Revised Final Geotechnical Engineering Structure Report
Retaining Walls
Final Plans For Review (FPFR) Submission
State Project 63-H137
Hartford, Connecticut

Vol. I

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Table of Contents

1.0 GENERAL INFORMATION 1
1.1 General 1
1.2 Datum 1
1.3 Design Criteria 1
1.4 Proposed Roadway Alignments 1
1.5 Existing Conditions, 1.6 Existing Utilities, 1.7 Proposed Retaining Wall 2
2.0 GEOLOGY 2
2.1 Fill 3
2.2 Glaciolacustrine Deposit 3
2.3 Glacial Till 3
2.4 Bedrock 3
3.0 EXISTING GEOTECHNICAL INFORMATION 4
3.1 Boring Data 4
3.2 Laboratory Test Data 4
4.0 SUBSURFACE EXPLORATIONS 4
4.1 Test Borings 4
4.2 Observation Well 4
5.0 LABORATORY TESTING 4
5.1 Atterberg Limits 5
5.2 Moisture Contents 5
5.3 Gradation Analyses (Sieve and Hydrometer) 5
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 6
6.1 Subsurface Profiles 6
6.2 General Subsurface Summary 6
6.3 Subsurface Summary at Retaining Walls 7
6.4 Geotechnical Design Parameters 7
6.5 Groundwater 7
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 7
8.0 CONSTRUCTION RECOMMENDATIONS 7
9.0 LIMITATIONS 7

Appendix:

Vol. I
Appendix 1 Figures and Tables
Appendix 2 Limitations

Vol. II
Appendix 3 2008 Boring Logs
Appendix 4 2008 Laboratory Data
Appendix 5 2003 Boring Logs and Laboratory Data

1.0 GENERAL INFORMATION

1.1 General

This report summarizes the final design subsurface exploration program, inferred subsurface conditions, and geotechnical analyses; and provides geotechnical engineering recommendations for retaining wall foundation design along the Hartford North segment of the proposed New Britain-Hartford Busway (Busway) in Hartford, Connecticut. This portion of the proposed Busway alignment is shown on Figure 1 (Appendix 1).

The Busway project entails the design and construction of a 9.4-mile corridor between downtown New Britain and downtown Hartford that follows an abandoned railroad right-of-way. The Busway will be a dedicated roadway that will be reserved for buses as part of the Bus Rapid Transit System (BRT).

The Hartford North segment of the Busway begins approximately 725 feet south of the proposed Sigourney Station at Sta. 450+00, and ends at city street level at Asylum Street at Sta. 490+55. The resulting project length along the baseline is approximately 4,055 feet or about 0.77 miles. This segment of the project is bordered to the south by the Hartford South segment.

H.W. Lochner (Lochner) is the Prime Designer for this section of the Busway. Geo**Design**, Inc. (Geo**Design**) is the Geotechnical Subconsultant to Lochner.

1.2 Datum

All elevations referenced in this report are in feet and are based on NGVD 1929. The coordinates are based on Connecticut Coordinate System, NAD 1983.

1.3 Design Criteria

We understand that wherever possible, proprietary retaining walls are to be utilized.

Foundation design recommendations are based on AASHTO Load and Resistance Factor Bridge Design Specifications 4th Edition, 2007 (AASHTO LRFD) with 2008 Interims, ASHTO Standard Specifications for Highway Bridges, 17th Edition, 2002 (ASHTO Working Stress), and Connecticut Department of Transportation Geotechnical Engineering Manual, 2005 Edition. Recommendations are also based on State of Connecticut Department of Transportation (ConnDOT) Standard Specifications for Roads, Bridges, and Incidental Construction, Form 816 (2004). American Society for Testing and Materials (ASTM) publications were followed as the reference standards for all field and laboratory tests applicable.

1.4 Proposed Roadway Alignments

The railroad tracks generally run southwest to northeast. For this report the railroad and Busway Alignment will be considered to run along a south-north alignment, with the proposed Busway to

be located to the west of the existing tracks. The Busway base line Stationing increases from south to north.

There are five alignments included in this report. Each alignment corresponds to the roadways and stationing described below.

Alignment 1 (*NB Busway)* – The main alignment has northbound (NB) Busway Stationing from 450+00 to 490+88.06. This alignment travels under Sigourney Street, across Flower Street, across proposed Bridge 03 (Busway NB over I-84W Ramp from Capitol Avenue), and ends at grade at Asylum Street.

Alignment 2 (*SB Busway)* – On the south, the Busway has a separate SB alignment from SB Station 803+50 to 813+91.89, where it connects with Alignment 1 at NB Station 460+32.95. On the north, the alignment breaks off from Alignment 1 at NB Station 481+30.57, with SB Stationing from 900+00 to 906+96.82, where it connects to Alignment 3 at WB on-ramp Station 204+75.5. This alignment will travel both across proposed Bridge 02 (Busway SB I-84 WB Ramp from Capitol Avenue), and under a Bridge carrying the I-84 EB off-ramp to Asylum Street.

Alignment 3 (I-84 WB on-ramp from Asylum Street) – This alignment begins at Station 200+00 under I-84 EB bridge, and extends north, ending at Asylum Street at Station 207+08.54.

Alignment 4 (I-84 WB on-ramp from Capitol Avenue) – This alignment begins at Station 300+00 under I-84 EB bridge, and extends east, ending at Capitol Avenue at Station 303+50.

Alignment 5 (Hawthorn Street) – This alignment begins at Station 10+11 and ends at Station 16+88 at Sigourney Street

1.5 Existing Conditions, 1.6 Existing Utilities, 1.7 Proposed Retaining Wall

Refer to the retaining wall-specific tabs (appended).

2.0 GEOLOGY

Published geologic data for this locale generally indicate Artificial Fill over Glaciolacustrine deposits, over Glacial Till, over Bedrock. Mapping indicates Fill is present at the surface throughout the project area. Glaciolacustrine deposits are shown near the surface outside the limits of mapped Fill. To the north and south of the project area, Till is shown to be present at the surface. These strata are described below. They were formed in a bottom to top sequence; thus, the shallower a layer the younger its geological age.

2.1 Fill

Fill is defined as any material that was not placed naturally (e.g. man made). Due to a significant amount of construction associated with the railroad, I-84, and cross streets, Fill is mapped throughout the project area.

2.2 Glaciolacustrine Deposit

When the late Pleistocene ice sheet in New England retreated about fifteen thousand (15,000) years ago, the Glaciolacustrine deposit was formed in Glacial Lake Hitchcock. The Glaciolacustrine deposit in this area is distinctively featured by alternating layers of clay and silt. Each clay and silt pair is called a "varve", which corresponds to glacial lake deposit of one year. As the glacier melted, melt water streams brought soil particles into Glacial Lake Hitchcock. During the summer, a larger volume of water formed a more turbulent flow. This flow was capable of carrying silt particles (sometimes even larger particles) and settling them on the lake bottom. During the winter, when the volume of melt water decreased and frozen lake surface calmed the water, clay particles were deposited out of suspension. As a result of many years' deposit, the "varved" structure dominated the Glaciolacustrine deposit in this region. The deposit could contain several hundred or even several thousand varves. The thickness of the varves is variable.

Although this deposit contains significant amount of Silt, the literature typically refers to the Glaciolacustrine deposit in this area as Varved Clay. Conforming to tradition, the term "Varved Clay" is used in this report.

2.3 Glacial Till

Glacial Till consists of a heterogeneous mixture of different sized particles. The composition of Till demonstrates a wide range of variation in particle size and distribution. Two extremes of these variations are stony till and clayey till. The former contains more than fifty percent of gravels, pebbles, cobbles and boulders. The latter consists of more than fifty percent of clay size particles.

2.4 Bedrock

The Portland Arkose formation, a sedimentary bedrock unit, is the dominating formation in this locale. Its texture ranges from coarse conglomerate to shale. Depth to bedrock is indicated on mapping to be up to 75 feet on the southwest to less than 25 feet on the northeast. Rock outcroppings are mapped to the south along the Park River; between 100 to 1,000 feet south of the project area.

3.0 EXISTING GEOTECHNICAL INFORMATION

3.1 Boring Data

During the preliminary design phase in 2003, Baker Engineering (Baker) and their subcontractors drilled 13 borings throughout the Busway North alignment. These borings include RB-42, and SB-88 through SB-99, and are provided in Appendix 5.

3.2 Laboratory Test Data

Baker conducted the following variety of laboratory tests on samples retrieved from their borings: Moisture Content, Atterberg Limits, and Gradation (Sieve and Hydrometer) Analyses, and Unconfined Compressive Strength Rock Testing. The results from these tests are presented in Appendix 5. Details of each test and a discussion of the results are provided in Section 5.0.

4.0 SUBSURFACE EXPLORATIONS

Geo**Design** conducted additional subsurface explorations during final design. Details of these explorations are described in this section:

4.1 Test Borings

Geo**Design** coordinated the services of New England Boring Contractors of CT, Inc. (NEBC) to perform Standard Penetration Test (SPT, ASTM D 1586) borings along the Busway North alignment in the fall of 2008. These borings were performed near the proposed retaining walls, along the proposed roadways, and at three proposed bridges. A total of 74 borings were performed; 33 for retaining walls, 24 for roadways, and 17 for bridges. Boring locations were initially field located by tape measurement and line of sight. Connecticut Department of Transportation (ConnDOT) survey crews then recorded the locations and elevations of the borings by surveying the as-drilled locations. Borings locations for each retaining wall are shown on Figures included in each wall-specific tab, and boring logs are included in Appendix 3.

4.2 Observation Well

Observation wells were installed in Borings R-23, RW-103-2, and RW-105-1. Information on well installation is shown on the boring logs (Appendix 3).

5.0 LABORATORY TESTING

Geo**Design** assigned laboratory tests to estimate engineering properties of the Varved Clay and Fill Materials to verify field classifications and determine material drainage properties. Testing was performed by GeoTesting, Inc. of Boxborough, Massachusetts. Laboratory tests included Atterberg Limits, Sieves, and Hydrometer Analyses. The results of these tests are discussed below, and are included in Appendix 4. As previously noted, laboratory testing was also performed by Baker Engineering in 2003, and the results are included in Appendix 5.

Based on the stiffness of the Varved Clay, and inability to obtain undisturbed tube samples, we did not perform consolidation or strength tests on the Varved Clay stratum.

5.1 Atterberg Limits

Baker performed 16 Atterberg Limit Tests on samples obtained in the 2003 pilot borings. Seven new Atterberg Limit tests were performed on samples obtained in the 2008 borings. Atterberg Limits (ASTM D 4318) provide the Liquid Limit (LL), the Plastic Limit (PL), and the Plasticity Index (PI) of cohesive soil samples. These tests can characterize cohesive soils and provide a reference to compare soil properties at different depths and locations.

Test results are summarized in Table 1 (Appendix 1) for Varved Clay samples. The test results indicate a LL range of 28 to 61, a PL range of 19 to 28, and a PI (recent testing only) range of 21 to 35. The LL, PL, and PI generally increased together, with little correlation with depth.

5.2 Moisture Contents

Baker Engineering performed 29 moisture content tests on samples obtained in the 2003 pilot borings. The water contents ranged from 10.4 to 49.7 percent in the Clay, from 10.6 to 17.2 percent in the Fill, and from 2.3 to 14.1 percent in natural granular soils. A summary of these moisture content results are included in Table 2 (Appendix 1).

5.3 Gradation Analyses (Sieve and Hydrometer)

Baker Engineering performed 16 gradation analyses on samples obtained in the 2003 pilot borings. Forty new Sieve and Hydrometer tests were performed on samples taken in the 2008 borings; twenty-eight sieve tests, five hydrometer tests, and eight combined sieve-hydrometer tests. Test results are summarized in Table 3, (Appendix 1) and are discussed below by strata type.

Tests performed on Fill samples (26 tests total) indicate that about 80 percent of the samples tested were granular despite containing more than 50 percent Silt (percent passing the No. 200 sieve). The varying constituents within the Fill include up to 20 percent fine Gravel, 25 to 70 percent fine to coarse Sand, 15 to 70 percent fines (passing the No. 200 Sieve).

Tests performed on the Varved Clay (six tests total) indicate a range of 30 to 50 percent Silt (between the No. 200 Sieve and 0.002 mm) and 50 to 70 percent Clay (less than 0.002 mm). Two of the samples tested indicated 1.5 to 3 percent fine Sand.

Tests performed on the Glacial Till (seven tests total) indicate the gradations being evenly split between being mostly granular or fine grained. The varying constituents within the Glacial Till generally include up to about 15 percent fine Gravel, and 30 to 60 percent of fine to coarse Sand or Silt/Clay.

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.1 Subsurface Profiles

Subsurface profiles for each retaining wall are included in each wall-specific tab. These profiles depict the generalized subsurface conditions at each wall based on the available subsurface exploration data. The legend for the subsurface profiles is included as Figure 11, Appendix 1.

