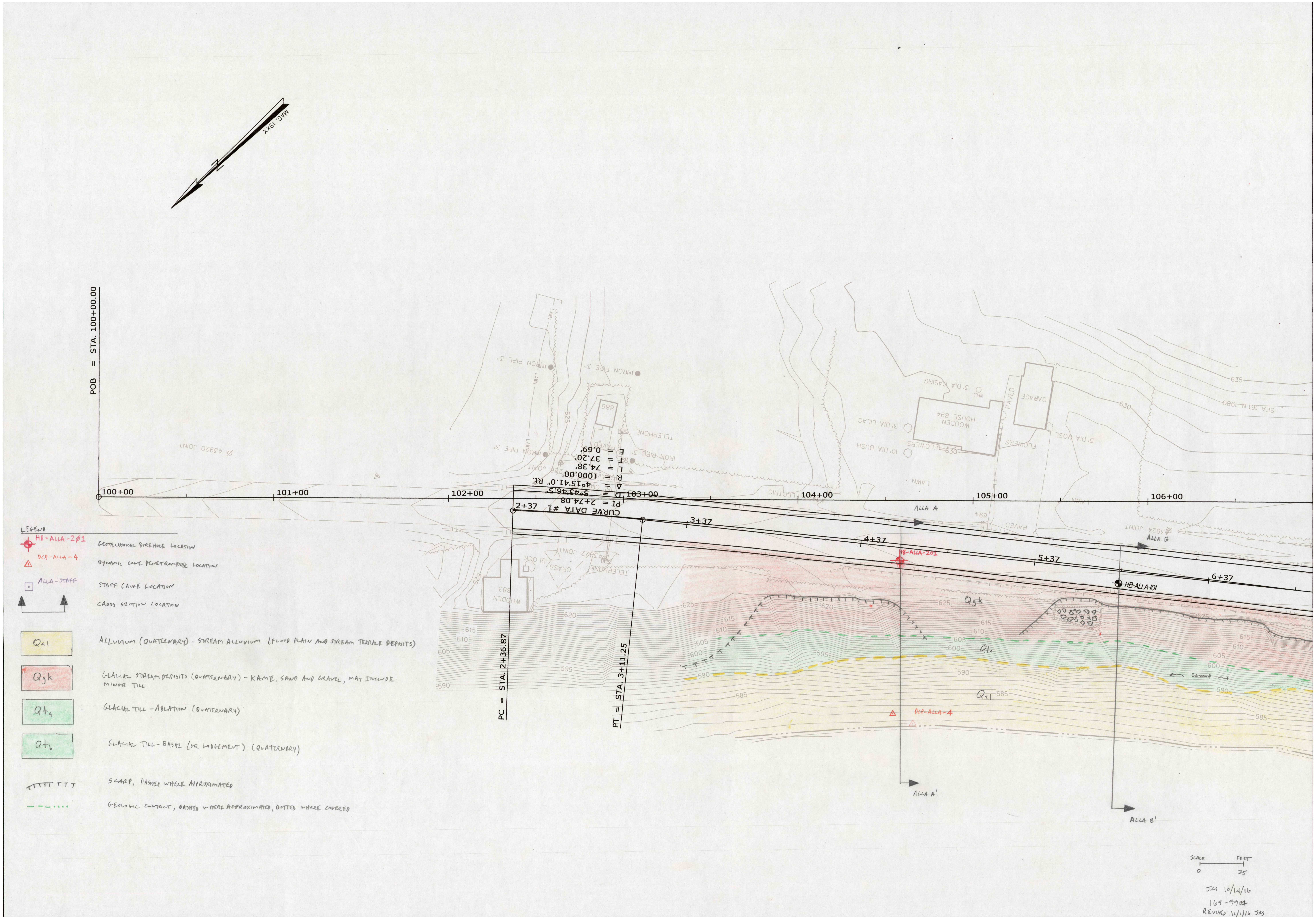


LEGEND

HB-ALLA-2Ø1	GEOTECHNICAL BOREHOLE LOCATION
DCP-ALLA-4	DYNAMIC CONE PENETROMETER LOCATION
ALLA-STAFF	STAFF GAUGE LOCATION
	CROSS SECTION LOCATION
Qal	ALLUVIUM (QUATERNARY) - STREAM ALLUVIUM (FLOOD PLAIN AND STREAM TERRACE DEPOSITS)
Qgk	GLACIAL STREAM DEPOSITS (QUATERNARY) - KAME, SAND AND GRAVEL, MAY INCLUDE MINOR TILL
Qt_a	GLACIAL TILL - ABLATION (QUATERNARY)
Qt_b	GLACIAL TILL - BASAL (OR LODGEMENT) (QUATERNARY)
TTTTTT T T T	SCARP, DASHED WHERE APPROXIMATED
— — —	GEOLOGIC CONTACT, DASHED WHERE APPROXIMATED, DOTTED WHERE COVERED

SCALE 0 — 25 FEET

JRS 10/14/16
165-9907
REVISED 11/1/16 JRS

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2019-03-28		JRS	MPB	JDL	MSP

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION

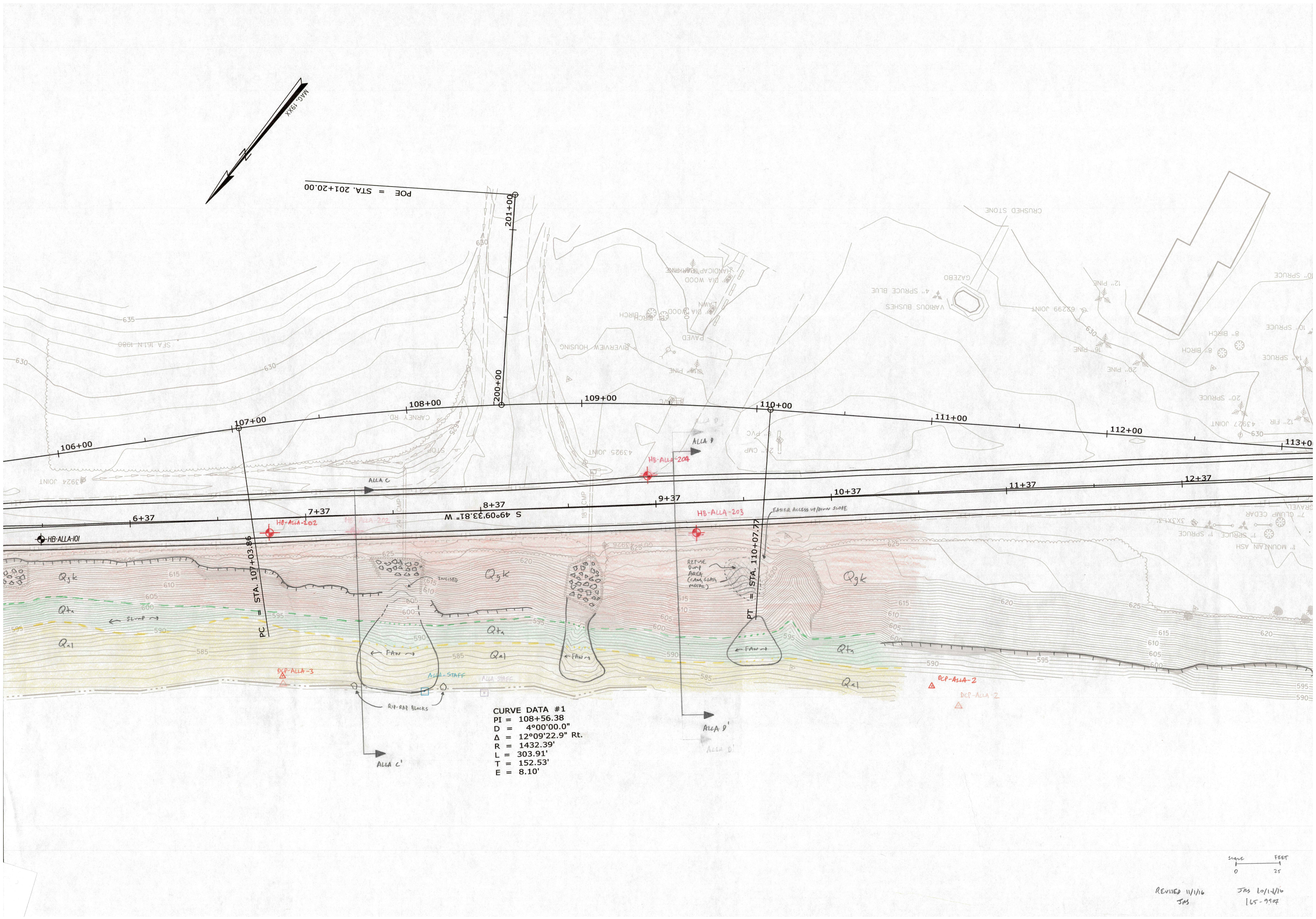
CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

PROJECT
ALLAGASH SLOPE STABILIZATION
ALLAGASH, MAINE

TITLE
ALLAGASH GEOLOGIC MAPPING (SHEET 1 OF 3)

PROJECT NO. 165-9907
PHASE 4
REV. A
FIGURE C.1.1

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D



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PI = 108+56.38
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Δ = 12°09'22.9" Rt.
R = 1432.39'
L = 303.91'
T = 152.53'
E = 8.10'

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2019-03-28		JRS	MPB	JDL	MSP

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MAINE DEPARTMENT OF TRANSPORTATION

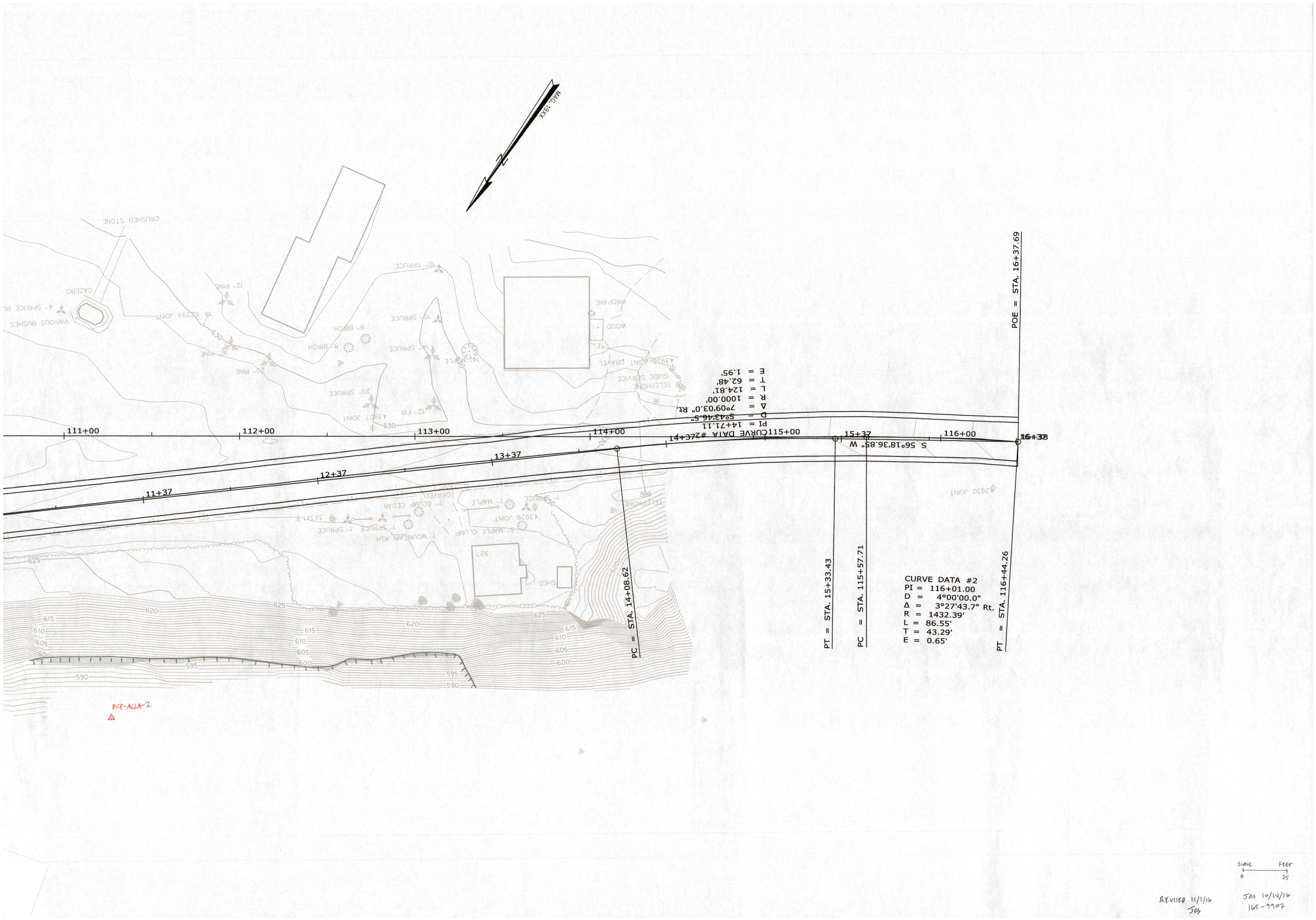
CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

PROJECT
ALLAGASH SLOPE STABILIZATION
ALLAGASH, MAINE

TITLE
ALLAGASH GEOLOGIC MAPPING (SHEET 2 OF 3)

PROJECT NO. 165-9907
PHASE 4
REV. A
of
FIGURE C.1.2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
0 1 in



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T = 43.29'
E = 0.65'

REVISED 11/1/16
JRS

JRS 10/14/16
165-9907

A	2019-03-28		JRS	MPB	JDL	MSP
REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED

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CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

PROJECT
ALLAGASH SLOPE STABILIZATION
ALLAGASH, MAINE

TITLE
ALLAGASH GEOLOGIC MAPPING (SHEET 3 OF 3)

PROJECT NO.
165-9907

PHASE
4

REV.
A

of

FIGURE
C.1.3

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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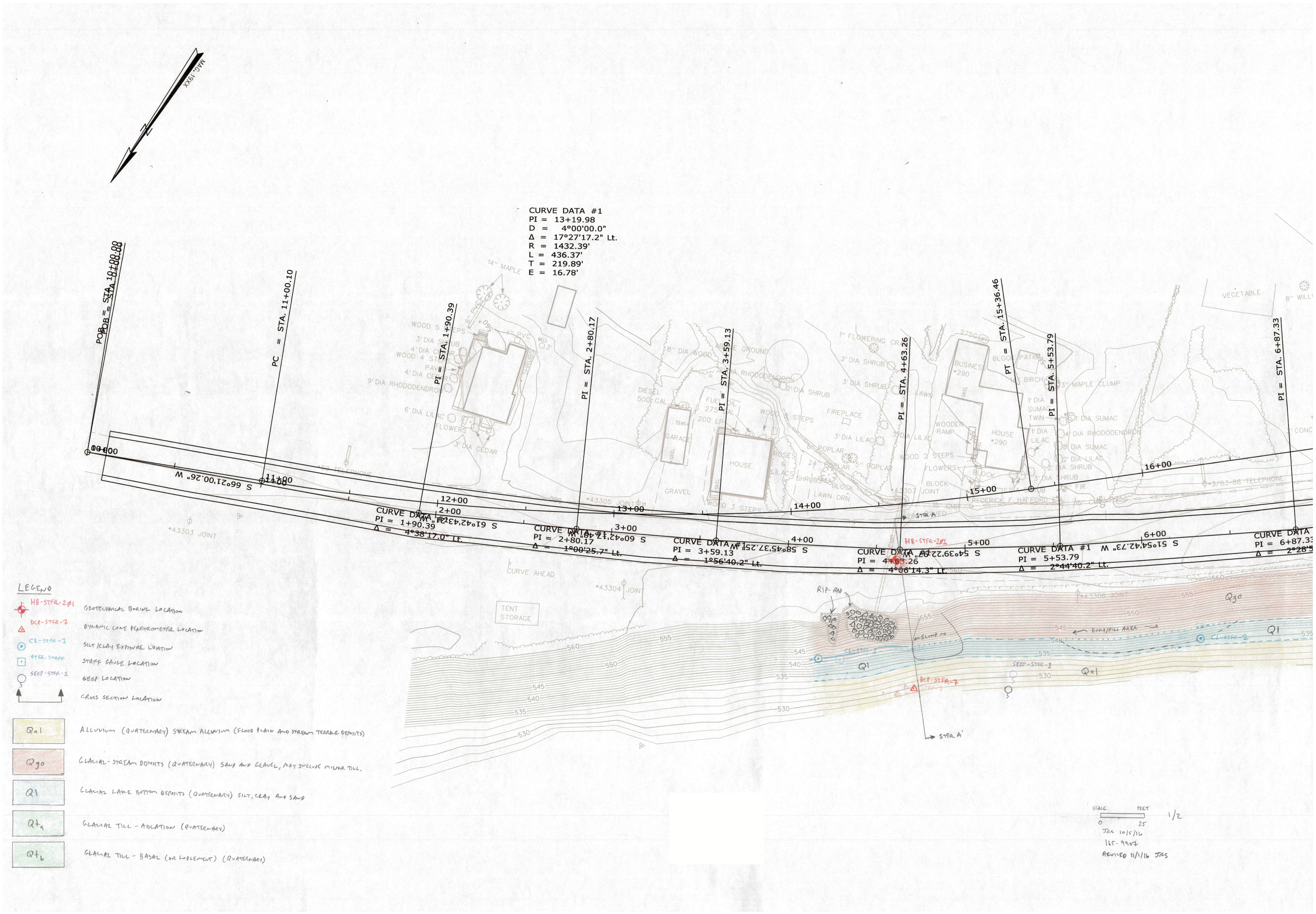
APPENDIX C.2

St. Francis Geologic Mapping



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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED

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MAINE DEPARTMENT OF TRANSPORTATION

CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

PROJECT
ALLAGASH SLOPE STABILIZATION
ALLAGASH, MAINE

TITLE
ST. FRANCIS GEOLOGIC MAPPING (SHEET 1 OF 2)

PROJECT NO. 165-9907
PHASE 4
REV. A
of
FIGURE C.2.1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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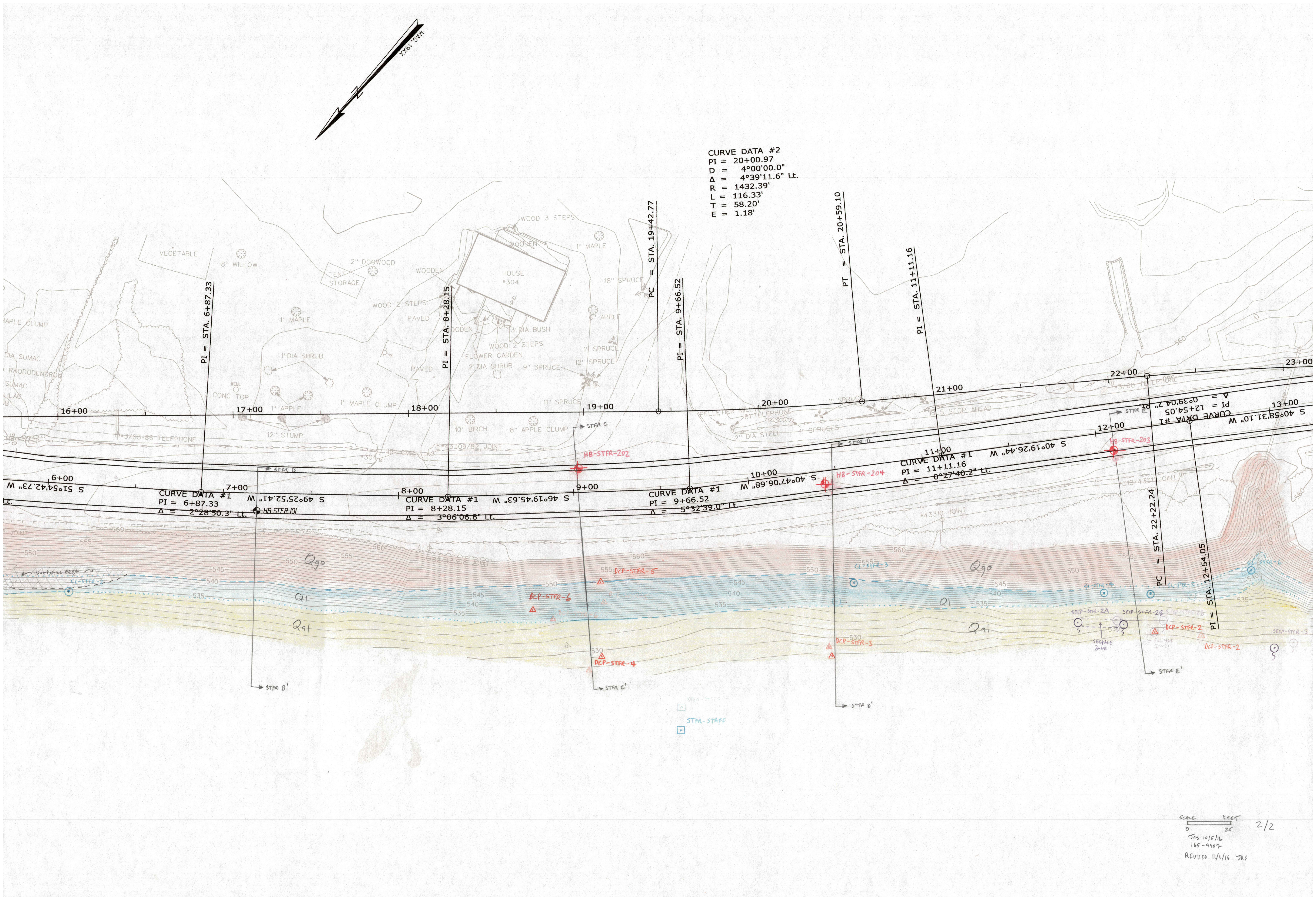


SCALE FEET
0 25
2/2
JRS 10/5/16
165-9907
REVISED 11/1/16 JRS

REV.	DATE	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2019-03-28		JRS	MPB	JDL	MSP
REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED

CLIENT
MAINE DEPARTMENT OF TRANSPORTATION

CONSULTANT
GOLDER
Freeport, Maine
174 South Freeport Road
Freeport, ME 04032
U.S.A.
[+1] (603) 668 0880
www.golder.com

PROJECT
ALLAGASH SLOPE STABILIZATION
ALLAGASH, MAINE

TITLE
ST. FRANCIS GEOLOGIC MAPPING (SHEET 2 OF 2)

PROJECT NO. 165-9907
PHASE 4
REV. A
of
FIGURE C.2.2

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

APPENDIX D

Geomorphic Assessment

Field Geology Services
Fluvial Geomorphology
P.O. Box 985 Farmington, ME 04938 207.491.9541
jfield@field-geology.com www.field-geology.com

February 2, 2017

Via Electronic Mail

Mark S. Peterson, P.E.
Golder Associates Inc.
174 South Freeport Road, Suite 2D
Freeport, Maine 04032

Re: Geomorphic assessment of St. John River in Allagash and St. Francis, ME

Dear Mr. Peterson:

This letter shall serve as a memorandum discussing the results of a geomorphic assessment of the St. John River at sites of bank erosion that are threatening Route 161 in Allagash and St. Francis, ME. The purpose of the assessment was to establish the morphological condition of the river near the bank erosion sites to provide clues to the causes, potential severity, and possible remedies of the erosion. The assessment consisted of a site visit to both locations on September 26, 2016, examination of archival data at the Allagash Historical Society, review of topographic maps and aerial photographs available on Google Earth, and analysis of topographic surveys, hydraulic modeling, ice jam information, and geological mapping provided by Golder Associates and Maine Department of Transportation (DOT). The findings from these different aspects of the geomorphic assessment are integrated into the discussion of the two sites provided below:

Allagash site

The approximately 40-foot high steep bank at the Allagash Site is partially vegetated (Figure 1) with several narrow isolated planar slip failures observed near the top of the bank that appear to align with where local drainage is concentrated (Figure 2). A more gently sloping colluvial slope composed of material eroded from upslope has developed at the base of the bank (Figure 1 – red arrow highlights the top of the colluvial slope). The colluvium has likely been present for several years and is unlikely to be removed by a single flood, thus serving to buttress the base of the bank from direct fluvial attack and undermining. Therefore, erosion at the site is likely driven by scour occurring above the top level of the colluvial slope. While vegetation obscures ongoing erosion over most of the bank face, repeat surveys of the site by DOT indicate significant bank retreat focused in the area just above the colluvial slope. This portion of the bank aligns with a geologic contact between permeable glacial outwash sediments above and a less permeable glacial till below. (Geological mapping at both sites was completed by Golder Associates Inc staff.) Groundwater seeps developed along this contact would tend to destabilize the bank just above the colluvial slope, but no evidence of seeps was seen during the site visit completed in the midst of a long dry spell. While the colluvial slope was above the water level during the site visit, the St. John River rises above the colluvium during flood stage. In addition to flood waters flowing against the bank above the colluvial slope, ice jams are a common occurrence on the St. John River as documented at the

Allagash Historical Society and in the U.S. Army Corps of Engineers ice jam database (see http://icejams.crrel.usace.army.mil/). Consequently, the colluvial slope, by buttressing the base of the bank, may prevent potentially catastrophic bank failures, but persistent and, over time, significant erosion still occurs through fluvial, groundwater, and ice attack on the bank above the colluvial slope.