6.2 General Subsurface Summary

A general summary of the soil and rock profile along the alignment can be summarized as follows:

- **Crushed Stone/Asphalt/Concrete** – 0 to 2 feet thick;
- **Fill** – 0 to 24 feet thick;
- **Varved Clay (Glaciolacustrine Deposit)** – 0 to over 26 feet thick;
- **Glacial Till** – 0 to 23 feet thick;
- **Decomposed Bedrock –** 0 to 6 feet thick; over
- **Bedrock (Siltstone/Shale).**

Fill was observed in most of the borings and generally consisted of loose to very dense, fine to coarse Sand with varying proportions of Silt, and (where present) fine to coarse Gravel, Asphalt, Ash, Cinders, Brick/Concrete fragments, Roots, and Wood.

Varved Clay was only observed south of Flower Street (NB Station 471+50) and locally in two borings near Asylum Street; R-23 (NB Station 490+10) and R-24 (NB Station 489+45). Where encountered, the Varved Clay generally consists of stiff to very stiff Silty Clay and Clayey Silt layers, with localized soft zones. From south to north (between NB Stations 450+00 and 471+50), the Varved Clay generally decreases in thickness and its stiffness increases.

Glacial Till was encountered in most borings that fully penetrated the Fill and/or the Varved Clay, except in six Borings (R-19, -21, -22, and B-02-1, -2, -4), which encountered Fill over Decomposed Bedrock or Bedrock; and Boring R-24 which encountered Varved Clay over Decomposed Bedrock. Where fully penetrated, the Glacial Till thickness varied from approximately 2 to 24 feet. The Till generally consisted of red brown Clayey Silt and fine to coarse Sand, with variable proportions of fine to coarse Gravel. SPT "N" values indicate the density of this layer ranges from dense to very dense.

Decomposed Bedrock of very dense consistency was encountered in five borings.

Bedrock was encountered or inferred at approximate Elevations 10 to 36 feet. Rock cores were taken at each of the Bridge borings included in this report (B-01-3, B-01-4, B-02-1, B-02-2, B-02-3, B-02-4, B-03-1, and B-03-2). Rock Quality Designation (RQD) values ranged between 0 and 88 percent indicating very poor to good rock mass quality.

6.3 Subsurface Summary at Retaining Walls

Refer to the retaining wall-specific tabs (appended).

6.4 Geotechnical Design Parameters

As appropriate, engineering design parameters of the subsurface soils were based on the boring data and laboratory test results. The engineering design parameters of the Varved Clay were determined from correlation of index tests to published data and/or data from the adjacent Busway South segment. The following table summarizes the engineering design parameters.

Strata	Total Unit Weight (pcf)	Friction Angle (degrees)	Undrained Shear Strength (psf)	Recompression Ratio (Cr)
Fill	125	32	-	-
Varved Clay	110	-	1,500	0.04
Glacial Till	135	34	-	-
Decomposed Bedrock	138	36	-	-

6.5 Groundwater

Stabilized groundwater readings were made in observation wells installed in Borings R-23, RW-103-2, and RW-105-1. Table 5, Appendix 1, presents groundwater observations made in the wells and in the borings during drilling. Groundwater depths ranged from 2.5 to 16 feet below grade. Refer to Table 5 for more detailed data along the NB and SB Busway Alignments.

Groundwater conditions will vary depending on factors such as temperature, season, precipitation, construction activity and other conditions, which may be different from those at the time of these readings.

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Refer to the retaining wall-specific tabs (appended).

8.0 CONSTRUCTION RECOMMENDATIONS

Refer to the retaining wall-specific tabs (appended).

9.0 LIMITATIONS

This report is subject to the limitations attached in Appendix 2.

INSERT TAB
102
HERE

Retaining Wall 102

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 102

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 2
6.3 Subsurface Summary at Retaining Walls 2
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 3
7.4 Design Parameters 3
7.4.1 Design of Proprietary Retaining Walls 3
7.4.2 Design of Cast-in-Place Retaining Walls 3
7.5 Settlement Analyses 3
7.6 Drainage 5
7.7 Stability 5
7.8 Seismic Design 5
7.9 Utilities 5
8.0 CONSTRUCTION RECOMMENDATIONS 5
8.1 Subgrade Preparation 5
8.2 Reuse of Fill 6
8.3 Dewatering 6
8.4 Temporary Lateral Support 6

Attached Figures:

102-1 Boring Location Plan
102-2A/B Subsurface Profile

RETAINING WALL 102
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 102 is shown on Figure 102-1 (attached).

This retaining wall will extend from NB Station 452+47 to 459+00 (Right). The existing railroad grade is at about El. 53 feet. South of NB Station 454+50, the ground surface is generally level within approximately 20 to 25 feet to the west of the embankment. Further west, the ground slopes up at about 2H:1V to about El. 57 feet, and flattens to about 15H:1V. Between NB Stations 454+50 and 455+50, Sigourney Street crosses overhead; the ground surface is generally level within approximately 20 feet to the west of the embankment and then rises to about El. 59 feet. North of NB Station 455+50, the ground surface is generally level at El. 50.5 feet within approximately 20 feet to the west of the embankment; the grade then slopes downward at about 15H:1V to El. 49 feet.

1.6 Existing Utilities

Based on drawings provided by Lochner, Geo**Design** has identified where utilities which cross below the proposed retaining wall. The table below indicates the utility station and type, and the proposed filling to take place at these locations.

Approx. Station	Utility	Proposed Filling	Retaining Wall No.
453+80	18-inch RCP	5 feet fill	102
458+50	42-inch RCP	4 feet fill	102

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	NB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
102	452+47 to 459+00 R	653	6 to 11	45.75	Fill

*BFE = Bottom of Footing Elevation
R = Right (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata at this retaining wall are summarized below. Table 4 (Appendix 1) summarizes the strata by boring. Figure 102-2A/B depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**NB Busway Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
102	452+47 to 459+00 R	1.5 to 5	20 to 70	unknown

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam. However, to reduce settlement at an existing utility crossing, light weight fill is recommended locally.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. This retaining wall will retain/protect the proposed Busway and proprietary walls are feasible.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 45.75 feet. We anticipate footing subgrade material to consist of soft to stiff Varved Clay. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend over excavating 18-inches and using the following Maximum Factored Bearing Resistances:

Service Limit State – 3.0 ksf
Strength Limit State – 6.0 ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

To reduce settlement at the utility located at NB Station 453+80, the use of lightweight fill is recommended for a minimum length of 70 feet behind Retaining Wall 102, between NB Stations 453+45 to 454+15. Refer to Section 7.9 for further discussion. In all other areas, conventional 125 pcf backfill should be used.

7.4 Design Parameters

Between NB Stations 453+45 and 454+15, we recommend using Lightweight Fill behind this retaining wall. Due to the proposed Busway behind the proposed retaining wall, earth pressure calculations should assume a surface surcharge of 24 inches soil depth or 250 psf.

7.4.1 Design of Proprietary Retaining Walls

We understand a proprietary wall will not be used at this location.

7.4.2 Design of Cast-in-Place Retaining Walls

We recommend the following static design parameters for cast-in-place walls backfilled with either Lightweight Fill or Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

	Lightweight Fill	**Conventional 125 pcf Fill**
Unit Weight of soil above the water table, pounds per cubic foot (pcf)	60	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	n/a	62.6
Soil Angle of Internal Friction, φ	38	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*	
Bearing Resistance Factor (φ_b)	0.45	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.45	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	4.0	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.25	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.35	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analyses

Due to the Varved Clay present at this retaining wall, consolidation settlements were estimated.

Proposed fills in excess of approximately three feet will occur between NB Stations 452+47 and 454+00. We performed analyses of the consolidation settlement and rate of settlement in this location.

7.5.1 Consolidation Settlement

About 15 feet of stiff desiccated clay overlies about 50 feet of very soft to medium Varved Clay. The proposed fill is thickest and the Varved Clay is softest near NB Station 452+00. The following parameters were used for the Varved Clay layer:

Preconsolidation Stress, γ: 110 lbs/ft^3
Modified Recompression Ratio, $C_{r€}$: 0.04 (dimensionless)
Consolidation Stress, σ'_p : 5,300 lbs/ft^2
Apparent Coefficient of Consolidation, C_v: 4.0 ft^2/day

Based on existing laboratory test data, the Varved Clay is pre-consolidated from existing conditions, such that all consolidation from new loads will occur in the re-compression range.

Under the combined load of the structure and retained soil, our analyses predict that this retaining wall from about NB Station 452+47 to 454+00, will settle about 0.5 to 1.5 inches, with the maximum settlement near NB Station 452+47. We estimated settlements for the remainder of this wall (north of NB Station 454+00) will be less than one-half inch.

At Station 452+47 where the greatest amount of settlement is anticipated along this retaining wall, we estimate track settlement up to about 1-inch. We anticipate the estimated settlement at the track to decrease gradually to the south and north of Station 452+47.

We estimate differential settlements of about 1-inch over 200 feet. The settlements should be gradual across the 200 foot length and is not anticipated to be abrupt. Therefore, the estimated differential settlement is considered tolerable for the CIP wall.

Preloads or waiting periods are not required.

7.5.2 Rate of Consolidation Settlement

In estimating the rate of consolidation, we used "*Field Consolidation of Varved Clay*", a report by Professor Richard P. Long, Professor Kent A. Healy and Mr. Peter J. Carey from University of Connecticut. Figure 13 of this report provides the field-measured apparent coefficient of consolidation for different loading geometries quantified as the ratio of the Varved Clay

Thickness and to the Embankment Width (dimension ratio). For a dimension ratio of one, the field-measured apparent coefficient of consolidation is 4 ft^2/day.

The proposed embankment from about 452+47 to 454+00 will be about 50 feet wide, compared to the thickness of the Varved Clay about 65, for a dimension ratio of 1.3. Due to the anisotropic properties of Varved Clay, horizontal drainage will control the rate of consolidation. We estimate that the consolidation settlement will occur over about 6 to 12 months; and consolidation settlements for the remainder of Wall 102 (north of NB Station 454+00) will occur in less than 6 months.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on this wall with Slide Software by Rock Science (Version 5.0). We assumed a height of 11 feet, level backfill, and footing embedment of at least four feet below final grade. We also assumed 18-inches of over excavation and replacement with Granular Fill over soft to stiff Varved Clay. The resulting safety factor against global slope failure was about 3.6, which exceeds 1.5 and is therefore considered stable.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Two utilities are located below this proposed retaining wall (at NB Stations 453+80 and 458+50). At NB Station 458+50, minor filling (up to one foot) is proposed, and the settlement is estimated to be less than one-quarter inch.

At NB Station 453+80, using conventional 125 pcf fill, we estimated up to approximately 1 to 1.5 inches of consolidation settlement (see Section 7.5.1). To reduce settlement of this utility crossing, we recommend backfilling with Lightweight Fill. Limits of Lightweight Fill should extend to a minimum distance of 35 feet on either side of the utility. Use of Lightweight Fill will reduce predicted settlement to about three-quarter inch.

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend over excavating 18-inches, with the final six inches of excavation being performed with a smooth-edged bucket. We recommend a separation layer be placed over varved clay subgrades prior to placement of Granular Fill or light weight fill.

Disturbed subgrades should be over-excavated to firm stable ground and replaced with Granular Fill or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

Fill with elevated fines content and Varved Clays are not expected to be suitable for reuse on the project, except for placement of “unsuitable” materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Proposed footing elevations are at or below observed ground water observations. Although large volumes of groundwater are not anticipated during foundation construction and cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control ground water.

If moist or wet Clay is present at subgrade, we recommend a six-inch layer of crushed stone placed over the Clay, with filter fabric placed above and below the stone to reduce disturbance of the Clay stratum during compaction of Granular Fill.

8.4 Temporary Lateral Support

In the event that during construction the nearest railroad track is live, excavations to construct this retaining wall will entail cuts that will encroach on the protected zone adjacent to railroad tracks. In this case specifically, temporary sheeting will be required for excavations extending into “Zone 2” below the boundary defined as a 1V:1.5H downward slope beginning 10 feet outside the centerline of the nearest railroad tracks. Temporary sheeting to be left-in-place will

be required for excavations extending into “Zone 3” below the boundary defined as a 1V:1H downward slope beginning at the closest end of the railroad tie.