The Allagash site is situated just downstream of the confluence with the Allagash River and, in some respects, can be considered to be more on the Allagash River than the St. John River as the main channel of the St. John River is separated from the site by a large gravel bar (Figure 3). While high flows do overtop the bar and impinge on the eroding bank at the site, hydraulic modeling shows that the flow velocities are reduced by the site, compared to further upstream and downstream, due to the flow spreading out over a wider area (Figure 4). Two conditions near the site increase the potential for the current channel configuration to be rearranged and greater erosive forces to be redirected towards the site. First, the Allagash River supplies large volumes of gravel to the river that could result in the redirection of flow as new gravel bars form or existing ones enlarge. Second, the valley constriction immediately downstream of the site (Figure 3) will enhance gravel deposition as a backwatering effect, with a consequent reduction in flow velocities, likely occurs upstream of the constriction during floods. Consequently, in recognition of the potential influence of these conditions on bank erosion at the site, bank stabilization efforts should be designed to withstand the highest near-bank forces modeled in the area rather than the highest forces modeled at the site itself (Figure 4).

St. Francis site

The eroding bank at the St. Francis site is also an approximately 40-foot high steep bank (Figure 5). While some vegetation is present, the St. Francis site is bare over much of the bank face. In addition to the bare slopes, evidence for recent erosion on the slopes includes severely leaning trees and short near vertical head scarps below which bank material has slid downslope (Figure 6). The absence of individual well defined planar slip failures as at the Allagash Site is not because such slips have not occurred but rather because such slips have occurred along the entire slope such that the evidence of individual slips is no longer visible. A more gently sloping colluvial slope composed of material eroded from upslope has developed at the base of the bank and is wider and less steep than at the Allagash site (Figure 5 – red arrow highlights the top of the colluvial slope). Like the Allagash site, the colluvium has likely persisted for several years, thus serving to buttress the base of the bank from direct fluvial attack and undermining. Scour just above the top level of the colluvial slope has oversteepened the bank, leading to failure of the upper bank above as well. Repeat surveys of the site by DOT indicate that most of the bank above the colluvial slope has eroded with the portion immediately above the colluvium experiencing the greatest amounts of retreat. The area of greatest retreat also aligns with a geologic contact between permeable glacial outwash sediments above and less permeable glaciolacustrine deposits below. Groundwater seeps were observed during the site visit, despite being in the midst of a prolonged dry period, and may further contribute to instability where the greatest amount of bank erosion has occurred. While the colluvial slope was above the water level during the site visit, the St. John River rises above the colluvium during flood stage. In addition to flood waters flowing against the bank above the colluvial slope, ice jams are a common occurrence on the St. John River. A photographic log from a local resident documented an April 2014 ice jam alongside the St. Francis site (Figure 7). Consequently, as at the Allagash site, the colluvial slope, by buttressing the base of the bank, may prevent potentially catastrophic bank failures, but persistent and, over time, significant erosion still occurs through fluvial, groundwater, and ice attack on the bank above the colluvial slope.

The St. Francis site is situated just downstream of a valley constriction (Figure 8). A considerable amount of sediment is accumulating immediately upstream of the constriction where two large tributaries enter the river and supply a large volume of gravel. Both the large gravel supply and the limited transport capacity resulting from backwatering behind the constriction may have led to the formation of the overflow channel on the floodplain when the river channel may have been temporarily blocked by gravel (along with ice potentially). Some gravel does pass through the constriction as evidenced by the large bar across the river from the St. Francis site and may deflect flow towards the site. However, the constriction limits the amount of gravel that moves downstream such that rapid growth of the bar or complete reconfiguration of flow patterns near the site during a single flood are unlikely, standing in contrast to the Allagash site that is situated just upstream of a valley constriction. Consequently, the 100-year event velocities estimated by hydraulic modeling (Figure 9), although higher than at the Allagash site, are more likely to hold for the design life of any proposed bank stabilization efforts.

A considerable volume of gravel is present in the St. John River and contributes to the wide shallow nature of the channel at both sites. While the Allagash site may be particularly prone to the rearrangement of flow patterns associated with gravel deposition, the influence of gravel deposition must be considered in the bank stabilization efforts at both sites. For this reason, flow deflection structures at the base of the eroding banks, such as bendway weirs, may be particularly helpful in preventing flows from being redirected towards the sites due to gravel deposition. Bank stabilization will also need to include other bank treatments such as riprap given that erosion of the banks seems focused higher up the slopes where flow deflection structures will be less effective.

Please let me know if you have further questions regarding my assessment of the two sites on the Allagash River described above. Feel free to contact me at any time at 207-491-9541 or jfield@field-geology.com if you would like further assistance in the design, permitting, and implementation of the bank stabilization projects.

Sincerely,

John Field, PhD

Enclosures

Figure 1. Eroding bank at Allagash site.

Figure 2. Planar slip bank failure at the top of the bank at the Allagash site.

Figure 3. Google Earth image showing the relationship of the Allagash site to nearby features.

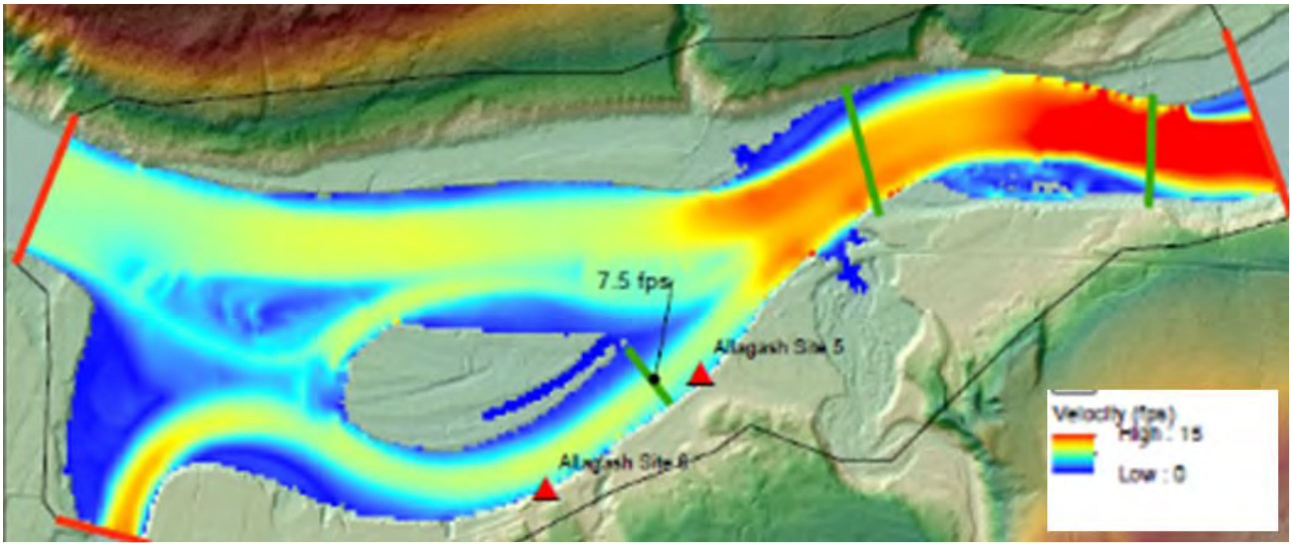


Figure 4. Modeled flow velocities for the 100-year event (without ice) near the Allagash site based on 2D TUFLOW modeling completed by Golder Associates Inc.

Figure 5. Eroding bank at St. Francis site.

Figure 6. Leaning tree and vertical head scarp (at top of bank) are evidence of recent erosion at the St. Francis site.

Figure 7. April 2014 ice jam alongside the St. Francis site.

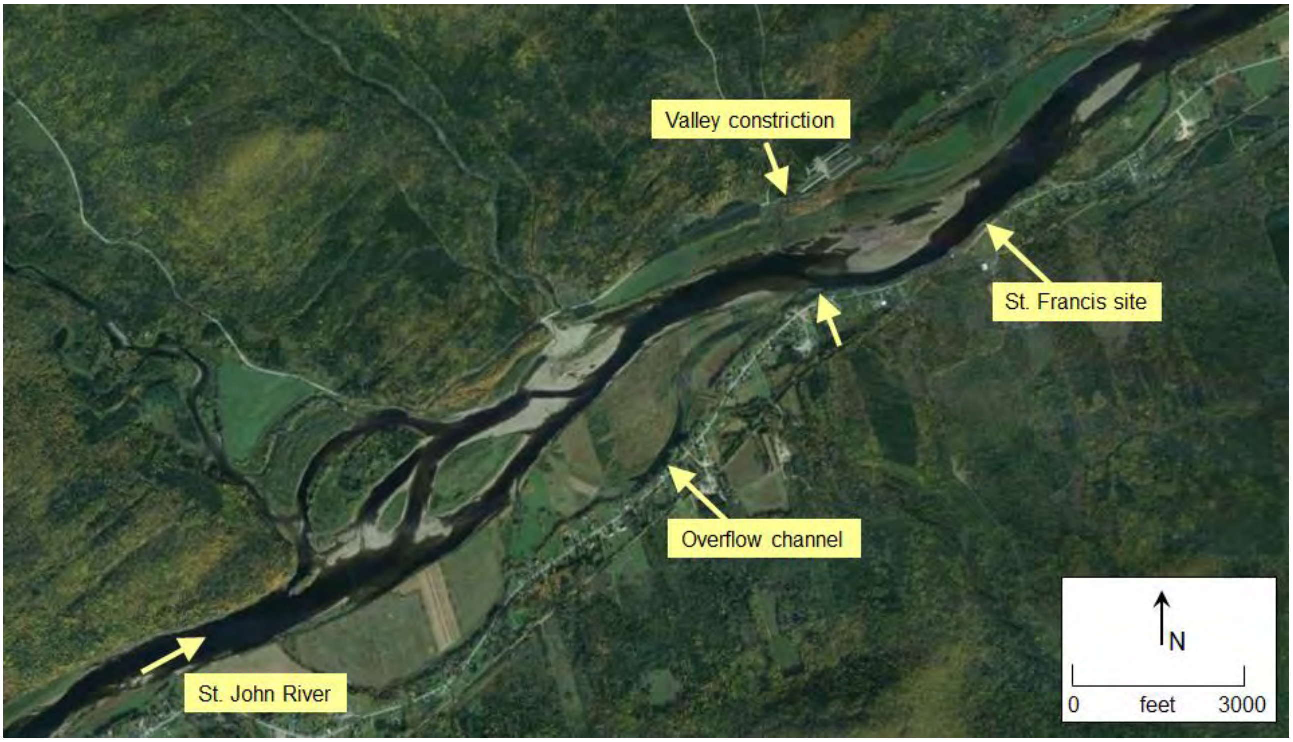


Figure 8. Google Earth image showing the relationship of the St. Francis site to nearby features.

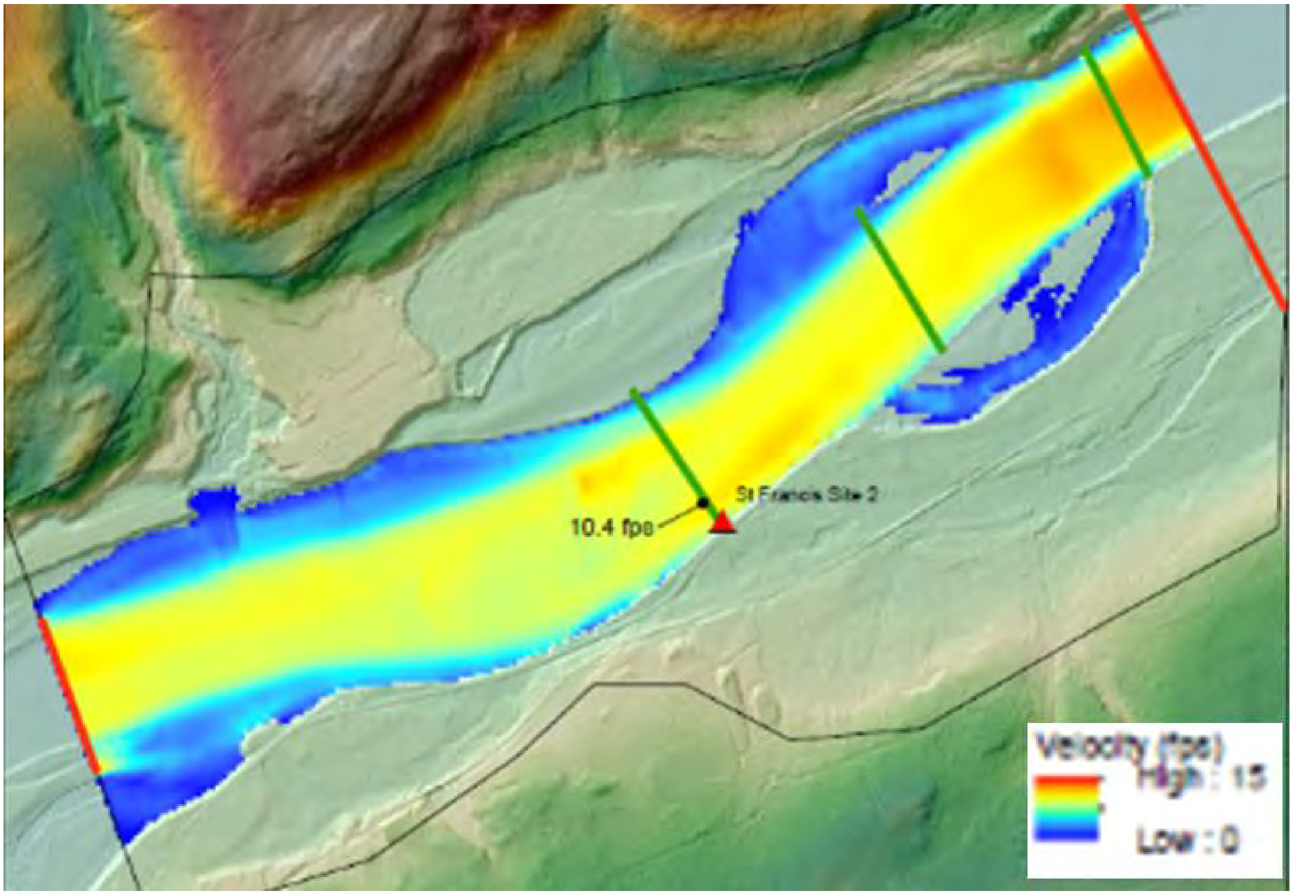


Figure 9. Modeled flow velocities for the 100-year event (without ice) near the St. Francis site based on 2D TUFLOW modeling completed by Golder Associates Inc.

APPENDIX E

Test Boring Logs

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-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-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):

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

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

Correlation of RQD to Rock Mass Quality

Rock Mass 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 mass quality (very poor, poor, etc.)
ref: ASTM D6032 and AASHTO Standard Specification for Highway Bridges, 17th Ed. Table 4.4.8.1.2A
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

October 2016

APPENDIX E.1

2014 Boring Logs

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 161 Slope Failer
Location: Allagash, Maine

Boring No.: HB-ALLA-101
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	627.5	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/23/2014; 08:00-13:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	5+86, 7.0 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed

Hammer Efficiency Factor: 0.867
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 (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.
0							SSA	627.2		4" PAVEMENT. 0.33	
5	1D/A	24/17	5.00 - 7.00	12/11/8/7	19	27				1D (5.0-6.0 ft bgs.) Brown, dry, medium dense, fine to coarse SAND, some gravel, little silt.	G#243132 A-1-b, SM WC=3.8%
								621.5		6.00 1D/A (6.0-7.0 ft bgs.) Olive-brown, moist, medium dense, fine to medium SAND, some silt.	G#243133 A-4, CL-ML WC=22.4%
								619.0		8.50 Cobble from 8.6-9.0 ft bgs.	
10	2D	24/19	10.00 - 12.00	10/10/10/12	20	29	32			Brown, moist, medium dense, fine to coarse SAND, some gravel, some silt.	G#243134 A-1-b, SM WC=6.7%
							42				
							43				
							37	614.5		13.00	
	3D	24/14	14.00 - 16.00	6/7/6/7	13	19	9			Brown, wet, medium dense, fine to coarse SAND, little gravel, little silt.	G#243135 A-2-4, SM WC=16.1%
15							19				
							42				
							74				
							69	609.5		18.00	
	4D	24/14	19.00 - 21.00	36/32/20/22	52	75	61			Brown, wet, very dense, gravelly fine to coarse SAND, some silt, occasional cobbles.	G#243136 A-1-b, GM WC=10.0%
20							69				
							147	606.5		21.00	
							95				
							82				
	5D	24/15	24.00 - 26.00	15/21/25/22	46	66	18			Grey-brown, wet, dense, gravelly fine to coarse SAND, some silt, (Till).	G#243137 A-1-b, SM
25											

Remarks:

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

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

Maine Department of Transportation

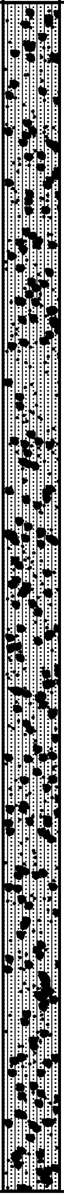
Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 161 Slope Failer
Location: Allagash, Maine

Boring No.: HB-ALLA-101
WIN: 17236.00

Driller: MaineDOT
Elevation (ft.) 627.5
Auger ID/OD: 5" Solid Stem
Operator: Giles/Daggett/Giles
Datum: NAVD88
Sampler: Standard Split Spoon
Logged By: B. Wilder
Rig Type: CME 45C
Hammer Wt./Fall: 140#/30"
Date Start/Finish: 7/23/2014; 08:00-13:00
Drilling Method: Cased Wash Boring
Core Barrel: N/A
Boring Location: 5+86, 7.0 ft Rt.
Casing ID/OD: NW
Water Level*: None Observed
Hammer Efficiency Factor: 0.867
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 (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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
25							21			Roller Coned ahead to 29.0 ft bgs.	WC=10.8%
							50				
							62				
							63				
	6D	24/16	29.00 - 31.00	21/15/15/16	30	43	56			Simuilar to above, except medium dense.	G#243138 A-1-a, GM WC=8.7%
30							62				
							96				
							140				
							71				
	7D	24/17	34.00 - 36.00	15/17/22/22	39	56	45			Similar to above, except dense.	G#243139 A-1-a, GM WC=8.1%
35							54				
							66				
							87				
							95				
	8D	24/16	39.00 - 41.00	20/21/21/23	42	61	39			Similar to above.	G#243140 A-1-b, SM WC=12.0%
40							79				
							101				
							101				
							129				
	9D	24/15	44.00 - 46.00	25/16/19/21	35	51	52			Similar to above.	G#243141 A-1-a, SM WC=9.2%
45							63				
							73				
							77				
							76				
50	10D	24/13	49.00 - 51.00	16/16/16/16	32	46	OPEN			Similar to above.	G#243142 A-1-b, GC

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 161 Slope Failer
Location: Allagash, Maine

Boring No.: HB-ALLA-101
WIN: 17236.00

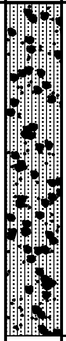
Driller:	MaineDOT	**Elevation (ft.)**	627.5	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/23/2014; 08:00-13:00	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	5+86, 7.0 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.867	**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 (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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
50							HOLE				WC=9.8%
55	11D	24/18	55.00 - 57.00	13/13/20/19	33	48				Similar to above.	G#243143 A-1-a, GW-GM WC=11.7%
								570.5		57.00 **Bottom of Exploration at 57.00 feet below ground surface.** NO REFUSAL	
60											
65											
70											
75											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 161 Slope Failer
Location: St. Francis, Maine

Boring No.: HB-STFR-101
WIN: 17236.10

Driller:	MaineDOT	**Elevation (ft.)**	562.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/24/2014; 08:00-11:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	7+19.3, 10.1 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.867	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:

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

Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
0							SSA	561.7		7½" PAVEMENT. 0.63 Brown, dry, gravelly fine to coarse SAND, some silt.	
								560.3		2.00	
5	1D	24/18	5.00 - 7.00	10/11/15/12	26	38				Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt.	G#243144 A-1-b, SW-SM WC=3.8%
10	2D	24/19	10.00 - 12.00	15/26/27/22	53	77	59			Grey-brown, wet, dense, gravelly fine to coarse SAND, little silt, occasional cobble.	G#243145 A-1-b, SW-SM WC=9.0%
							73				
							46				
							71	549.3		13.00	
	3D	24/18	14.00 - 16.00	21/22/19/14	41	59	18			Grey, wet, dense, gravelly fine to coarse SAND, some silt, occasional cobble, (Till).	G#243146 A-1-a, GW-GM WC=11.0%
15							59				
							66				
							106				
							84	544.3		18.00	
	4D	24/17	19.00 - 21.00	11/15/17/23	32	46	23			Brown, wet, dense, fine to coarse SAND, little gravel, little silt.	G#243147 A-2-4, SM WC=10.6%
20							59				
							95				
							121				
							104				
	5D	24/16	24.00 - 26.00	16/15/12/15	27	39	25			Simuilar to above, except medium dense.	G#243148 A-1-b, SW-SM
25											

Remarks:

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

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

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Route 161 Slope Failer
Location: St. Francis, Maine

Boring No.: HB-STFR-101
WIN: 17236.10

Driller:	MaineDOT	**Elevation (ft.)**	562.3	**Auger ID/OD:**	5" Solid Stem
Operator:	Giles/Daggett/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	7/24/2014; 08:00-11:30	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	7+19.3, 10.1 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.867	**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 (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							49				WC=11.3%
							52				
							53	534.3		28.00	
							86				
	6D	24/16	29.00 - 31.00	13/10/11/13	21	30	OPEN HOLE			Grey, wet, medium dense, gravelly fine to coarse SAND, little silt, occasional cobble.	G#243149 A-1-a, SW-SM WC=11.8%
30											
	7D	24/15	34.00 - 36.00	8/9/9/11	18	26				Similar o above.	G#243150 A-1-a, SW-SM WC=13.2%
35								526.3		36.00 **Bottom of Exploration at 36.00 feet below ground surface.** NO REFUSAL	
40											
45											
50											

Remarks:

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

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APPENDIX E.2

2016 Boring Logs

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-201

WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	628.91	**Auger ID/OD:**	5" solid stem
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Truck Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/19/16(9:00am), 9/20/16(10:00am)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 4+60, Offset: 7.4 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.943	**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 (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

Sample Information

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	628.5		5" Pavement 0.4	
	1D	24/16	1.00 - 3.00	7/23/26/29	49	77				Brown, damp, dense, gravelly fine to coarse SAND, little silt, occasional cobble (Fill).	
5	2D	24/21	5.00 - 7.00	15/14/15/16	29	46		623.9		5.0 Brown, damp, medium dense, gravelly fine to coarse SAND, little silt, occasional cobble (Glaciofluvial Deposit).	
							89				
	3D	24/21	9.00 - 11.00	13/11/10/8	21	33	164			Brown, wet, medium dense, gravelly fine to coarse SAND, trace silt, occasional small cobble (Glaciofluvial Deposit).	G#304151 WC: 9.7% A-1-a; SW-SM
10							55				
							47				
							49				
							49				
	4D	24/13	14.00 - 16.00	10/7/10/8	17	27	50			Brown, wet, medium dense, gravelly fine to coarse SAND, trace silt, occasional small cobble (Glaciofluvial Deposit).	
15							20				
							22				
							35				
							47				
	5D	24/17	19.00 - 21.00	7/7/6/6	13	20	49			Top 12": Brown, wet, medium dense, gravelly fine to coarse SAND, trace silt, occasional small cobble. Bottom 12": Brown, wet, stiff, SILT, trace sand (Glaciofluvial Deposit).	
20							12				G#304152 Specific Grav.: 2.62 WC: 24.1% A-4; CL
							30				
							70	606.4		22.5	
							111				
25	6D	24/14	24.00 - 26.00	25/26/25/25	51	80	104			Gray-brown, wet, very dense, gravelly fine to coarse SAND, some silt, (Ablation Till).	G#304169 LL=21, PL=18,

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole caved to 41.2 ft bgs after removing casing.

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: Evaluation and Stabilization of Unstable Slopes State Route 161

Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-201

WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	628.91	**Auger ID/OD:**	5" solid stem
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Truck Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/19/16(9:00am), 9/20/16(10:00am)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 4+60, Offset: 7.4 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:

D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample 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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
25							31				PI=2 WC: 21.3% A-4; ML
							77				
							81				
							94				
	7D	24/14	29.00 - 31.00	29/31/37/31	68	107	163			Brown, wet, very dense, fine to coarse GRAVEL, little silt, occasional small cobble (Ablation Till).	
30							67				
							86				
							82				
							116				
	8D	24/15	34.00 - 36.00	24/34/42/28	76	119	158			Brown, wet, very dense, fine to coarse sandy GRAVEL, little silt, occasional small cobble (Ablation Till). Roller cone ahead to 40.0 ft bgs then drove casing.	G#304153 WC: 7.8% A-1-a; GW-GM
35							40				
							24				
							37				
							36				
	9D	24/14	39.00 - 41.00	19/23/24/26	47	74	32			Brown, wet, dense, fine to coarse sandy GRAVEL, little silt, occasional small cobble (Ablation Till). Roller cone ahead to 44.0 ft bgs then drove casing.	
40							27				
							59				
							51				
							57				
	MD	6/0	44.00 - 44.50	70/6"	R		95	584.4		No recovery 44.5	
45							OPEN	583.8		Cobble. 45.1	
50											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole caved to 41.2 ft bgs after removing casing.

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-201
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	628.91	**Auger ID/OD:**	5" solid stem
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Truck Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/19/16(9:00am), 9/20/16(10:00am)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 4+60, Offset: 7.4 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	None Observed
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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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

	Sample Information										
Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
50	10D	24/14	50.00 - 52.00	21/17/14/16	31	49				Brown, wet, dense, fine to coarse sandy GRAVEL, little silt, occasional small cobble (Ablation Till).	
								576.9		52.0	
										Bottom of Exploration at 52.0 feet below ground surface.	
55											
60											
65											
70											
75											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole caved to 41.2 ft bgs after removing casing.