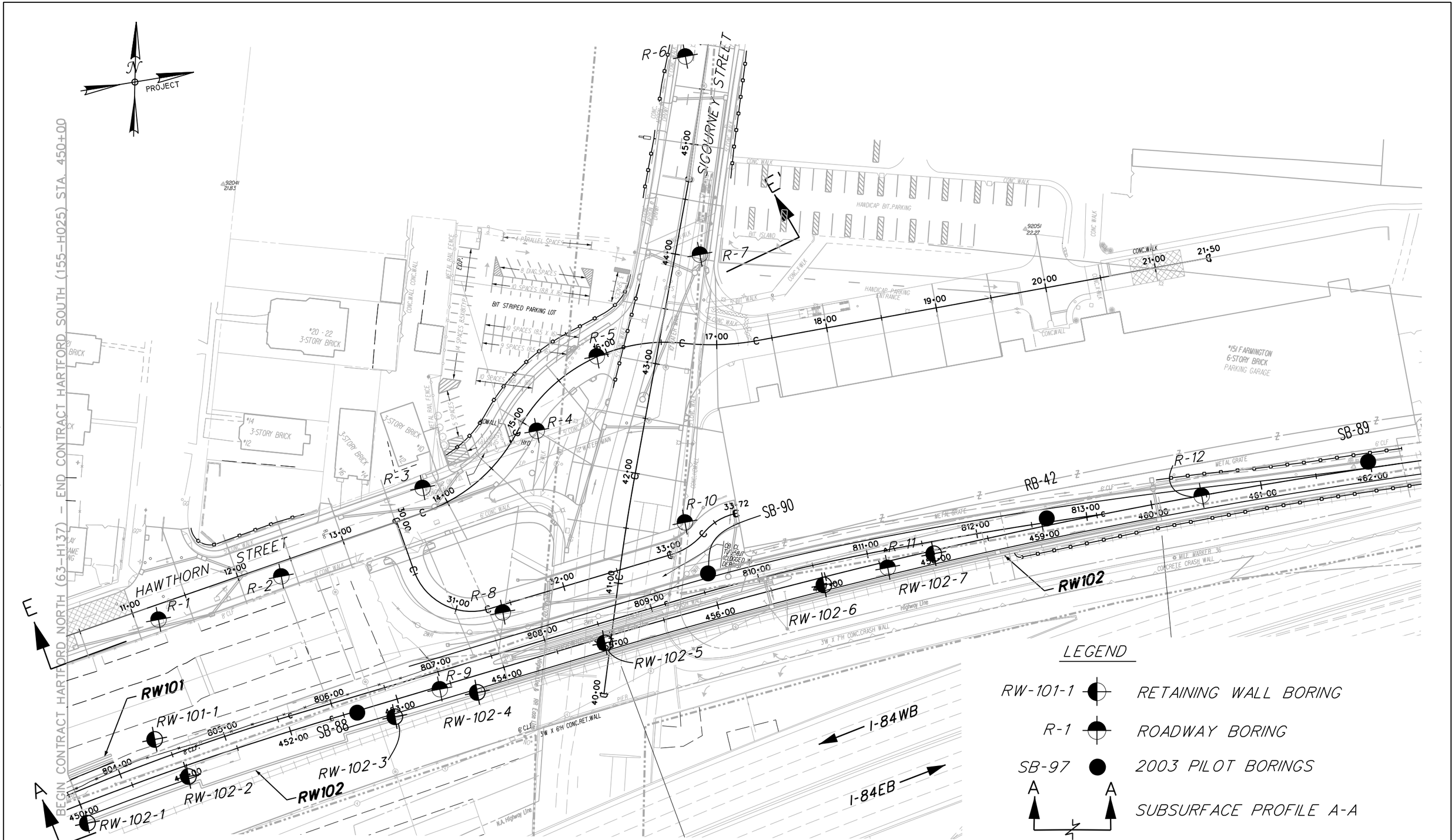
Based on soil and groundwater conditions, and depth to bedrock, we recommend cantilever steel sheet piling be used to provide the support of excavation. Appropriate contractor coordination with Amtrak will also need to be specified in the contract documents.

We recommend applicable railroad surcharges, and the following design parameters for temporary lateral earth support with level backfill:

Existing Embankment Fill:
- Unit weight = 125 pounds per cubic foot (pcf)
- Phi = 32degrees
- $K_a = 0.31$
- $K_p = 3.2$

Stiff Varved Clay (above El. 45 feet):
- Unit weight = 115 pcf
- c = 2.5 kips per square foot (ksf)

Soft Varved Clay (below El. 45 feet):
- Unit weight = 105 pcf
- c = 1.5 ksf



DESIGNED BY JWK						
DRAWN BY SMC						
CHECKED BY JWK						
APPROVED BY ULF		NO.	DATE		DRWN.	CHKD	APPVD
		REVISIONS				

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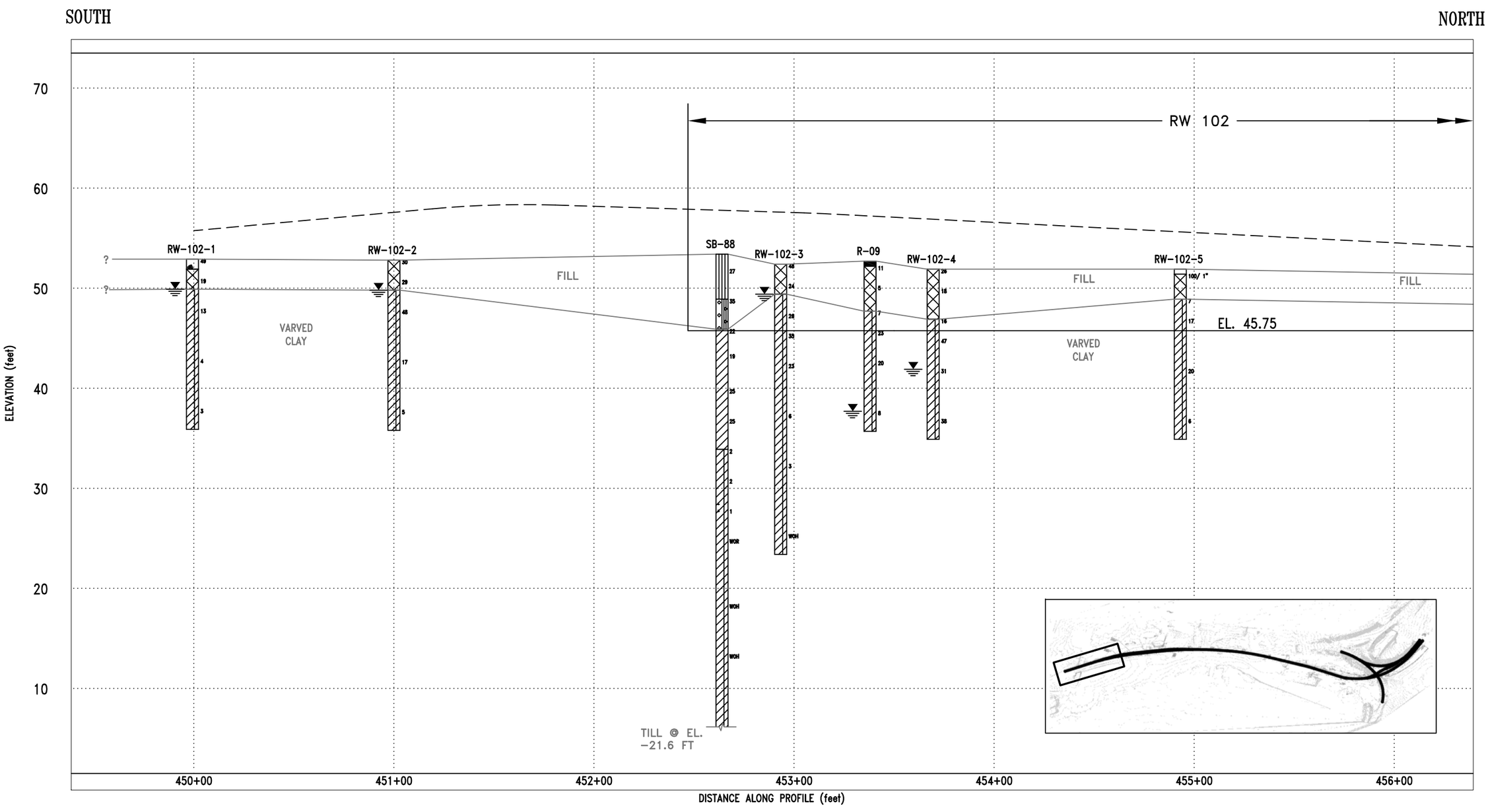
DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FILE NO. 331-14
SCALE 1" = 80' DATE 4-8-09
FIGURE NO. 102-1

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of 12-24-09)



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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.
4. Profiles include all 2008 Roadway and Retaining Wall borings, and select Bridge and 2003 Pilot borings.

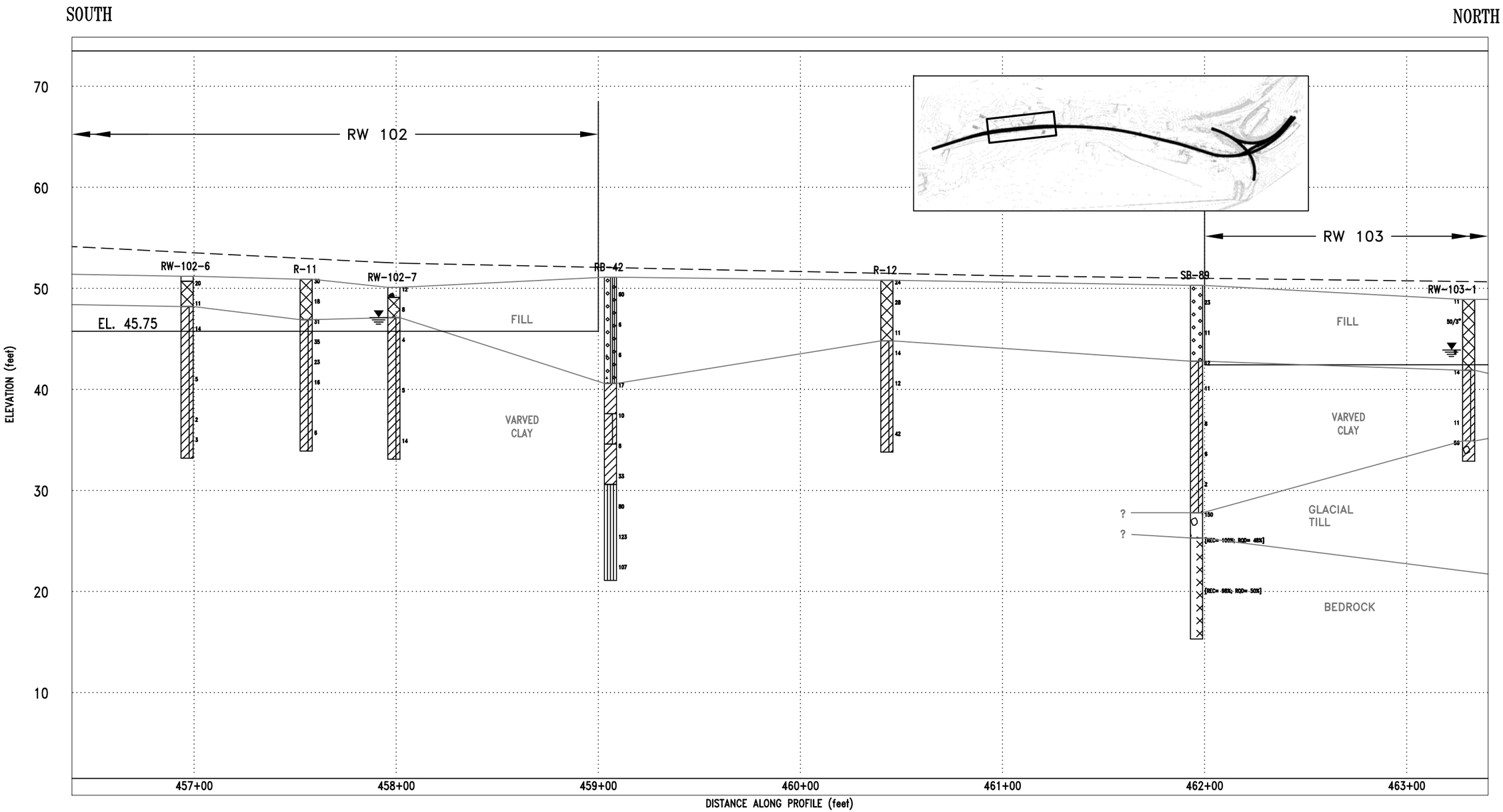
Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

File No.: 0331-014.0 | Figure No.: 102-2A

M:\C\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.



M:\C\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.
4. Profiles include all 2008 Roadway and Retaining Wall borings, and select Bridge and 2003 Pilot borings.

Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

File No.: 0331-014.0 | Figure No.: 102-2B

INSERT TAB
103
HERE

Retaining Wall 103

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 103

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 2
6.3 Subsurface Summary at Retaining Walls 2
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 3
7.4.1 Design of Proprietary Retaining Wall 3
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 4
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 5
8.4 Temporary Lateral Support 5

Attached Figures:

103-1 Boring Location Plan
103-2 Subsurface Profile

RETAINING WALL 103
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 103 is shown on Figure 103-1 (attached).

This retaining wall will extend from NB Station 462+00 to 474+00 (Right). Existing I-84 EB is located overhead to the east of the proposed wall. Piers supporting I-84 are present in this general area. The existing railroad grade is at about El. 49 feet. The ground surface is generally level to the west of the embankment.

1.6 Existing Utilities

Based on drawings provided by Lochner, Geo**Design** has identified where utilities which cross below the proposed retaining wall. The table below indicates the utility station and type, and the proposed filling to take place at these locations.

Approx. NB Station	Utility	Proposed Filling	Retaining Wall No.
463+45	36-inch RCP	3 feet fill	103

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	NB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
103	462+00 to 474+00 R	1200	9.5	42.5	Fill

*BFE = Bottom of Footing Elevation
R = Right (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata summary at this retaining wall follows. Table 4 (Appendix 1) summarizes the strata by boring. Figure 103-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**NB Busway Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
103	462+00 to 474+00 R	7 to 11	0 to 7	13 to 18

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. This retaining wall will retain/protect the proposed Busway and proprietary walls are feasible.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 42.5 feet. We anticipated footing subgrade material to consist of loose to medium dense Fill (0 to 5 ft.), over stiff Varved Clay (0 to 15 ft), over very dense Glacial Till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 6.0 ksf
Strength Limit State – 10.1_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation recommendations (Section 8.1).

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

Due to the proposed Busway behind the proposed retaining wall, earth pressure calculations should assume a surface surcharge of 24 inches soil depth or 250 psf.

7.4.1 Design of Proprietary Retaining Wall

We understand a proprietary wall will not be used in this location.

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

Up to three feet of fill is proposed for this retaining wall. Due to the stiff nature of the thin deposit of Varved Clay, we estimate settlements at this retaining wall to be less than one-half inch.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and

weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade. The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 103 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this wall will exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

A utility crosses this proposed retaining wall at NB Station 463+45. We estimate settlement of this utility under about three feet of fill, will be less than one-half inch.

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend over excavating 12-inches. Where subgrades are granular, we recommend proof compacting the exposed subgrade with at least 10 passes of a self propelled drum roller with compaction force of at least 8 tons. Where subgrades consist of Varved Clay, we recommend the final 6-inches of excavation be performed with a smooth-edged bucket.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

Fill with elevated fines content and Varved Clays are not expected to be suitable for reuse on the project, except for placement of "unsuitable" materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Proposed footing elevations are at or just below observed ground water observations. Although large volumes of groundwater are not anticipated during foundation construction and cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control groundwater.

Contractors should take extra precautions when excavating in Varved Clay layer. A six-inch layer of crushed stone placed on top of the Varved Clay is recommended to reduce disturbance to this stratum. If the Varved Clay stratum is disturbed, the disturbed portions must be removed and replaced with crushed stone.

8.4 Temporary Lateral Support

In the event that during construction the nearest railroad track is live, excavations to construct this retaining wall will entail cuts that will encroach on the protected zone adjacent to railroad tracks. In this case specifically, temporary sheeting will be required for excavations extending into "Zone 2" below the boundary defined as a 1V:1.5H downward slope beginning 10 feet outside the centerline of the nearest railroad tracks. Temporary sheeting to be left-in-place will be required for excavations extending into "Zone 3" below the boundary defined as a 1V:1H downward slope beginning at the closest end of the railroad tie.

Based on soil and groundwater conditions, and depth to bedrock, we recommend cantilever steel sheet piling be used to provide the support of excavation. Appropriate contractor coordination with Amtrak will also need to be specified in the contract documents.

We recommend applicable railroad surcharges, and the following design parameters for temporary lateral earth support with level backfill:

Existing Embankment Fill:

- Unit weight = 125 pounds per cubic foot (pcf)
- Phi = 32degrees
- $K_a = 0.31$
- $K_p = 3.2$

Stiff Varved Clay (above El. 45 feet):

Unit weight = 115 pcf

c = 2.5 kips per square foot (ksf)

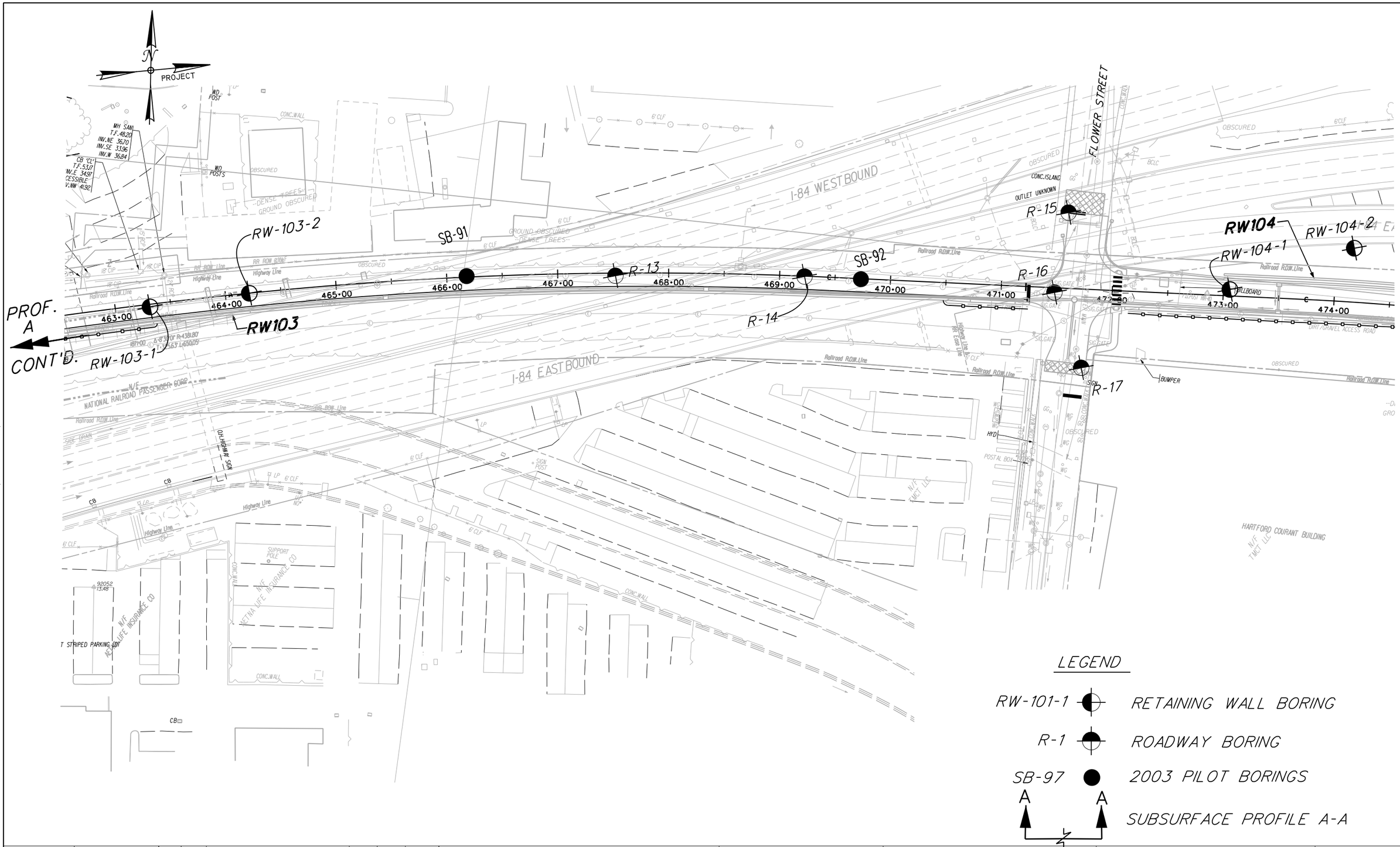
Glacial Till:

Unit weight = 135 pcf

Phi = 36 degrees

$K_a = 0.26$

$K_p = 4.5$



DESIGNED BY JWK							
DRAWN BY SMC							
CHECKED BY JWK							
APPROVED BY ULF		NO.	DATE		DRWN.	CHKD	APPVD
		REVISIONS					

PRIME DESIGNER:

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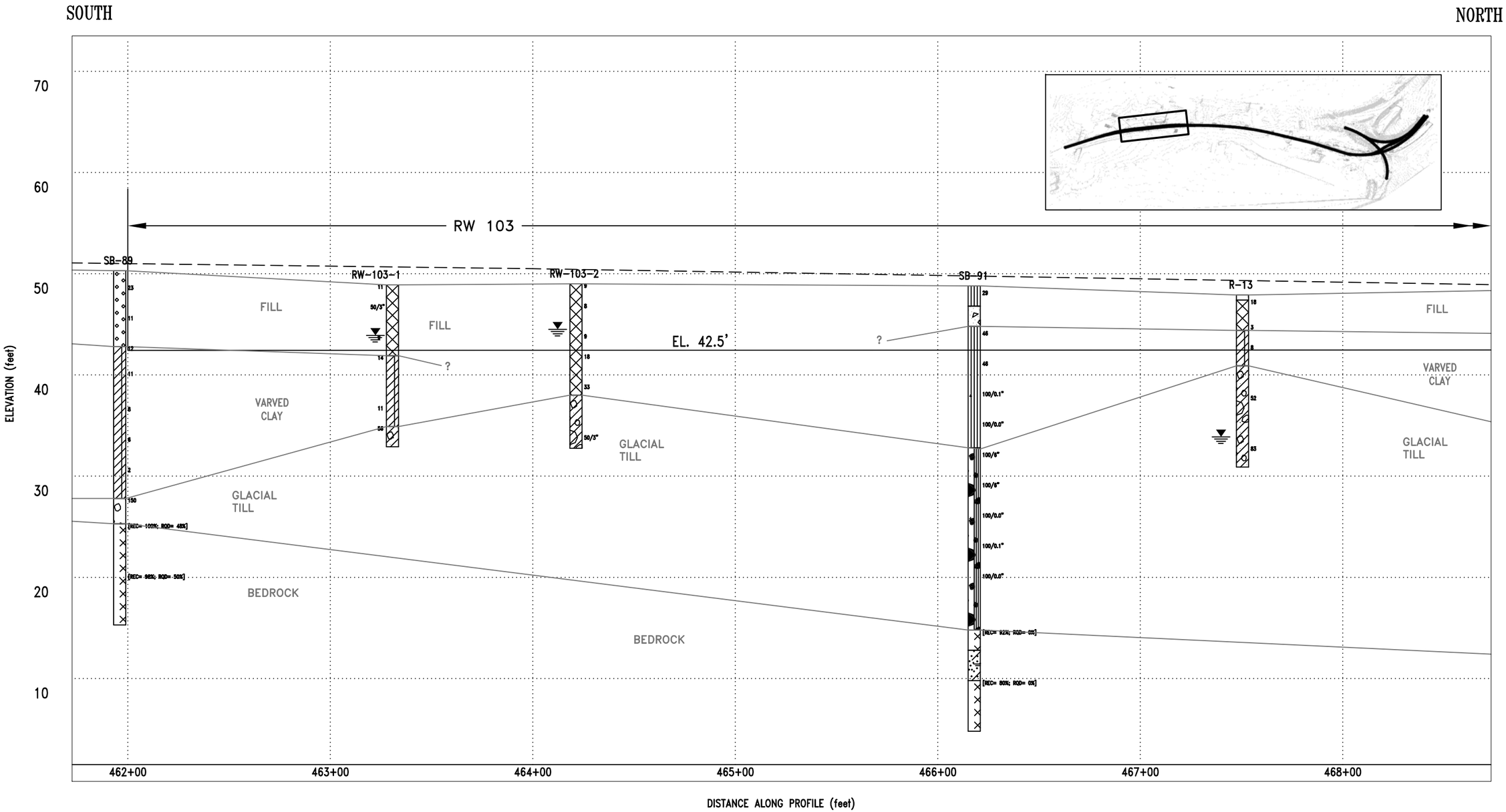
DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FILE NO. 331-14
SCALE 1" = 80'
DATE 4-8-09
FIGURE NO. 103-1

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of2-24-09)



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0 50
Horizontal Scale (feet)

Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.
4. Profiles include all 2008 Roadway and Retaining Wall borings, and select Bridge and 2003 Pilot borings.

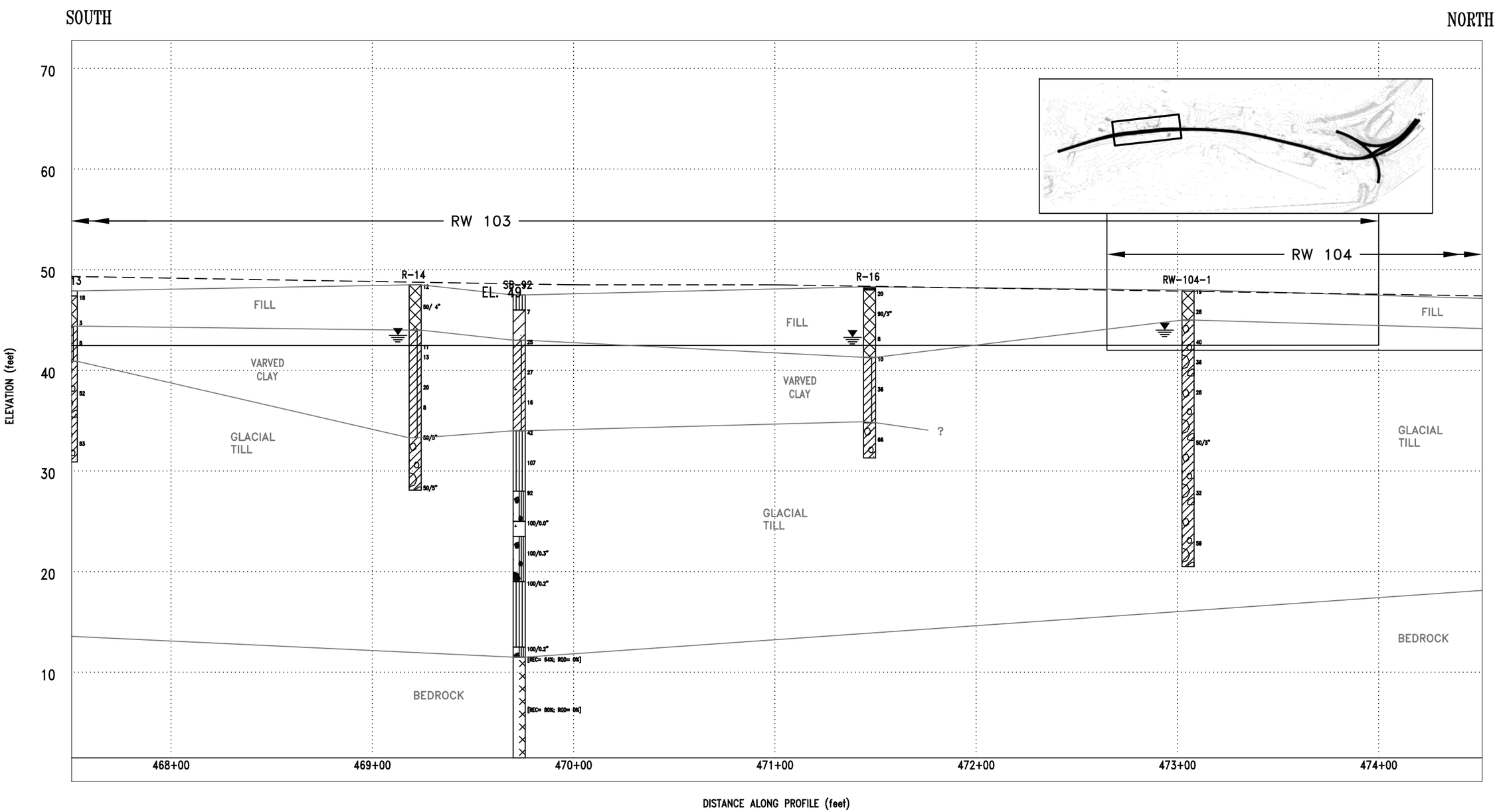
Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

File No.: 0331-014.0 | Figure No.: 103-2A

M:\C\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.