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Maine Department of Transportation

Soil/Rock Exploration Log

US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161

Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-202

WIN: 17236.00

Driller:	New England Boring	**Elevation (ft.)**	627.87	**Auger ID/OD:**	5" solid stem
Operator:	C. Dupuis	**Datum:**	NAV88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/19/16(12:15pm)-9/21/16(4:30pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 7+17, Offset: 8.1 ft RT	**Casing ID/OD:**	HW	**Water Level*:**	46.3 ft bgs
Hammer Efficiency Factor:	0.569	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:

D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
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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 (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

	Sample Information										
Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA			6" PAVEMENT.	
	1D	24/14.5	1.00 - 3.00	8/13/15/23	28	27		626.9		1.0 Brown with some rust coloring, damp, medium dense, fine to medium SAND, little gravel, little silt, trace brown organics. Gray rock fragments in the bottom 6" of the spoon (Fill).	
5	2D	24/13	5.00 - 7.00	12/18/17/24	35	33	48	622.9		5.0 Tan to brown, dry, dense, fine to coarse SAND, little gravel, little silt. Piece of gravel in the tip of spoon (Glaciofluvial Deposit).	
							52				
							66				
							70				
							65				
10	3D	24/11	10.00 - 12.00	12/12/9/12	21	20	12			Brown, damp, medium dense, fine to coarse SAND, little gravel, little silt (Glaciofluvial Deposit).	G#304154 WC: 13.8 % A-1-b; SM
							30				
							44				
							50				
							63				
15	4D	24/11	15.00 - 17.00	11/19/39/15	58	55	28			Brownish gray, wet, very dense, gravelly fine to coarse SAND, little silt, fractured gravel throughout (Glaciofluvial Deposit).	
							52				
							35				
							40				
							66				
20	5D	24/11	20.00 - 22.00	17/22/28/23	50	47	19			Brownish gray, wet, dense, GRAVEL, some fine to coarse sand, trace silt, trace clay bonded to gravel. Gravel is subrounded to subangular (Glaciofluvial Deposit).	G#304155 WC: 5.6% A-1-a; GW-GM
							83				
							55				
							70				
25							89				

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water levels: Dry - Casing at 15 ft bgs (2:00pm 9/19/16); 24.2 ft bgs - Casing at 51 ft bgs (2:00pm 9/20/16); 33.3 ft bgs - Casing at 51 ft bgs (7:40am 9/21/16); 46.3 ft bgs - Read in standpipe 9/21/16; 46.5 ft bgs - Read in standpipe 9/26/16; 46.5 ft bgs - Read in standpipe 9/27/16
3. Well installation details: Screen installed from 55 to 30 ft bgs.; 1S Hollison Sand to 28 ft bgs.; Bentonite plug from 28 to 25 ft bgs.; Rest of the hole is backfilled with partial bags of sand and cuttings.

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Evaluation and Stabilization of Unstable Slopes State Route 161 **Location:** St. Francis and Allagash, Maine	**Boring No.:** HB-ALLA-202 **WIN:** 17236.00

Driller:	New England Boring	**Elevation (ft.)**	627.87	**Auger ID/OD:**	5" solid stem
Operator:	C. Dupuis	**Datum:**	NAV88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/19/16(12:15pm)-9/21/16(4:30pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 7+17, Offset: 8.1 ft RT	**Casing ID/OD:**	HW	**Water Level*:**	46.3 ft bgs
Hammer Efficiency Factor:	0.569	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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WC = Water Content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

	Sample Information										
Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	6D		25.00 - 27.00	20/23/25/21	48	46	30			Brown to dark gray, wet, dense, GRAVEL, some fine to coarse sand, trace silt, trace clay. Gravel is subrounded to subangular. Gravel stuck in tip of spoon. Some brick-red colored weathering around select pieces of gravel (Glaciofluvial Deposit).	
							76				
							66				
							83				
							81				
30	7D	24/11	30.00 - 32.00	14/21/19/15	40	38	39			Brown to dark gray, wet, dense, GRAVEL, some fine to coarse sand, trace silt. Gravel is subrounded to subangular (Glaciofluvial Deposit).	G#304156 WC: 20.8 % A-1-a; GW-GM
							61				
							56				
							60				
							102				
35	8D	24/9.5	35.00 - 37.00	15/21/15/11	36	34	41			Brownish gray, wet, dense, GRAVEL, some fine to coarse sand, trace clay. Gravel is subrounded to subangular (Glaciofluvial Deposit).	
							57				
							51				
							61				
							50				
40	9D	24/11	40.00 - 42.00	17/15/16/17	31	29	53			Brown, saturated, medium dense, fine to medium SAND, little silt, trace gravel (Glaciofluvial Deposit).	G#304157 WC: 17.3 % A-2-4; SM
							78				
							95				
							112	584.9		43.0	
							133				
45	10D	24/9	45.00 - 47.00	22/43/32/30	75	71	92			Gray to orange brown, damp to wet, very dense, fine to coarse SAND, little gravel, little clay. Material is bonded by the clay in an unsorted matrix. Rock in tip of spoon (Ablation Till).	
							100				
							89				
							71				
50							69				

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water levels: Dry - Casing at 15 ft bgs (2:00pm 9/19/16); 24.2 ft bgs - Casing at 51 ft bgs (2:00pm 9/20/16); 33.3 ft bgs - Casing at 51 ft bgs (7:40am 9/21/16); 46.3 ft bgs - Read in standpipe 9/21/16; 46.5 ft bgs - Read in standpipe 9/26/16; 46.5 ft bgs - Read in standpipe 9/27/16
3. Well installation details: Screen installed from 55 to 30 ft bgs.; 1S Hollison Sand to 28 ft bgs.; Bentonite plug from 28 to 25 ft bgs.; Rest of the hole is backfilled with partial bags of sand

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-202
WIN: 17236.00

Driller:	New England Boring	**Elevation (ft.)**	627.87	**Auger ID/OD:**	5" solid stem
Operator:	C. Dupuis	**Datum:**	NAV88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/19/16(12:15pm)-9/21/16(4:30pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 7+17, Offset: 8.1 ft RT	**Casing ID/OD:**	HW	**Water Level*:**	46.3 ft bgs
Hammer Efficiency Factor:	0.569	**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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
50	11D	24/13	50.00 - 52.00	35/24/26/36	50	47	OPEN			Gray, wet to saturated, very dense, gravelly fine to coarse SAND, little clay. Gravel is weathered. Material is bonded by clay in unsorted matrix (Ablation Till).	G#304158 Sp. G=2.67 WC: 10.4 % A-1-b; SC-SM
55	12D	24/13	55.00 - 57.00	25/40/40/35	80	76	99			Top 12": Gray, wet to saturated, very dense, fine to coarse sandy SILT, little gravel Bottom 12": Gray, wet to saturated, very dense, SILT, some sand, little gravel, little clay, moderate plasticity (Ablation Till).	G#304160 Sp. G=2.70 WC: 11.6 % A-4; SC-SM
							125				
							94				
							74				
							75				
60	13D	24/15	60.00 - 62.00	32/38/27/28	65	62	OPEN			Top 12": Gray, satruated, very dense, fine SAND, some silt, trace gravel, trace clay bonding (Ablation Till).	
								566.9		61.0 Bottom 12": Gray, saturated, very dense, SILT, little fine sand, little silt, trace gravel, no structure (Basal Till).	
65	14D	13.5/10	65.00 - 66.13	39/50/50/1.5"	R					Gray, wet to saturated, very dense, SILT, little fine sand, trace gravel. Black rock fragment in tip of spoon (Basal Till).	G#304159 PI=NP Sp. G=2.65 WC: 15.7 % A-4; ML
70	15D	3/3	70.00 - 70.25	50/3"	R					Gray, moist to damp, very dense, SILT, some fine sand, trace gravel, trace clay (Basal Till).	
75											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water levels: Dry - Casing at 15 ft bgs (2:00pm 9/19/16); 24.2 ft bgs - Casing at 51 ft bgs (2:00pm 9/20/16); 33.3 ft bgs - Casing at 51 ft bgs (7:40am 9/21/16); 46.3 ft bgs - Read in standpipe 9/21/16; 46.5 ft bgs - Read in standpipe 9/26/16; 46.5 ft bgs - Read in standpipe 9/27/16
3. Well installation details: Screen installed from 55 to 30 ft bgs.; 1S Hollison Sand to 28 ft bgs.; Bentonite plug from 28 to 25 ft bgs.; Rest of the hole is backfilled with partial bags of sand

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: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-202

WIN: 17236.00

Driller:	New England Boring	**Elevation (ft.)**	627.87	**Auger ID/OD:**	5" solid stem
Operator:	C. Dupuis	**Datum:**	NAV88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/19/16(12:15pm)-9/21/16(4:30pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 7+17, Offset: 8.1 ft RT	**Casing ID/OD:**	HW	**Water Level*:**	46.3 ft bgs
Hammer Efficiency Factor:	0.569	**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.
75	16D	3/3	75.00 - 75.25	50/3"	R					Gray, damp, very dense, gravelly fine SAND, some silt, trace clay (Basal Till).		
80	17D	4/2	80.00 - 80.33	55/4"	R			547.9		Dark gray rock fragments in tip of spoon. Suspected boulder.	80.0	
								545.9		**Bottom of Exploration at 82.0 feet below ground surface.**	82.0	
85												
90												
95												
100												

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water levels: Dry - Casing at 15 ft bgs (2:00pm 9/19/16); 24.2 ft bgs - Casing at 51 ft bgs (2:00pm 9/20/16); 33.3 ft bgs - Casing at 51 ft bgs (7:40am 9/21/16); 46.3 ft bgs - Read in standpipe 9/21/16; 46.5 ft bgs - Read in standpipe 9/26/16; 46.5 ft bgs - Read in standpipe 9/27/16
3. Well installation details: Screen installed from 55 to 30 ft bgs.; 1S Hollison Sand to 28 ft bgs.; Bentonite plug from 28 to 25 ft bgs.; Rest of the hole is backfilled with partial bags of sand

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:** Evaluation and Stabilization of Unstable Slopes State Route 161 **Location:** St. Francis and Allagash, Maine	**Boring No.:** HB-ALLA-203 **WIN:** 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	626.73	**Auger ID/OD:**	5" solid stem
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/20/16(10:00am)-9/21/16(10:00am)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 9+59, Offset: 17.2 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	35.0 ft bgs
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
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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 (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 Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)			
0	1D	24/16	0.00 - 2.00	2/2/7/7	9	14	SSA			Brown, damp, loose, fine to coarse SAND, some gravel, some silt. Upper 2" is sod and grass (Glaciofluvial Deposit).	
5	2D	24/16	5.00 - 7.00	2/5/7/11	12	19				Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt, trace clay. (Glaciofluvial Deposit).	G#304161 Sp. G=2.66 WC: 8.6% A-1-b; SC-SM
10	3D	24/18	10.00 - 12.00	14/24/23/35	47	74				Brown, damp, dense, gravelly fine to coarse SAND, little silt, occasional small cobble (Glaciofluvial Deposit).	
	4D	24/20	14.00 - 16.00	8/8/13/20	21	33				Brown, damp, medium dense, fine to coarse SAND, some gravel, little silt (Glaciofluvial Deposit).	
15							33				
							42				
							60				
							60				
	5D	24/12	19.00 - 21.00	10/11/11/9	22	35	77			Gray-brown, wet, medium dense, gravelly fine to coarse SAND, little silt (Glaciofluvial Deposit).	G#304162 WC: 9.5% A-1-a; SW-SM
20							23				
							36				
							57				
							66				
25	6D	24/15	24.00 - 26.00	14/14/11/11	25	39	98			Gray-brown, wet, medium dense, gravelly fine to coarse SAND, little silt (Glaciofluvial Deposit).	

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water level at end of drilling at 35.0 ft bgs.
3. Hole caved to 38.3 ft bgs after casing was removed.
4. No water in the hole after casing was removed.

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: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-203

WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	626.73	**Auger ID/OD:**	5" solid stem
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/20/16(10:00am)-9/21/16(10:00am)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 9+59, Offset: 17.2 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	35.0 ft bgs
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = 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							29				
							47				
							44				
							106	598.4		28.3 Cobble. Roller cone ahead to 29 ft bgs.	
	7D	24/17	29.00 - 31.00	12/13/20/24	33	52	119	597.7		29.0 Gray-brown, wet, dense, gravelly fine to coarse SAND, lttle silt, occasional small cobble (Ablation Till).	
30							54				
							61				
							89				
							120				
	8D	24/12	34.00 - 36.00	22/35/31/30	66	104	131			Gray-brown, wet, very dense, gravelly fine to coarse SAND, little silt, occasional small cobble (Ablation Till). Roller cone ahead to 39.0 ft bgs.	
35							15				
							15				
							32				
							20				
	9D	24/13	39.00 - 41.00	11/22/20/20	42	66	51			Gray-brown, wet, dense, fine to coarse SAND, some gravel, little silt, trace clay, occasional small cobble (Ablation Till). Roller cone ahead to 44.0 ft bgs.	G#304163 Sp. G=2.65 WC: 10.1% A-1-b; SC-SM
40							44				
							55				
							39				
							51				
	10D	24/17	44.00 - 46.00	14/17/17/15	34	53	77			Gray-brown, wet, dense, gravelly fine to coarse SAND, little silt, occasional small cobble (Ablation Till).	
45							OPEN				
							↓				
50	11D	24/13	49.00 - 51.00	15/18/17/20	35	55				Gray, wet, dense, silty fine to coarse SAND, some gravel (Ablation Till).	