M:\CL\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
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2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.
4. Profiles include all 2008 Roadway and Retaining Wall borings, and select Bridge and 2003 Pilot borings.

Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

File No.: 0331-014.0 | Figure No.: 103-2B

INSERT TAB
104
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Retaining Wall 104

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 104

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 1
6.3 Subsurface Summary at Retaining Walls 1
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 3
7.4.1 Design of Proprietary Retaining Wall 3
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 4
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 4
8.4 Temporary Lateral Support 5

Attached Figures:

104-1 Boring Location Plan
104-2 Subsurface Profile

RETAINING WALL 104
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 104 is shown on Figure 104-1 (attached).

This retaining wall will extend from NB Station 472+65 to 475+34 (Left). The proposed retaining wall is located south of Broad Street, and Broad Street crosses the proposed Busway overhead. The existing west abutment of the Broad Street Bridge is full height with U-type stepped masonry wing walls. Existing grades beneath the bridge and along the Amtrak railroad are at approximately El. 46 feet, and existing grades behind the bridge abutments are at approximately El. 70 feet. The grade behind the south wingwall generally slopes up at a 2H:1V from El. 52 to 66 feet.

1.6 Existing Utilities

Not Applicable

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	NB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
104	472+65 to 475+34 L	269	10 to 28	42	Cut

*BFE = Bottom of Footing Elevation
L = Left (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata summary at this retaining wall follows. Table 4 (Appendix 1) summarizes the strata by boring. Figure 104-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**NB Busway Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
104	472+65 to 475+34 L	3 to 4	0 to 7	30

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. However, at this location, a proprietary wall would require deep cuts into existing steep embankments, and is not economical and is therefore not recommended.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 42 feet. We anticipated footing subgrade material to consist of very dense Fill (less than 2 ft) over stiff Varved Clay and/or medium dense to very dense Glacial Till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 5.0 ksf
Strength Limit State – 5.9_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

7.4.1 Design of Proprietary Retaining Wall

Not Applicable

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate that the maximum settlements will be less than one-half inch, and will occur rapidly (i.e. during construction). We estimate differential settlements along these walls to be negligible.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade. The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 104 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this wall will exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Not Applicable

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend excavating to subgrade and proof compacting the exposed subgrade with at least 4 passes of a compactor with a compaction force of at least 3 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

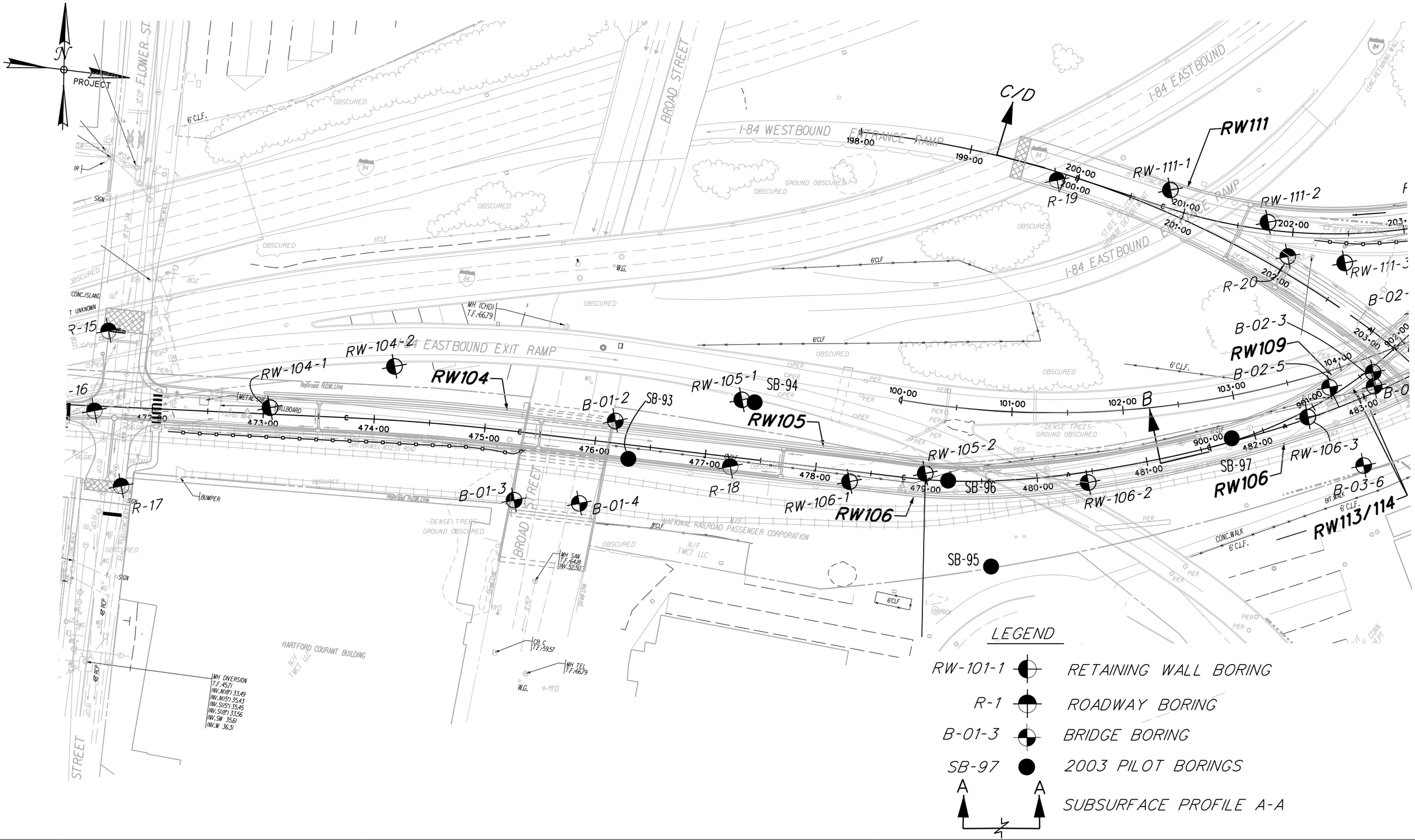
Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of “unsuitable” materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Proposed footing elevations are at or below observed groundwater observations. Although large volumes of groundwater are not anticipated during foundation construction and cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control groundwater and surface water.

8.4 Temporary Lateral Support

Temporary lateral support will be required for construction of this retaining wall. Based on soil and groundwater conditions, and depth to bedrock, we recommend continuous steel sheet piling be used to provide the support of excavation. This wall will support sloped backfill (approximately 2H:1V). The effects of this sloped backfill must be considered in the support of excavation design. Due to the absence of traffic within the zone of influence of this wall, only construction surcharge loads need to be considered.



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DRAWN BY SMC							
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APPROVED BY ULF		NO.	DATE		DRWN.	CHKD	APPVD
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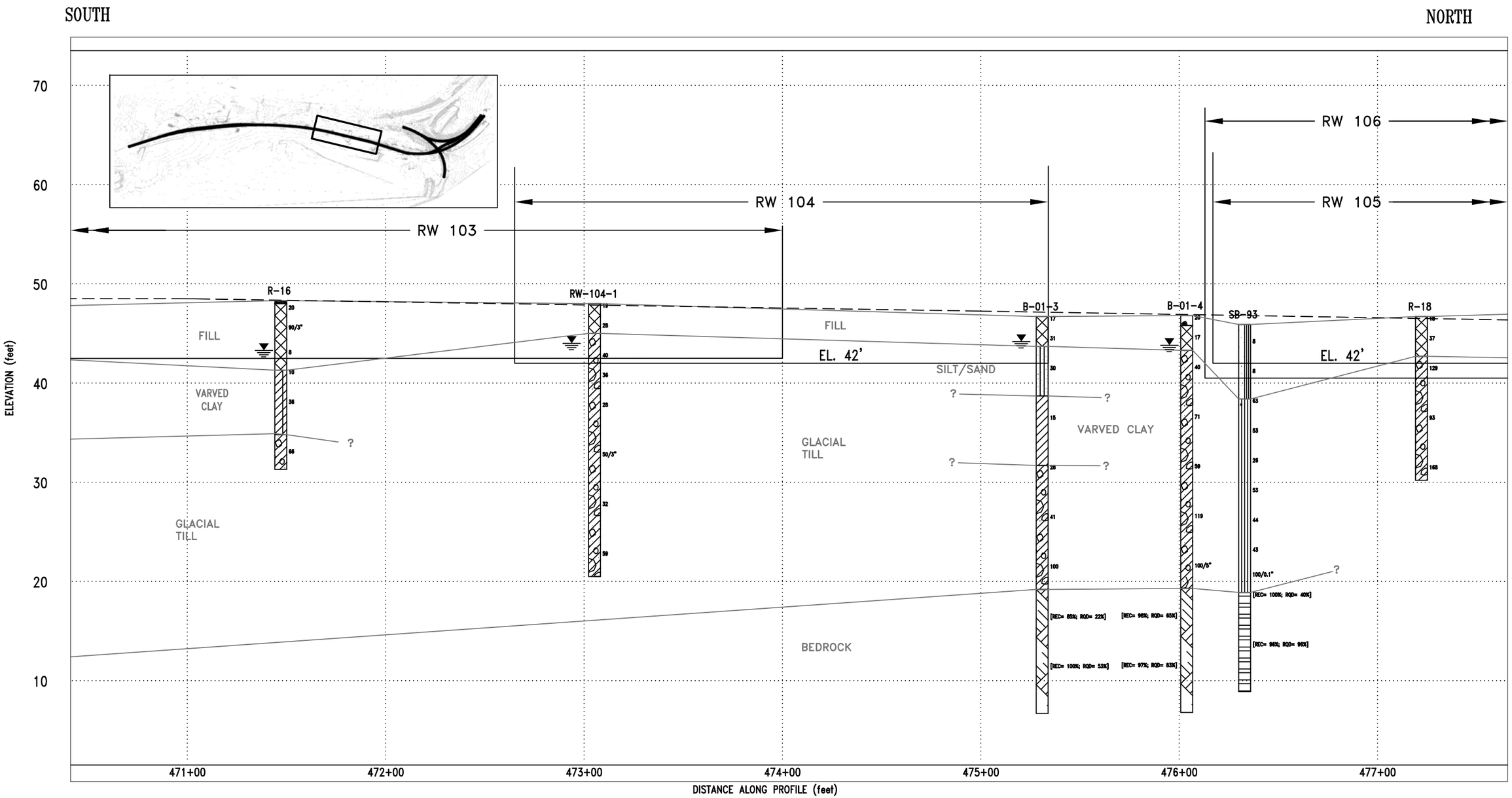
DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FILE NO. 331-14
SCALE 1" = 80'
DATE 4-8-09
FIGURE NO. 104-1

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of2-24-09)



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Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

Date: 2-23-2009	Drawn By: MJV/DSF	Reviewed By: MGB	File No.: 0331-014.0	Figure No.: 104-2

M:\CL\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

INSERT TAB
105
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Retaining Wall 105

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 105

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 1
6.3 Subsurface Summary at Retaining Walls 1
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 2
7.4.1 Design of Proprietary Retaining Wall 2
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 3
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 4
8.4 Temporary Lateral Support 4

Attached Figures:

105-1 Boring Location Plan
105-2 Subsurface Profile

RETAINING WALL 105
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 105 is shown on Figure 105-1 (attached).