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water level at end of drilling at 35.0 ft bgs.
3. Hole caved to 38.3 ft bgs after casing was removed.
4. No water in the hole after casing was removed.

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: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-203
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	626.73	**Auger ID/OD:**	5" solid stem
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/20/16(10:00am)-9/21/16(10:00am)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 9+59, Offset: 17.2 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	35.0 ft bgs
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
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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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
50											
								574.7		52.0 **Bottom of Exploration at 52.0 feet below ground surface.**	
55											
60											
65											
70											
75											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water level at end of drilling at 35.0 ft bgs.
3. Hole caved to 38.3 ft bgs after casing was removed.
4. No water in the hole after casing was removed.

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: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-204
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	627.26	**Auger ID/OD:**	5" solid stem
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/21/16(10:30am)-9/21/16(3:30pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 9+33, Offset: 16.5 ft LT	**Casing ID/OD:**	NW	**Water Level*:**	16.0 ft bgs
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
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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 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 (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 Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)			
0	1D	24/16	0.00 - 2.00	7/11/11/10	22	35	SSA			Brown, damp, medium dense, gravelly fine to coarse SAND, little silt. Upper 2" Sod (Topsoil).	
5	2D	24/14	5.00 - 7.00	13/9/13/14	22	35				Brown, damp, medium dense, gravelly fine to coarse SAND, little silt (Glaciofluvial Deposit).	G#304164 WC: 4.6% A-1-b; SW-SM
10	3D	24/18	10.00 - 12.00	15/16/25/25	41	64				Brown, damp, medium dense, gravelly fine to coarse SAND, little silt (Glaciofluvial Deposit).	
							43				
							82	614.8 614.4		12.5 Cobble. Roller cone ahead to 14.0 ft bgs. 12.9	
							133				
	4D	24/17	14.00 - 16.00	10/16/21/22	37	58	105			Gray-brown, moist, dense, gravelly fine to coarse SAND, trace silt, (Glaciofluvial Deposit).	
15							34				
							72				
							218				
							169				
	5D	24/13	19.00 - 21.00	18/11/9/8	20	31	59			Gray-brown, moist, medium dense, gravelly fine to coarse SAND, trace silt (Glaciofluvial Deposit).	G#304165 WC: 10.5% A-1-a; SW-SM
20							27				
							88				
							49				
							52				
	6D	24/15	24.00 - 26.00	15/18/29/23	47	74	84			Gray-brown, moist, dense, gravelly fine to coarse SAND, little silt (Glaciofluvial Deposit).	
25											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole caved to 17.5 ft bgs after casing was removed.

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: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-ALLA-204

WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	627.26	**Auger ID/OD:**	5" solid stem
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/21/16(10:30am)-9/21/16(3:30pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	Station: 9+33, Offset: 16.5 ft LT	**Casing ID/OD:**	NW	**Water Level*:**	16.0 ft bgs
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = 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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
25							22				
							47				
							72				
							71				
	7D	24/16	29.00 - 31.00	9/10/14/12	24	38	66	598.3		29.0 Brown, wet, medium dense, fine to coarse SAND, some gravel, little silt (Ablation Till). Roller cone ahead to 34.0 ft bgs.	
30							OPEN				
	8D	24/18	34.00 - 36.00	18/21/31/48	52	82				Gray-brown, wet, dense, gravelly SILT, little fine to coarse sand, trace clay, (Ablation Till).	G#304166 Sp. G=2.71 WC: 7.6% A-4; SC-SM
35											
	9D	24/14	39.00 - 41.00	11/22/30/66	52	82				Gray-brown, wet, dense, gravelly fine to coarse SAND, some silt, occasional cobbles (Ablation Till).	
40											
								586.3		41.0 **Bottom of Exploration at 41.0 feet below ground surface.**	
45											
50											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole caved to 17.5 ft bgs after casing was removed.

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: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-201
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	559.75	**Auger ID/OD:**	5" SSA
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/22/16(7:30am)-9/22/16(3:30pm)	**Drilling Method:**	Cased Wash Borehole	**Core Barrel:**	n/a
Boring Location:	Station: 4+61, Offset: 5.8 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	3.30 ft bgs
Hammer Efficiency Factor:	0.943	**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 (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	N60	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	559.3		5" of pavement. 0.4	
	1D	24/20	1.00 - 3.00	6/6/4/5	10	16				Brown, damp, loose, fine to coarse SAND, little gravel, little silt (Fill).	
5	2D	24/17	5.00 - 7.00	2/3/5/16	8	13		554.8		5.0 Brown, damp, loose, fine to coarse SAND, little gravel, little silt (Glaciofluvial Deposit).	G#304167 WC: 8.9% A-2-4; SM
10	3D	24/16	10.00 - 12.00	10/22/21/60	43	68				Brown, damp, dense, gravelly fine to coarse SAND, some silt, occasional small cobbles (Glaciofluvial Deposit).	
15	4D	24/20	15.00 - 17.00	5/10/8/10	18	28		544.8		15.0 Gray-brown, wet, medium dense, SILT, trace fine to medium sand (Glaciolacustrine Deposit).	G#304168 Sp. G=2.67 WC: 16.7% A-4; CL
							20				
							37				
							43				
	5D	24/18	19.00 - 21.00	8/8/11/9	19	30	42			Gray, wet, medium dense, SILT, trace gravel, trace fine to medium sand (Glaciolacustrine Deposit).	
20							14				
							30				
							23				
							26				
	6D	24/20	24.00 - 26.00	7/5/3/4	8	13	26			Gray, wet, medium stiff, SILT, trace fine sand (Glaciolacustrine Deposit).	
25											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole caved to 49.2 ft bgs upon removal of casing.
3. Water Level: 33.0 ft bgs - 3:30pm 9/22/16 open hole

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-201
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	559.75	**Auger ID/OD:**	5" SSA
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/22/16(7:30am)-9/22/16(3:30pm)	**Drilling Method:**	Cased Wash Borehole	**Core Barrel:**	n/a
Boring Location:	Station: 4+61, Offset: 5.8 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	3.30 ft bgs
Hammer Efficiency Factor:	0.943	**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 Information: 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							7			Roller coned ahead to 26 ft bgs.	
	V1						9	533.4		Vane would not push. 26.4	
							39				
							67				
	7D	24/15	29.00 - 31.00	10/11/11/13	22	35	73			Brown, wet, medium dense, fine to coarse SAND, little gravel, trace silt (Glaciofluvial Deposit). Roller coned ahead to 34.0 ft bgs.	
30							6				
							6				
							6				
							7				
	8D	24/16	34.00 - 36.00	10/12/14/17	26	41	10			Brown, wet, medium dense, fine to coarse SAND, little gravel, trace silt (Glaciofluvial Deposit). Roller coned ahead to 39.0 ft bgs.	G#304170 WC: 13.3% A-1-b; SW-SM
35							10				
							7				
							7				
							9				
	9D	24/13	39.00 - 41.00	11/13/12/10	25	39	21			Gray, wet, medium dense, gravelly fine to coarse SAND, some gravel, trace silt (Glaciofluvial Deposit).	
40							36				
							47				
							47				
							52				
	10D	24/14	44.00 - 46.00	11/13/15/13	28	44	48			Gray, wet, medium dense, gravelly fine to coarse SAND, some gravel, trace silt (Glaciofluvial Deposit).	
45							21				
							35				
							38				
							49				
50	11D	24/15	49.00 - 51.00	12/13/14/17	27	42	80			Gray, wet, medium dense, gravelly fine to coarse SAND, some gravel, trace silt (Glaciofluvial Deposit).	

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole caved to 49.2 ft bgs upon removal of casing.
3. Water Level: 33.0 ft bgs - 3:30pm 9/22/16 open hole

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-201
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	559.75	**Auger ID/OD:**	5" SSA
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/22/16(7:30am)-9/22/16(3:30pm)	**Drilling Method:**	Cased Wash Borehole	**Core Barrel:**	n/a
Boring Location:	Station: 4+61, Offset: 5.8 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	3.30 ft bgs
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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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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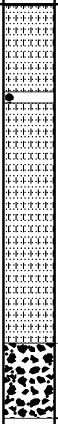
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field Vane Undrained Shear Strength (psf)
$S_{u(lab)}$ = Lab Vane Undrained Shear Strength (psf)
q_p = Unconfined Compressive 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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
50							OH			Roller cone ahead to 54.0 ft bgs.	
								507.5 507.2		52.3 Cobble. 52.6	
	12D	24/12	54.00 - 56.00	14/18/13/18	31	49				Gray, wet, medium dense, fine to coarse SAND, some gravel, trace silt (Glaciofluvial Deposit). Roller cone ahead to 59.0 ft bgs.	
55											
								500.8		59.0	
	13D	24/17	59.00 - 61.00	14/16/15/18	31	49				Gray, wet, dense, fine to coarse SAND, some gravel, trace silt (Ablation Till).	G#304171 WC: 11.8% A-1-b; SW-SM
60											
								498.8		61.0 **Bottom of Exploration at 61.0 feet below ground surface.**	
65											
70											
75											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole caved to 49.2 ft bgs upon removal of casing.
3. Water Level: 33.0 ft bgs - 3:30pm 9/22/16 open hole

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: Evaluation and Stabilization of Unstable Slopes State Route 161

Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-202

WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	563.57	**Auger ID/OD:**	5" SSA
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/26/16(11:35am)-9/28/16(1:51pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	n/a
Boring Location:	Station: 9+04, Offset: 13.2 ft LT	**Casing ID/OD:**	NW	**Water Level*:**	3.30 ft bgs
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

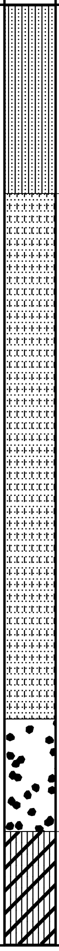
Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt

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 (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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows				
0	1D	24/17	0.00 - 2.00	15/16/11/10	27	42	SSA			Brown, damp, medium dense, gravelly fine to coarse SAND, some silt.	
5	2D	24/18	5.00 - 7.00	10/15/14/15	29	46		558.6		5.0 Brown, damp, medium dense, gravelly fine to coarse SAND, trace silt (Glaciofluvial Deposit).	G#304172 WC: 1.9% A-1-a; SW-SM
10	3D	24/19	10.00 - 12.00	11/39/32/27	71	112				Olive, wet, very dense, gravelly fine to coarse SAND, little silt (Glaciofluvial Deposit).	
							25				
							66				
							97				
	4D	24/14	14.00 - 16.00	13/12/9/12	21	33	152			Gray wet, medium dense, fine to coarse SAND, little gravel, little silt (Glaciofluvial Deposit).	
15							32				
							27				
							68				
							79				
	5D	24/1	19.00 - 21.00	22/32/30/27	62	97	92	544.6		19.0 Fragments of cobble stuck in tip of sampler.	
20							26				
							54				
							69	541.6		22.0	
							40				
25	V1/6D	24/19	24.00 - 26.00	5/8/7/9	15	24	46			Attemped field vane would not push. Gray, wet, stiff, SILT, little clay, trace gravel, trace fine sand,	G#304173 LL: 21; PL:19;



Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water Levels: 3.3 ft bgs - 3:15pm 9/26/16 casing at 40 ft bgs.; 6.6 ft bgs - 8:00am 9/28/16 casing at 40 ft bgs.; 33.2 ft bgs - 11:30am 9/28/16 open hole.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-202
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	563.57	**Auger ID/OD:**	5" SSA
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/26/16(11:35am)-9/28/16(1:51pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	n/a
Boring Location:	Station: 9+04, Offset: 13.2 ft LT	**Casing ID/OD:**	NW	**Water Level*:**	3.30 ft bgs
Hammer Efficiency Factor:	0.943	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
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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
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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
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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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
25							28		▨	(Glaciolacustrine Deposit).	PI: 2 Sp. G=2.69 WC: 18.9% A-4; ML
							42		▨		
							56		▨		
							68		▨		
	7D	24/20	29.00 - 31.00	9/8/10/11	18	28	19		▨	Gray, wet, medium dense, SILT, trace fine to medium SAND (Glaciolacustrine Deposit). Roller cone ahead to 34.0 ft bgs.	
30							12		▨		
							17		▨		
							18		▨		
							18		▨		
	8D	24/20	34.00 - 36.00	7/10/10/11	20	31	17		▨	Gray, wet, medium dense, SILT, trace fine to medium sand, trace clay, (Glaciolacustrine Deposit). Roller coned ahead to 39.0 ft bgs.	G#304174 Sp. G=2.66 WC: 20.4% A-4; ML
35							20		▨		
							29		▨		
							23		▨		
							21		▨		
	9D	24/21	39.00 - 41.00	5/6/7/11	13	20	22		▨	Gray, wet, medium dense, SILT, trace fine sand, trace clay (Glaciolacustrine Deposit). Roller coned ahead to 45 ft bgs.	
40							39		▨		
							42		▨		
							22		▨		
							25		▨		
							29		▨		
45	10D	24/13	45.00 - 47.00	8/15/16/14	31	49	37	518.6	▦	45.0 Gray, wet, dense, gravelly fine to coarse SAND, trace silt (Glaciofluvial Deposit).	G#304175 WC: 10.8% A-1-a; SW-SM
							58		▦		
							68		▦		
							64		▦		
50	11D	24/11	49.00 - 51.00	9/9/9/10	18	28	60		▦	Gray, wet, medium dense, gravelly fine to coarse SAND, little silt (Glaciofluvial Deposit).	