This retaining wall will extend from NB Station 476+17 to 479+30 (Left). The proposed retaining wall is located north of Broad Street, and Broad Street crosses the Busway overhead. The existing west abutment of the Broad Street bridge is full height with U-type stepped masonry wing walls. Existing grades along the Amtrak railroad beneath the bridge are at approximately El. 46 feet, and existing grades behind the bridge abutments are at approximately El. 70 feet. The grade behind the north wingwall slopes up at 2.5H:1V from El. 55 to 63 feet, and then flattens to 15H:1V.

1.6 Existing Utilities

Not Applicable

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	NB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
105	476+17 to 479+30 L	313	13 to 28	42	Cut

*BFE = Bottom of Footing Elevation
L = Left (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata summary at this retaining wall follows. Table 4 (Appendix 1) summarizes the strata by boring. Figure 105-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**NB Busway Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
105	476+17 to 479+30 L	8 to 10	0	15 to 24

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. However, at this location, a proprietary wall would require deep cuts into existing steep embankments, and is not economical and is therefore not recommended.

7.2 Bearing Pressures

Based our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we estimated the proposed bottom of wall footing elevation to be about El. 42 feet. We anticipated footing subgrade material to consist of very dense Fill (less than 2 ft) over medium dense to very dense Glacial Till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 8.0 ksf
Strength Limit State – 10.2_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

7.4.1 Design of Proprietary Retaining Wall

Not Applicable

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2.

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate that the maximum settlements will be less than one-half inch, and will occur rapidly (i.e. during construction). We estimate differential settlements along these walls to be negligible.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on this wall with Slide Software by Rock Science (Version 5.0). We assumed a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade. We also assumed a subgrade of very dense glacial till. The resulting safety factor against global slope failure was about 1.7, which exceeds 1.5 and is therefore considered stable.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Not Applicable

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend excavating to subgrade and proof compacting the exposed subgrade with at least 4 passes of a compactor with a compaction force of at least 3 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

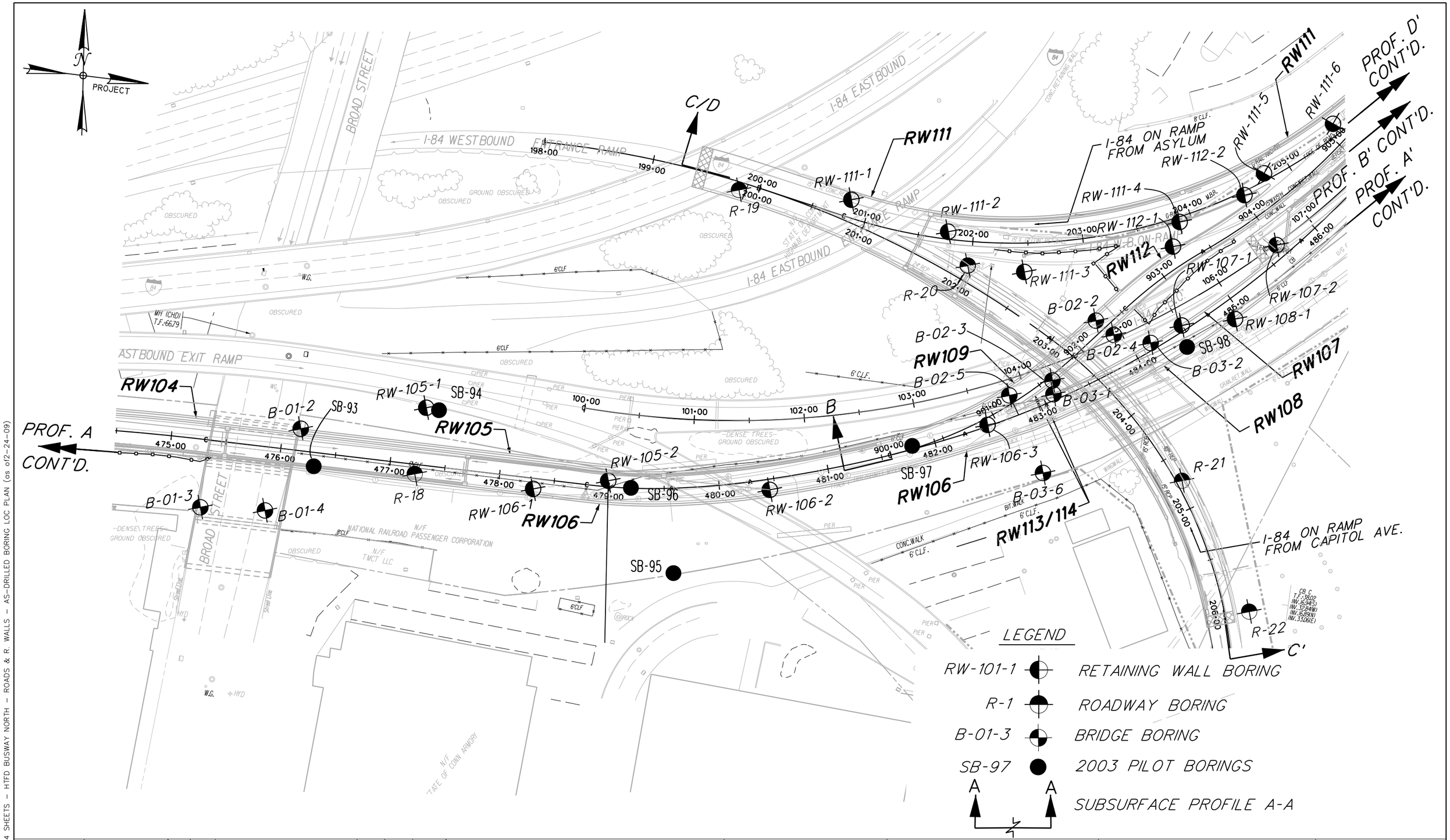
Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of “unsuitable” materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Proposed footing elevations are at or below observed groundwater elevations. Although cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control groundwater and surface water.

8.4 Temporary Lateral Support

Temporary lateral support will be required for construction of this retaining wall. Based on soil and groundwater conditions, and depth to bedrock, we recommend continuous steel sheet piling be used to provide the support of excavation. This wall will support sloped backfill (approximately 2H:1V). The effects of this sloped backfill must be considered in the support of excavation design. Due to the absence of traffic within the zone of influence of this wall, only construction surcharge loads need to be considered.



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DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

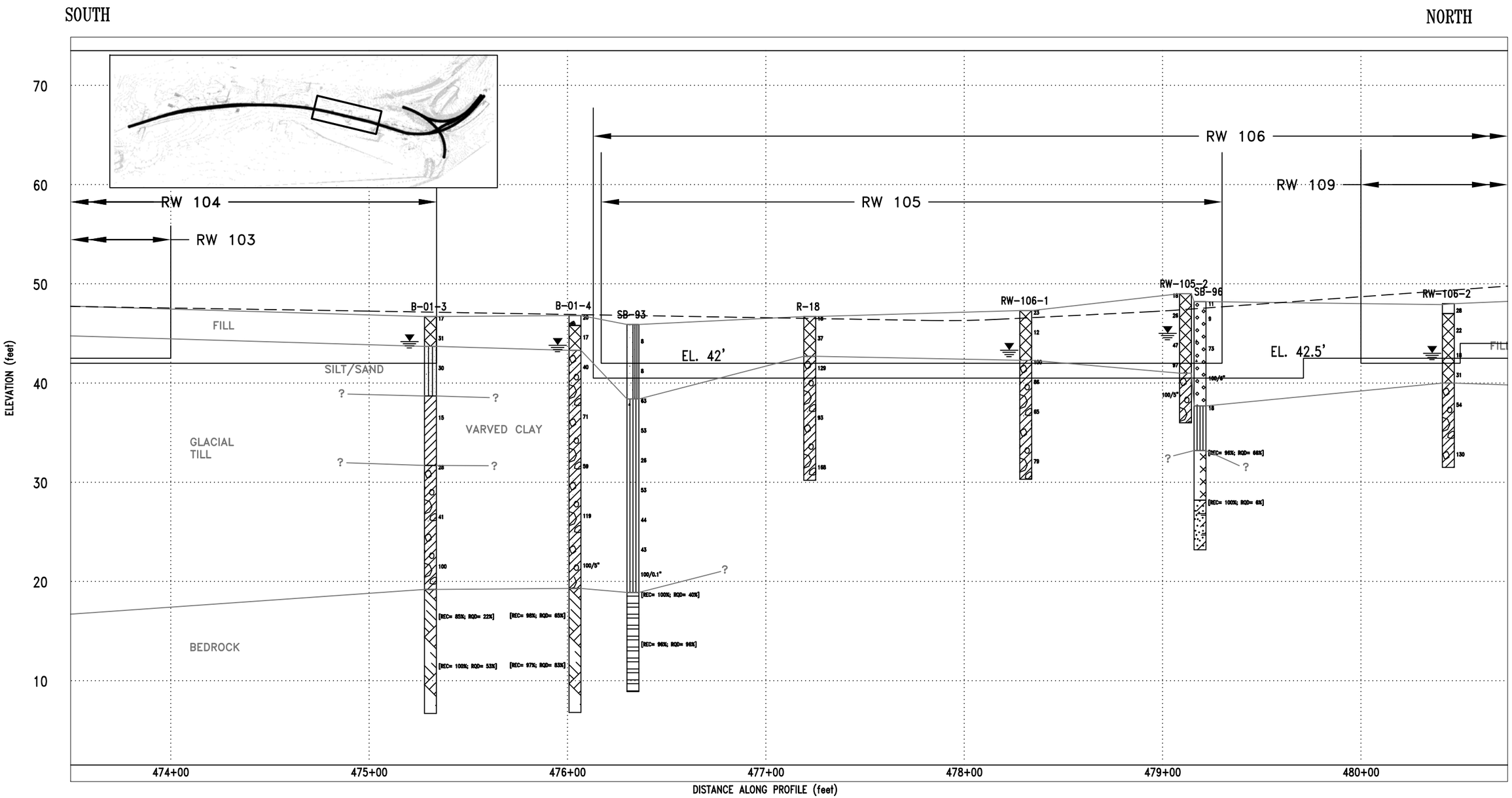
FILE NO. 331-14

SCALE 1" = 80' DATE 4-8-09

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FIGURE NO. 105-1

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of 2-24-09)



M:\CL\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

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Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

File No.: 0331-014.0 | Figure No.: 105-2

INSERT TAB
106
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Retaining Wall 106

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 106

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 2
6.3 Subsurface Summary at Retaining Walls 2
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 3
7.4.1 Design of Proprietary Retaining Wall 3
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 4
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 4
8.4 Temporary Lateral Support 5

Attached Figures:

106-1 Boring Location Plan
106-2 Subsurface Profile

RETAINING WALL 106
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 106 is shown on Figure 106-1 (attached).

This retaining wall will extend from NB Station 476+13 to 483+08 (Right). Existing I-84 EB off-ramp to Capitol Ave is overhead at NB Station 480+00. South of approximate NB Station 482+00, the existing railroad grade is at about El. 49 feet with the existing ground surface generally level within approximately 25 feet west of the railroad embankment. The grade then slopes upward at 2H:1V to El. 65 feet. North of approximate NB Station 482+00, the railroad grade is at about El. 52 feet. West of the tracks, the grade is pitched slightly toward the west for about 40 feet before sloping downward at a 3H:1V slope.

1.6 Existing Utilities

Based on drawings provided by Lochner, Geo**Design** has identified where utilities which cross below the proposed retaining wall. The table below indicates the utility station and type, and the proposed filling to take place at these locations.

Approx. NB Station	Utility	Proposed Filling	Retaining Wall No.
481+65	24-inch RCP	1 foot fill	106

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	NB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
106	476+13 to 483+08 R	695	6 to 8	40.5 to 44.5	Fill

*BFE = Bottom of Footing Elevation
R = Right (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata at this retaining wall are summarized below. Table 4 (Appendix 1) summarizes the strata by boring. Figure 106-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**NB Busway Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
106	476+13 to 483+08 R	5 to 7	0	11 to 29

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. This retaining wall will retain/protect the proposed Busway and proprietary walls are feasible.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 40.5 to 44.5 feet. We anticipated footing subgrade material to consist of loose to very dense Fill (0 to 3 ft), over dense Glacial Till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 5.0 ksf
Strength Limit State – 7.6_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

Due to the proposed Busway behind the proposed retaining wall, earth pressure calculations should assume a surface surcharge of 24 inches soil depth or 250 psf.

7.4.1 Design of Proprietary Retaining Wall

We understand a proprietary retaining wall will not be used at this location.

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2.

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate that the maximum settlement will be less than one-half inch, and will occur rapidly (i.e. during construction). We estimate differential settlements along these walls to be negligible.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade. The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 106 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this wall will exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

A utility crosses this proposed retaining wall at NB Station 481+65. We estimate settlement of this utility under about two feet of fill, will be less than one-half inch.

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend over excavating 12-inches, and proof compacting the exposed subgrade with at least 10 passes of a self propelled drum roller with a compaction force of at least 8 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact. Gradation testing indicates that the top three feet of soil encountered at this wall is mostly granular with less than 25-percent fines (passing No. 200 sieve).

Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of "unsuitable" materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Proposed footing elevations are at or just below observed ground water elevations. Although large volumes of groundwater are not anticipated during foundation construction and cofferdam and pumping are not expected to be required, contractors should be prepared with pumps to control surface water.

8.4 Temporary Lateral Support

In the event that during construction the nearest railroad track is live, excavations to construct this retaining wall will entail cuts that will encroach on the protected zone adjacent to railroad tracks. In this case specifically, temporary sheeting will be required for excavations extending into "Zone 2" below the boundary defined as a 1V:1.5H downward slope beginning 10 feet outside the centerline of the nearest railroad tracks. Temporary sheeting to be left-in-place will be required for excavations extending into "Zone 3" below the boundary defined as a 1V:1H downward slope beginning at the closest end of the railroad tie.

Based on soil and groundwater conditions, and depth to bedrock, we recommend cantilever steel sheet piling be used to provide the support of excavation. Appropriate contractor coordination with Amtrak will also need to be specified in the contract documents.

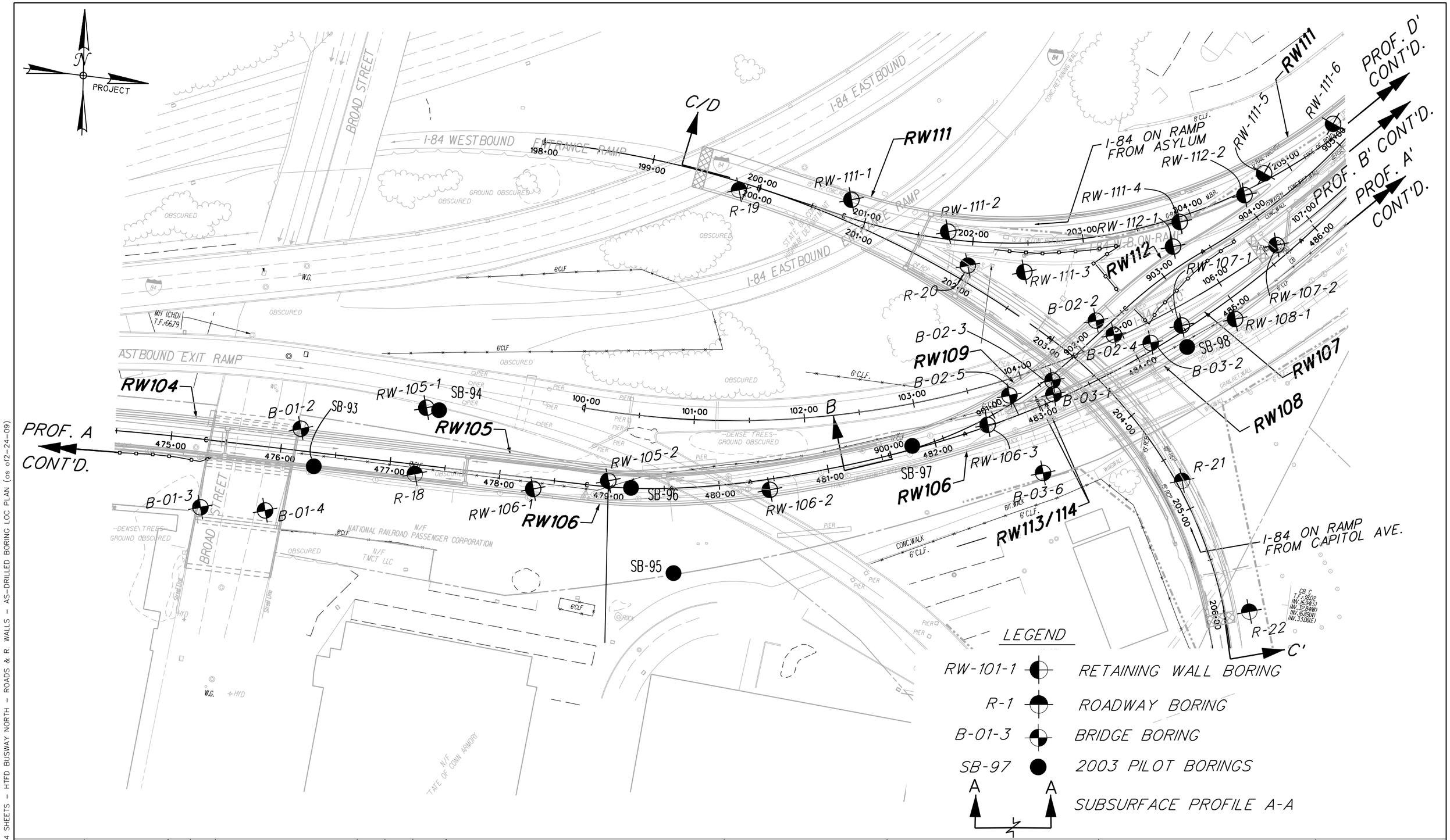
We recommend applicable railroad surcharges, and the following design parameters for temporary lateral earth support with level backfill:

Existing Embankment Fill:

Unit weight = 125 pounds per cubic foot (pcf)
Phi = 32degrees
$K_a = 0.31$
$K_p = 3.2$

Glacial Till:

Unit weight = 135 pcf
Phi = 36 degrees
$K_a = 0.26$
$K_p = 4.5$



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DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

FILE NO. 331-14

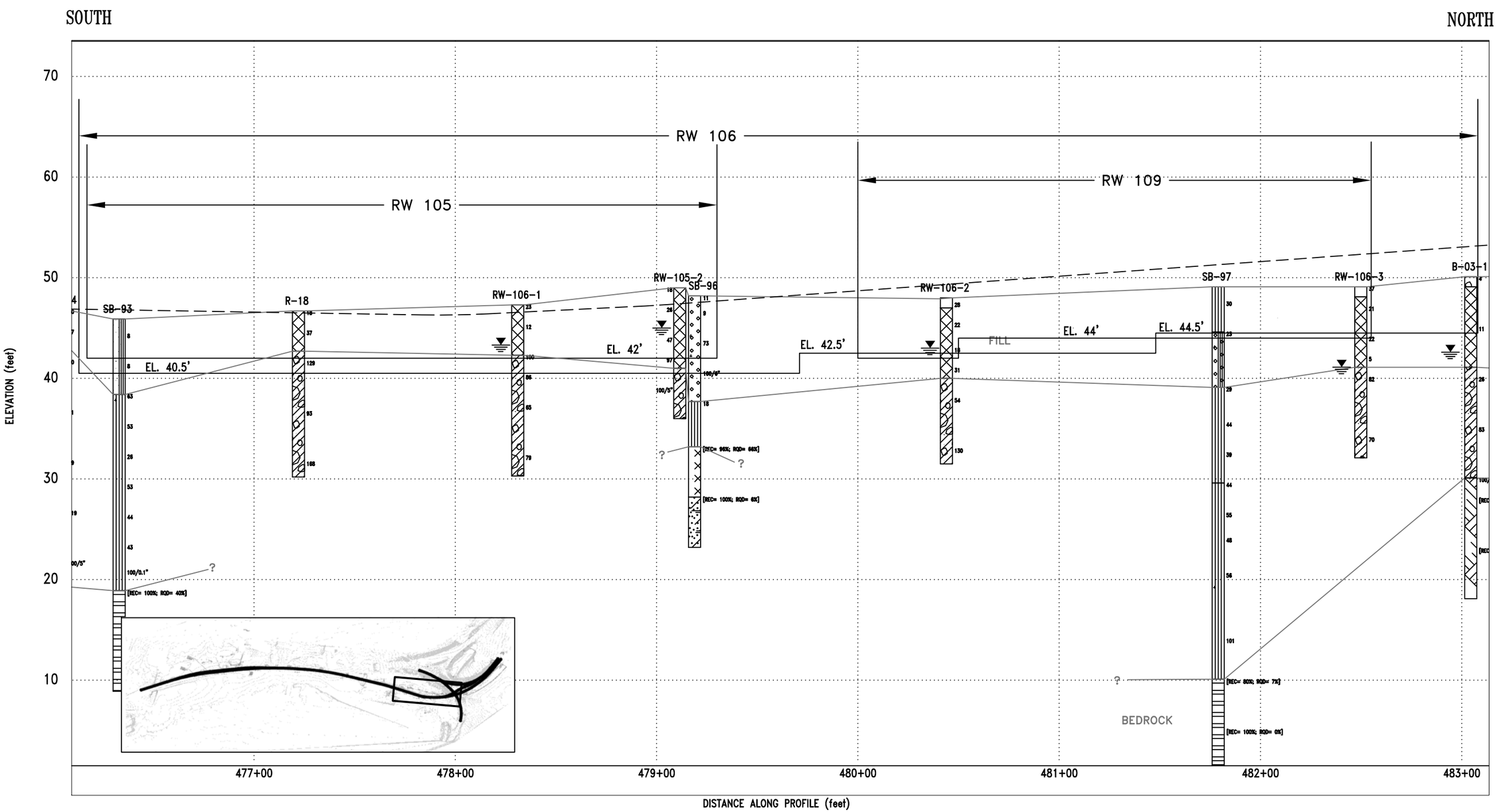
SCALE 1" = 80'

DATE 4-8-09

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FIGURE NO. 106-1

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of 2-24-09)



M:\CL\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

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Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

File No.: 0331-014.0 | Figure No.: 106-2

INSERT TAB
107
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Retaining Wall 107

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 107

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 1
6.3 Subsurface Summary at Retaining Walls 1
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 3
7.4.1 Design of Proprietary Retaining Wall 3
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 4
7.7 Stability 4
7.8 Seismic Design 4
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 5
8.4 Temporary Lateral Support 5

Attached Figures:

107-1 Boring Location Plan
107-2 Subsurface Profile

RETAINING WALL 107
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 107 is shown on Figure 107-1 (attached).

This retaining wall will extend from NB Station 484+34 to 485+40 (Left). The existing railroad grade is at about El. 51 feet. West of the tracks, the grade is pitched slightly toward the west for about 30 feet before sloping downward at a 3H:1V slope to El. 29 feet. The existing I-84 EB off-ramp to Asylum Street is elevated and located to the west of this wall.

1.6 Existing Utilities

Not Applicable

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	NB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
107	484+34 to 485+40 L	106	7 to 10	45 to 47	Fill

*BFE = Bottom of Footing Elevation
L = Left (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata summary at this retaining wall follows. Table 4 (Appendix 1) summarizes the strata by boring. Figure 107-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**NB Busway Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
107	484+34 to 485+40 L	8 to 10	0	8 to 20

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. This retaining wall will retain/protect the proposed Busway and proprietary walls are feasible.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 45 to 47 feet. We anticipated footing subgrade material to consist of loose to very dense Fill (1 to 3 ft), over dense Glacial Till.

For a proprietary wall, we recommended an Allowable Bearing Pressure of 3.0 kips per square foot (ksf).

For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 3.0 ksf
Strength Limit State – 8.7_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

Due to the proposed Busway behind the proposed retaining wall, earth pressure calculations should assume a surface surcharge of 24 inches soil depth or 250 psf.

7.4.1 Design of Proprietary Retaining Wall

We recommend the following static design parameters for proprietary walls backfilled with Conventional 125 pcf Fill.

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Allowable Bearing Capacity and Anticipated Subgrade	*See Section 7.2*
Coefficient of Friction for Sliding	0.55
Coefficient of Friction for Soil against Wall, tan δ	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate that the maximum settlement will be less than one-half inch, and will occur rapidly (i.e. during construction). We estimate differential settlements along these walls to be negligible.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade. The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 107 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this wall will exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Not Applicable

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend over excavating 12-inches, and proof compacting the exposed subgrade with at least 10 passes of a self propelled drum roller with a compaction force of at least 8 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