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water Levels: 3.3 ft bgs - 3:15pm 9/26/16 casing at 40 ft bgs.; 6.6 ft bgs - 8:00am 9/28/16 casing at 40 ft bgs.; 33.2 ft bgs - 11:30am 9/28/16 open hole.

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-202
WIN: 17236.00

Driller:	MaineDOT	**Elevation (ft.)**	563.57	**Auger ID/OD:**	5" SSA
Operator:	T. Daggett	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	B. Wilder	**Rig Type:**	Trailer Mounted CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/26/16(11:35am)-9/28/16(1:51pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	n/a
Boring Location:	Station: 9+04, Offset: 13.2 ft LT	**Casing ID/OD:**	NW	**Water Level*:**	3.30 ft bgs

Hammer Efficiency Factor: 0.943
Hammer Type: Automatic ☒ Hydraulic ☐ Rope & Cathead ☐

Definitions:
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MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample Attempt
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt

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SSA = Solid Stem Auger
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WOR/C = Weight of Rods or Casing
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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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
50							24			Roller coned ahead to 54 ft bgs.	
							21				
							36				
							42	510.6		53.0	
	12D	24/12	54.00 - 56.00	6/7/9/13	16	25	82			Gray, wet, medium dense, silty fine to coarse SAND, little gravel (Ablation Till). Roller coned ahead to 59.0 ft bgs.	
55							30				
							36				
							23				
							26				
	13D	24/14	59.00 - 61.00	6/13/16/12	29	46	30			Gray, wet, medium dense, fine to coarse SAND, some silt, little gravel (Ablation Till). Roller coned ahead to 64.0 ft bgs.	G#304201 Sp. G=2.69 WC: 8.9% A-2-4; SC-SM
60							OPEN				
	14D	12/12	64.00 - 65.00	65/56	R			499.6		64.0 Gray, wet, very dense, SILT, some gravel, some sand, (Basal Till). Roller coned ahead to 69 ft bgs.	
65											
	15D	24/14	69.00 - 71.00	23/29/35/43	64	101				Gray, wet, very dense, SILT, some gravel, some sand, (Basal Till).	G#304202 WC: 7.5% A-2-4; SM
70											
								492.6		71.0 **Bottom of Exploration at 71.0 feet below ground surface.**	
75											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Water Levels: 3.3 ft bgs - 3:15pm 9/26/16 casing at 40 ft bgs.; 6.6 ft bgs - 8:00am 9/28/16 casing at 40 ft bgs.; 33.2 ft bgs - 11:30am 9/28/16 open hole.

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: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-203
WIN: 17236.00

Driller:	New England Boring	**Elevation (ft.)**	562.86	**Auger ID/OD:**	5" SSA
Operator:	C. Dupuis	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart/B. Wilder	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/26/16(11:35am)-9/28/16(1:51pm)	**Drilling Method:**	Cased Wash Bore	**Core Barrel:**	NQ
Boring Location:	Station: 12+09, Offset: 11.0 ft RT	**Casing ID/OD:**	HW	**Water Level*:**	Perched (See Remarks)
Hammer Efficiency Factor: 0.569		**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 (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 Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)			
0	1D	24/16	0.00 - 2.00	9/19/17/16	36	34	SSA			Brown, dry to damp at 11", dense, fine to coarse SAND, little gravel, little silt, fractured piece of gray gravel in upper 1.5" of sample.	
5	2D	24/16	5.00 - 7.00	7/13/21/23	34	32		557.9		5.0 Brown to dark brown to gray, damp, dense, gravelly fine to coarse SAND, little silt (Glaciofluvial Deposit).	G#304203 WC: 1.9% A-1-b; SM
10	3D	24/20	10.00 - 12.00	18/15/10/12	25	24	NA			Top 9": Brown, to dark brown, damp, medium dense, fine to coarse SAND, some gravel, little silt. Bottom 15": Brown to gray, moist, medium dense, fine to medium SAND, trace gravel (Glaciofluvial Deposit).	
							51				
							60				
							59				
							54				
15	4D	24/9.5	15.00 - 17.00	11/19/21/19	40	38	19			Brownish-gray, wet, dense, fine to coarse SAND, some gravel, trace clay, trace silt (Glaciofluvial Deposit).	G#304204 Sp. G=2.65 WC: 6.0% A-1-b; SC-SM
							54				
							41				
							30				
							28				
20	5D	24/3	20.00 - 22.00	16/14/15/20	29	28	24			Gray, wet, medium dense, fine to coarse SAND, some gravel, little silt (Glaciofluvial Deposit).	
							50				
							45				
							30				
25							37				

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole collapsed to 70 ft when casing pulled.
3. Two wells installed: Well 1 screened from 40.0 to 50.0 ft bgs; Well 2 screened from 20.0-25.5 ft bgs.
4. Water Levels: 9.75 ft bgs - 9/26/16 4:50pm casing at 35 ft bgs; 10.5 ft bgs - 9/27/16 9:00am casing at 35 ft bgs; 24.3 ft bgs - 9/28/16 11:09am casing at 50 ft bgs; 9.15 ft bgs - 9/28/16 1:45pm Well 1; 39.89 ft bgs - 9/28/16 1:45pm Well 2; 9.16 ft bgs - 9/29/16 7:34am Well 1; 39.70 ft bgs - 9/29/16 7:35am Well 2

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-203
WIN: 17236.00

Driller:	New England Boring	**Elevation (ft.)**	562.86	**Auger ID/OD:**	5" SSA
Operator:	C. Dupuis	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart/B. Wilder	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/26/16(11:35am)-9/28/16(1:51pm)	**Drilling Method:**	Cased Wash Bore	**Core Barrel:**	NQ
Boring Location:	Station: 12+09, Offset: 11.0 ft RT	**Casing ID/OD:**	HW	**Water Level*:**	Perched (See Remarks)
Hammer Efficiency Factor:	0.569	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample Attempt
U = Thin Wall Tube Sample
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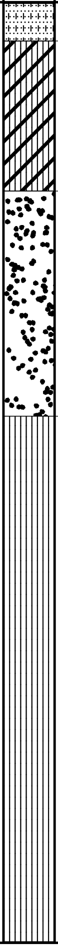
V = Field Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Field Vane Shear Test Attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = Weight of 140 lb. Hammer
WOR/C = Weight of Rods or Casing
WO1P = Weight of One Person
S_u = Peak/Remolded Field 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 Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
25	6D	24/15	25.00 - 27.00	14/9/4/6	13	12	34			Top 12": Gray, saturated, medium dense, fine to coarse SAND, little silt, trace gravel, trace clay. Thin fine sand laminae transitioning at 12"	
							23	536.9		26.0 Bottom 12": Gray, saturated, stiff, SILT, little clay, trace fine sand (Glaciolacustrine Deposit). PP = 2.75 tsf	G#304205 LL: 23; PL:22; PI: 1 Sp. G=2.62 WC: 21.7% A-4; ML
							44				
							52				
							86				
30	7D	24/11	30.00 - 32.00	19/19/19/16	38	36	55	532.9		30.0 Gray, wet, dense, fine to coarse SAND, some gravel, some silt, trace clay. 2" of fractured shale gravel at top of spoon (Ablation Till).	G#304206 Sp. G=2.70 WC: 9.3% A-2-4; SC-SM
							44				
							50				
							66				
							85				
35	8D	7/6	35.00 - 35.58	34/(50/1")	R		43			Gray, wet, very dense, fine to coarse SAND, some gravel, some silt, trace clay (Abaltion Till).	
							50	526.9		36.0	
							177				
							92				
							83				
40	9D	24/16	40.00 - 42.00	20/31/31/42	62	59	102			Gray, wet, very dense, silty fine to coarse SAND, little gravel (Basal Till). Roller cone ahead to 45.0 ft bgs.	
							35				
							26				
							48				
							33				
45	10D	24/19	45.00 - 47.00	26/38/44/54	82	78	27			Gray, wet, very dense, fine to coarse SAND, some silt, little gravel, little clay, (Basal Till). Roller Cone ahead to 50.0 ft bgs.	G#304207 Sp. G=2.71 WC: 8.2% A-4; SC-SM
							35				
							49				
							142				
							244			Casing refusal.	
50											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole collapsed to 70 ft when casing pulled.
3. Two wells installed: Well 1 screened from 40.0 to 50.0 ft bgs; Well 2 screened from 20.0-25.5 ft bgs.
4. Water Levels: 9.75 ft bgs - 9/26/16 4:50pm casing at 35 ft bgs; 10.5 ft bgs - 9/27/16 9:00am casing at 35 ft bgs; 24.3 ft bgs - 9/28/16 11:09am casing at 50 ft bgs; 9.15 ft bgs - 9/28/16

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-203

WIN: 17236.00

Driller:	New England Boring	**Elevation (ft.)**	562.86	**Auger ID/OD:**	5" SSA
Operator:	C. Dupuis	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart/B. Wilder	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/26/16(11:35am)-9/28/16(1:51pm)	**Drilling Method:**	Cased Wash Bore	**Core Barrel:**	NQ
Boring Location:	Station: 12+09, Offset: 11.0 ft RT	**Casing ID/OD:**	HW	**Water Level*:**	Perched (See Remarks)
Hammer Efficiency Factor:	0.569	**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.
			Sample Information								
50	11D	24/19	50.00 - 52.00	13/31/42/46	73	69	OH			Gray, wet, very dense, silty fine to coarse SAND, little gravel (Basal Till).	
								509.4		53.5	
								508.7		Cobble. 54.2	
55	12D	18/14	55.00 - 56.50	24/42/53	R					Gray, wet, very dense, fine to coarse sandy SILT, little gravel (Basal Till).	G#304208 WC: 6.9% A-4; SM
60	13D	6/5	60.00 - 60.50	53	R					Cobble/ boulder fragments.	
65	14D	3/3	65.00 - 65.25	50	R					Cobble/ boulder fragments.	
70	15D	4/4	70.00 - 70.33	50/4"	R					Gray, damp, very dense silty fine to coarse SAND, some clay, rock fragments throughout (Basal Till).	
								490.9		72.0 **Bottom of Exploration at 72.0 feet below ground surface.** Roller cone in very hard material with 2000 psf on the cone. Drillers cannot get the core barrel down to the sampling depth due to clogging of their casing.	
75											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Hole collapsed to 70 ft when casing pulled.
3. Two wells installed: Well 1 screened from 40.0 to 50.0 ft bgs; Well 2 screened from 20.0-25.5 ft bgs.
4. Water Levels: 9.75 ft bgs - 9/26/16 4:50pm casing at 35 ft bgs; 10.5 ft bgs - 9/27/16 9:00am casing at 35 ft bgs; 24.3 ft bgs - 9/28/16 11:09am casing at 50 ft bgs; 9.15 ft bgs - 9/28/16

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

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Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-204

WIN: 17236.00

Driller:	New England Boring	**Elevation (ft.)**	564.01	**Auger ID/OD:**	5" SSA
Operator:	C. Dupuis	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/22/16(9:20am)-9/22/16(4:00pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	n/a
Boring Location:	Station: 10+43, Offset: 8.2 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	15.0 ft bgs
Hammer Efficiency Factor:	0.569	**Hammer Type:**	Automatic ☒	Hydraulic ☐	Rope & Cathead ☐

Definitions:
D = Split Spoon Sample
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U = Thin Wall Tube Sample
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SSA = Solid Stem Auger
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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 (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 Information								Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N60	Casing Blows	Elevation (ft.)			
0							SSA			5" Pavement.	
	1D	24/11	1.00 - 3.00	14/42/22/8	64	61		563.0		1.0 Brown, dry, very dense, fine to coarse SAND, little silt, trace gravel, disks of asphalt in tip of spoon, petroleum odor noted (Fill).	
5	2D	24/17	5.00 - 7.00	20/21/20/22	41	39		558.5		Top 6": Brown, dry, dense, fine to coarse SAND, lttle silt, trace gravel, petroleum odor noted (Fill). 5.5 Bottom 18": Brown, dry, dense, fine to coarse SAND, little gravel, little silt (Glaciofluvial Deposit).	
10	3D	24/20	10.00 - 12.00	21/27/32/32	59	56	27			Brown, dry to damp (at 7"), very dense, fine to coarse SAND, some gravel, little silt, petroleum odor noted in upper 7" (Glaciofluvial Deposit).	
							51				
							40				
							50				
							58				
15	4D	24/12	15.00 - 17.00	12/20/53/20	73	69	17			Brown, wet, very dense, gravelly fine to coarse SAND, trace silt, trace clay, (Glaciofluvial Deposit).	G#304209 Sp. G=2.68 WC: 8.6% A-1-a; SW-SC
							43				
							80				
							78				
	5D	24/1	19.00 - 21.00	21/36/19/17	55	52	62			Rock/gravel fragments caught in tip of spoon. Rock/gravel is covered in gray silty fine to medium sand (Glaciofluvial Deposit).	
20							16				
							29				
							25				
							23				
							29				
25											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Casing broke with hole at 50.0 ft bgs. 35 ft of casing abandonded in the hole.
3. Washed ahead of casing from 25 ft bgs to end of hole.

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Maine Department of Transportation Soil/Rock Exploration Log US CUSTOMARY UNITS	**Project:** Evaluation and Stabilization of Unstable Slopes State Route 161 **Location:** St. Francis and Allagash, Maine	**Boring No.:** HB-STFR-204 **WIN:** 17236.00

Driller:	New England Boring	**Elevation (ft.)**	564.01	**Auger ID/OD:**	5" SSA
Operator:	C. Dupuis	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/22/16(9:20am)-9/22/16(4:00pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	n/a
Boring Location:	Station: 10+43, Offset: 8.2 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	$_1$5.0 ft bgs
Hammer Efficiency Factor:	0.569	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:

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

Depth (ft.)	Sample Information							Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows				
25	6D	24/16	25.00 - 27.00	7/8/9/11	17	16	WASH	539.0		25.0 Gray, wet, very stiff, fine SAND, some silt, trace clay (Glaciolacustrine Deposit). Tv = 0.275, 0.375 tsf; PP = 2.5, 2.0, 3.75 tsf Wash ahead of casing	G#304210 Sp. G=2.64 WC: 20.5% A-2-4; SC-SM
	7D	24/20	27.00 - 29.00	10/7/8/12	15	14				Top 6": Gray, wet, very stiff, fine sandy SILT, trace clay. Bottom 18": Gray, wet, stiff, SILT, some clay, trace fine sand, mostly silt in the tip (Glaciolacustrine Deposit). Tv = 0.250, 0.250, 0.375 tsf; Pp = 1.75, 1.50 tsf	G#304211 LL:26; PL:20; PI:6 Sp. G=2.7 6 WC: 25.6% A-4; CL-ML
30	8D	24/23	30.00 - 32.00	6/10/11/13	21	20				Gray, wet, very stiff, clayey silt (Glaciolacustrine Deposit). Tv = 0.475, 0.400 tsf; Pp = 2.0, 1.0 tsf	
	MV1	24/24	32.00 - 34.00	9/15/16/20	31	29				Gray, wet, hard, SILT some clay, trace fine sand. 5" fine sand seam noted in sample at 32.75 ft bgs. (Glaciolacustrine Deposit)	G#304212 LL:26; PL:23; PI:3 Sp. G=2.76 WC: 14.6% A-4; ML
35											
								527.3		36.7 Driller notes more granular material	
40	9D	20/11	40.00 - 41.67	13/16/16/(50/4")	32	30				Gray with some tan mottling, moist, dense, fine to coarse SAND, some gravel, some silt, trace clay, till like bonding observed. Refused on cobble (Ablation Till).	G#304213 Sp. G=2.65 WC: 8.0% A-2-4; SC-SM
45	10D	24/11	45.00 - 47.00	20/27/24/21	51	48				Gray, very dense, moist to wet, silty fine to coarse SAND, little gravel, (Ablation Till). Rock fragment noted in the top of spoon.	G#304214 WC: 8.7% A-4; SM
50											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Casing broke with hole at 50.0 ft bgs. 35 ft of casing abandonded in the hole.
3. Washed ahead of casing from 25 ft bgs to end of hole.

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: Evaluation and Stabilization of Unstable Slopes State Route 161
Location: St. Francis and Allagash, Maine

Boring No.: HB-STFR-204

WIN: 17236.00

Driller:	New England Boring	**Elevation (ft.)**	564.01	**Auger ID/OD:**	5" SSA
Operator:	C. Dupuis	**Datum:**	NAVD88	**Sampler:**	2" Split Spoon
Logged By:	C. Stuart	**Rig Type:**	Truck Mounted B53	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	9/22/16(9:20am)-9/22/16(4:00pm)	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	n/a
Boring Location:	Station: 10+43, Offset: 8.2 ft RT	**Casing ID/OD:**	NW	**Water Level*:**	$_1$5.0 ft bgs
Hammer Efficiency Factor:	0.569	**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

	Sample Information										
Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
50								514.0		Casing broke driving to 50'. No sample 50.0 **Bottom of Exploration at 50.0 feet below ground surface.**	
55											
60											
65											
70											
75											

Remarks:

1. Maine DOT provided the survey locations of the test boring referencing station and offset relative to the project baseline
2. Casing broke with hole at 50.0 ft bgs. 35 ft of casing abandonded in the hole.
3. Washed ahead of casing from 25 ft bgs to end of hole.

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.

Golder Associates
Manchester, New Hampshire

MONITORING WELL INSTALLATION LOG

JOB NO. 1659907
PROJECT RT 161 Unstable Slopes
WELL NO HB-STFR-203
SHEET 1 OF 1
GA INSP. CJS
DRILLING METHOD SSA & D+W
GROUND ELEV.
WATER DEPTH 19.15/39.8ft
WEATHER cloudy
DRILLING COMPANY NE Boring
COLLAR ELEV.
DATE/TIME 9/28/16 - 1345
TEMP. 55°F
DRILL RIG B53
STARTED 1135 9/26/16 (TIME / DATE)
COMPLETED 1351 / 9/28/16 (TIME / DATE)
LOCATION/COORDINATES

MATERIALS INVENTORY

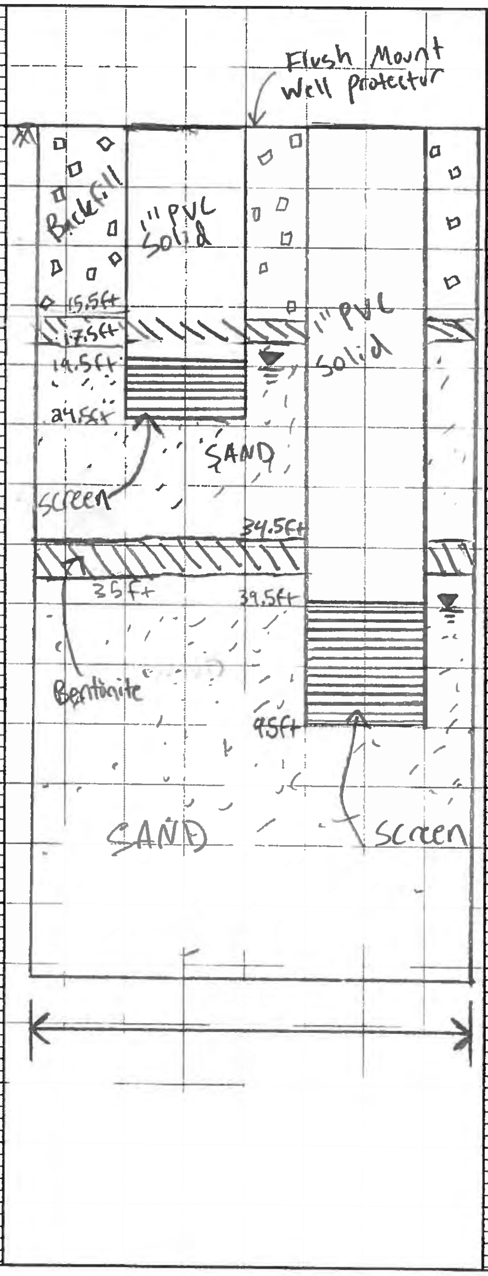
WELL CASING 1.0 IN. DIA. 15.5, 39.5 l.f.
CASING TYPE PVC Sch. 40
JOINT TYPE Flush threaded
GROUT QUANTITY N/A
GROUT TYPE N/A

WELL SCREEN 1 IN. DIA. 5, 10 l.f.
SCREEN TYPE machine slotted
SLOT SIZE 0.010"
CENTRALIZERS N/A
DRILL MUD TYPE N/A

BENTONITE SEAL hydrated hole plug
INSTALLATION METHOD gravity
FILTER PACK QTY ~8 bags (50lbs/bag)
FILTER PACK TYPE #15 Holliston Sand
INSTALLATION METHOD gravity

ELEV./ DEPTH	SOIL/ROCK DESCRIPTION
	GROUND SURFACE
0.0	Brown to dark brown, gravelly f+c SAND, little silt, (outwash)
10	
20	
	gray, silt, some clay, w/ fine sand laminae
30	Gray, silty f+c SAND, little to some gravel, (Till).
40	
50	
60	Lodgement Till
70	

WELL SKETCH



INSTALLATION NOTES

1" PVC
15 Holliston Sand

NOTES

MONITORING WELL INSTALLATION LOG

Golder Associates
Manchester, New Hampshire

JOB NO. 1659907
PROJECT RT 161 Unstable Slopes
WELL NO HB-Alla-202
SHEET 1 OF 1
GA INSP. CJS
DRILLING METHOD SSA & D+W
GROUND ELEV. ______
WATER DEPTH 46.3 ft
WEATHER Sunny
DRILLING COMPANY NE Boring
COLLAR ELEV. ______
DATE/TIME 9/21/16 - 1445
TEMP. ~70°F
DRILL RIG B53
STARTED 1215 9/19/16 (TIME / DATE)
COMPLETED 1430 9/21/16 (TIME / DATE)

LOCATION/COORDINATES ______

MATERIALS INVENTORY

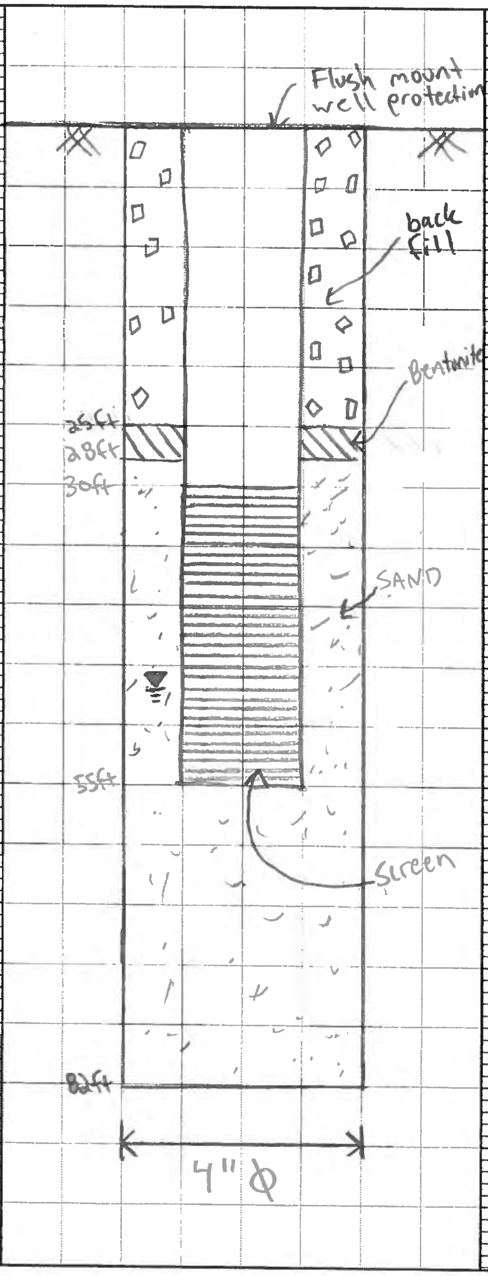
WELL CASING 1 IN. DIA. 30 l.f.
CASING TYPE PVC Sch.40
JOINT TYPE flush-threaded
GROUT QUANTITY n/a
GROUT TYPE n/a

WELL SCREEN 1 IN. DIA. 25 l.f.
SCREEN TYPE machine slotted
SLOT SIZE 0.010"
CENTRALIZERS n/A
DRILL MUD TYPE n/a

BENTONITE SEAL hydrated hole plug ~1/2 bag (50lb/bag)
INSTALLATION METHOD gravity
FILTER PACK QTY 8 bags of Sand from 73-28ft bgs
FILTER PACK TYPE #15 Holliston Sand
INSTALLATION METHOD gravity

ELEV./DEPTH	SOIL/ROCK DESCRIPTION
	GROUND SURFACE
0.0	brown, med. to very dense, f+c SAND, little gravel, litle silt grading to mostly gravel w/ depth, (Glacial Outwash)
10	
20	
30	
40	? ? ? ? Brown, med. dense, f+M SAND, little silt ? ? ?
50	Gray, very dense, f+c SAND, little gravel, little clay, (Till).
60	
70	
80	
90	

WELL SKETCH



INSTALLATION NOTES

1" PVC Pipe
15 Holliston SAND

NOTES

Drawing file: monitoringwell.DWG Aug 05, 2002 12:48pm