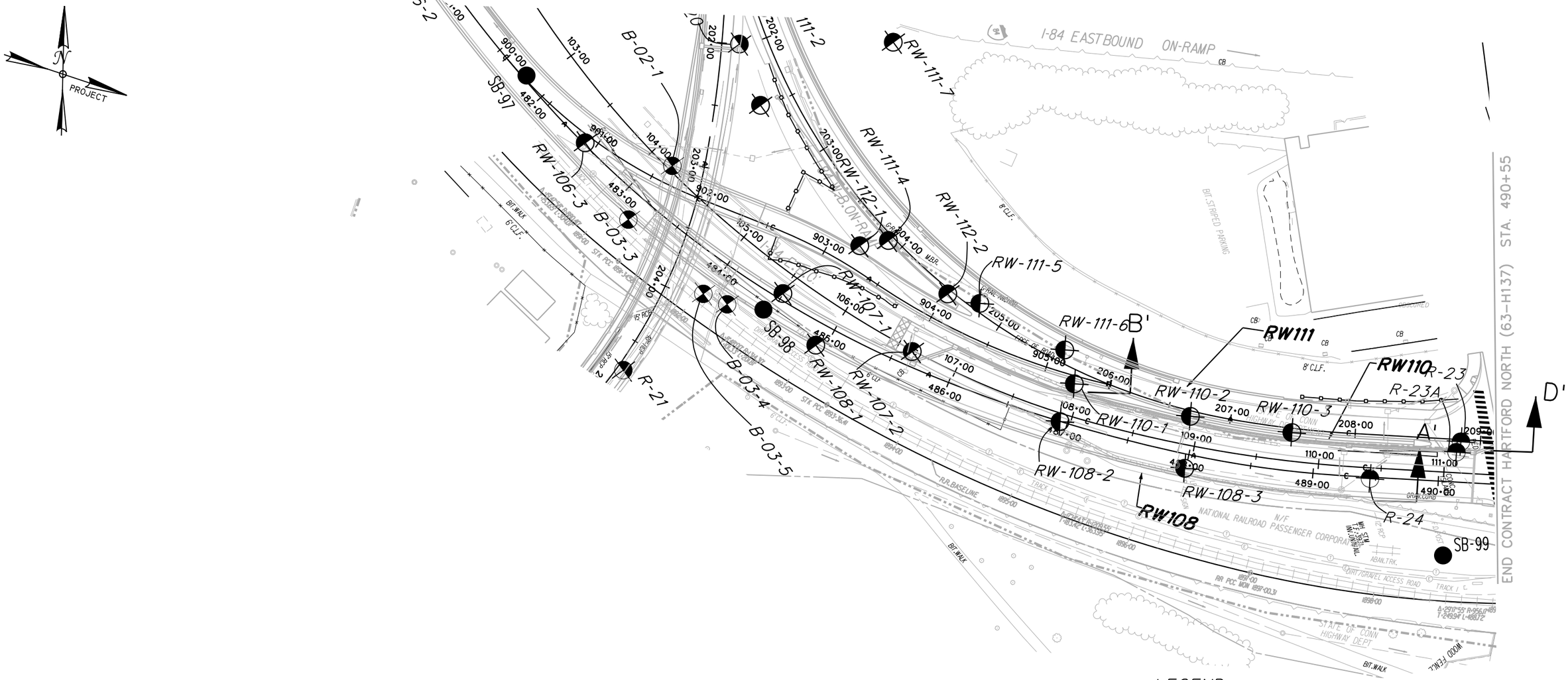
Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of "unsuitable" materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Large volumes of groundwater are not anticipated during foundation construction. Although cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control surface water.

8.4 Temporary Lateral Support

Not Applicable



LEGEND

RW-101-1	RETAINING WALL BORING
R-1	ROADWAY BORING
SB-97	2003 PILOT BORINGS
A — A	SUBSURFACE PROFILE A-A

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of2-24-09)

DESIGNED BY	JWK
DRAWN BY	SMC
CHECKED BY	JWK
APPROVED BY	ULF

NO.	DATE		DRWN.	CHKD	APPVD
		REVISIONS			

PRIME DESIGNER:

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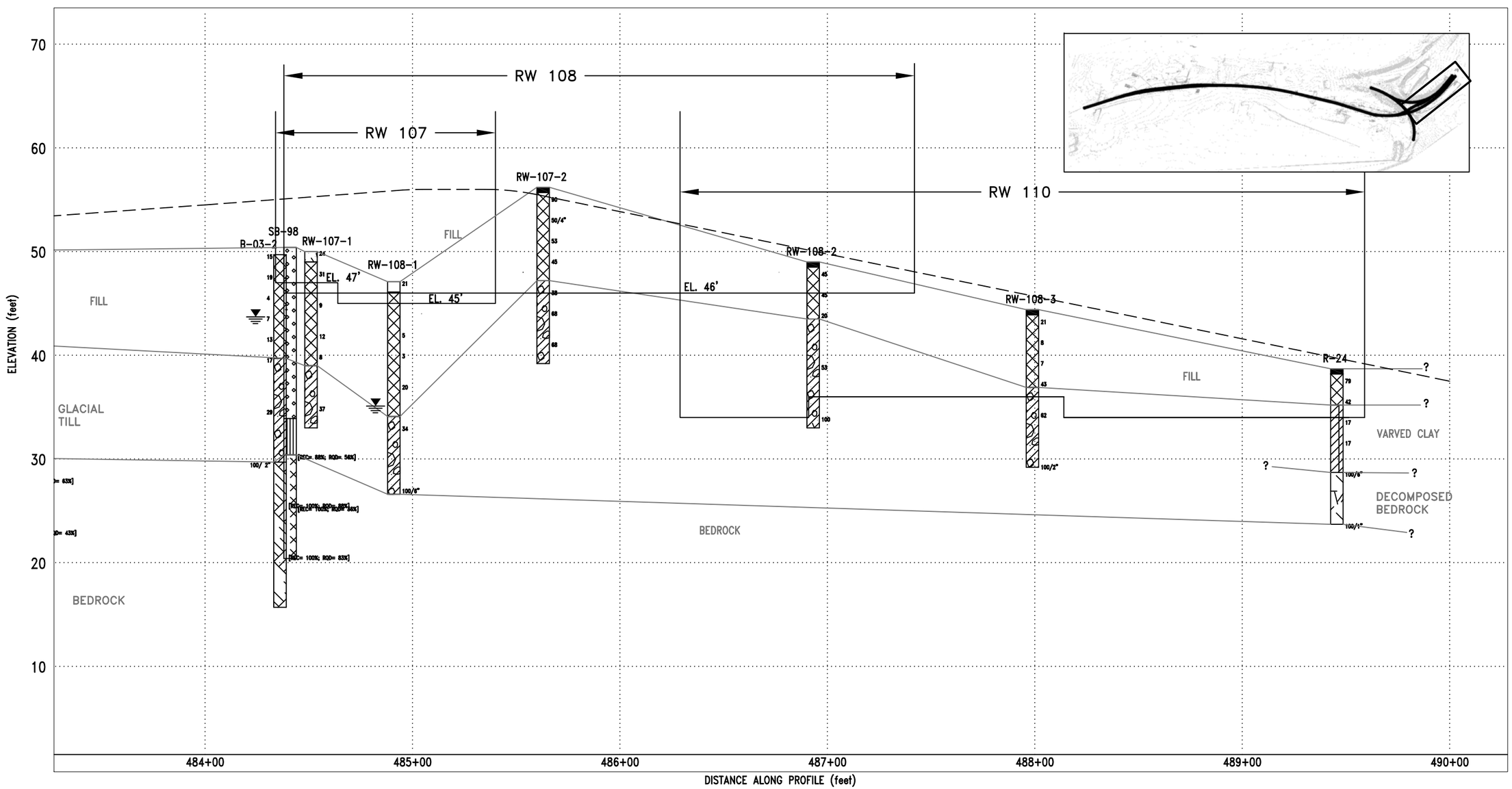
DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FILE NO. 331-14
SCALE 1" = 80'
DATE 4-8-09
FIGURE NO. 107-1



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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

Date: 2-23-2009	Drawn By: MJV/DSF	Reviewed By: MGB	File No.: 0331-014.0	Figure No.: 107-2

M:\C\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

INSERT TAB
108
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Retaining Wall 108

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 108

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 1
6.3 Subsurface Summary at Retaining Walls 1
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 2
7.4.1 Design of Proprietary Retaining Wall 3
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 4
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 4
8.4 Temporary Lateral Support 5

Attached Figures:

108-1 Boring Location Plan
108-2 Subsurface Profile

RETAINING WALL 108
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 108 is shown on Figure 108-1 (attached).

This retaining wall will extend from NB Station 484+38 to 487+42 (Right). The existing railroad grade is at about El. 51 feet. West of the tracks, the grade is pitched slightly toward the west for about 30 feet before sloping downward at a 3H:1V slope to El. 29 feet. The existing I-84 EB off-ramp to Asylum Street is elevated and located to the west of this wall.

1.6 Existing Utilities

Not Applicable

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	NB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
108	484+38 to 487+42 R	304	10	46	Fill

*BFE = Bottom of Footing Elevation
R = Right (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata at this retaining wall are summarized below. Table 4 (Appendix 1) summarizes the strata by boring. Figure 108-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**NB Busway Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
108	484+38 to 487+42 R	5 to 12	0	8 to 20

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. This retaining wall will retain/protect the proposed Busway and proprietary walls are feasible.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation to be about El. 46 feet. We anticipated footing subgrade material to consist of loose to very dense Fill (0 to 6 ft), over dense Glacial Till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 4.0 ksf
Strength Limit State – 6.7_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

Due to the proposed Busway behind the proposed retaining wall, earth pressure calculations should assume a surface surcharge of 24 inches soil depth or 250 psf.

7.4.1 Design of Proprietary Retaining Wall

We understand a proprietary retaining wall will not be used in this location.

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate that the maximum settlement will be less than one-half inch, and will occur rapidly (i.e. during construction). We estimate differential settlements along these walls to be negligible.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade.

The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 108 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this wall will exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Not Applicable

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend over excavating 12-nches, and proof compacting the exposed subgrade with at least 10 passes of a self propelled drum roller with a compaction force of at least 8 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact. Gradation testing indicates that the top three feet of soil encountered at this wall is mostly granular with less than 25-percent fines (passing No. 200 sieve).

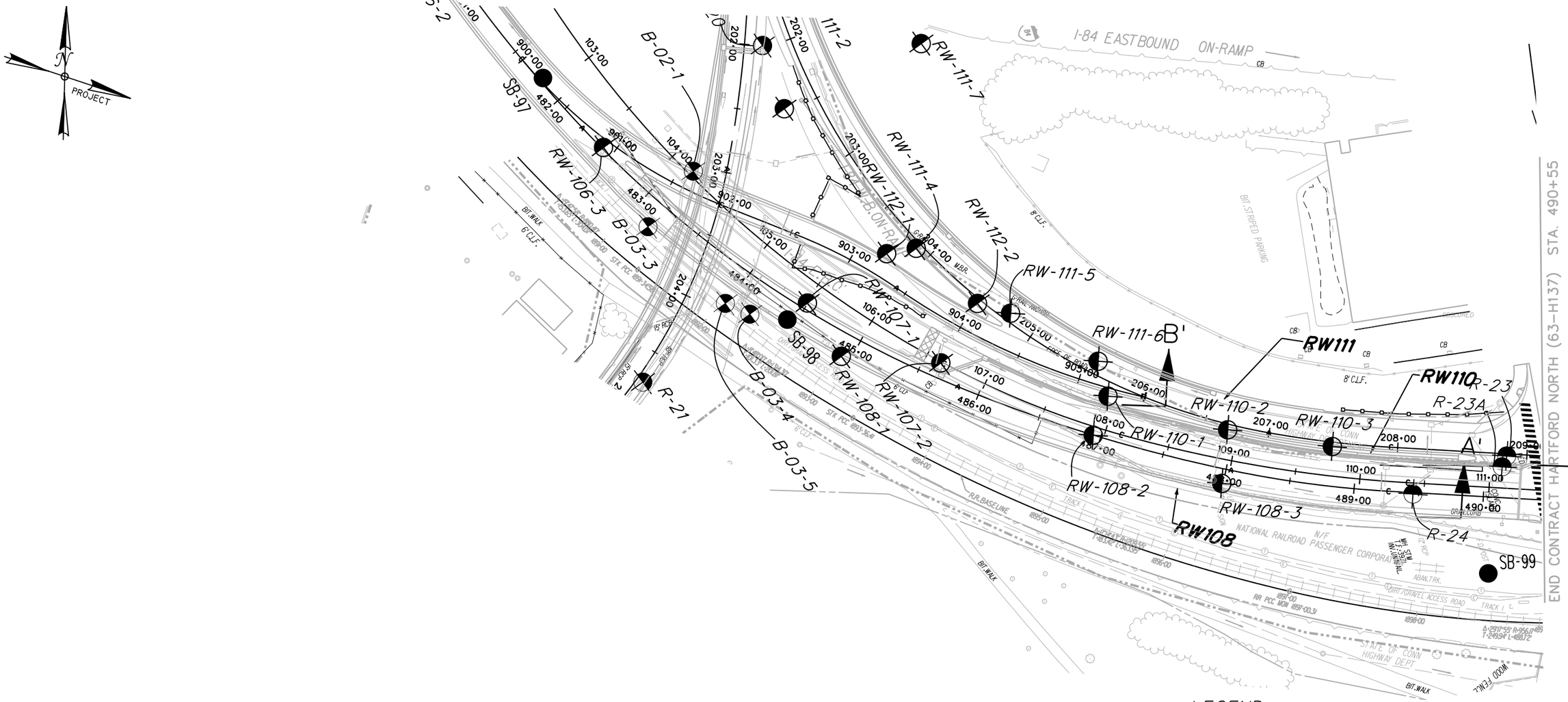
Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of “unsuitable” materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Large volumes of groundwater are not anticipated during foundation construction. Although cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control surface water.

8.4 Temporary Lateral Support

Temporary lateral support will be required for construction of this retaining wall. Based on soil and groundwater conditions, and depth to bedrock, we recommend continuous steel sheet piling be used to provide the support of excavation. We recommend a 250 pcf surcharge load plus any construction surcharge loading.



LEGEND

RW-101-1	RETAINING WALL BORING
R-1	ROADWAY BORING
SB-97	2003 PILOT BORINGS
A — A	SUBSURFACE PROFILE A-A

DESIGNED BY JWK							
DRAWN BY SMC							
CHECKED BY JWK							
APPROVED BY ULF		NO.	DATE		DRWN.	CHKD	APPVD
		REVISIONS					

PRIME DESIGNER:

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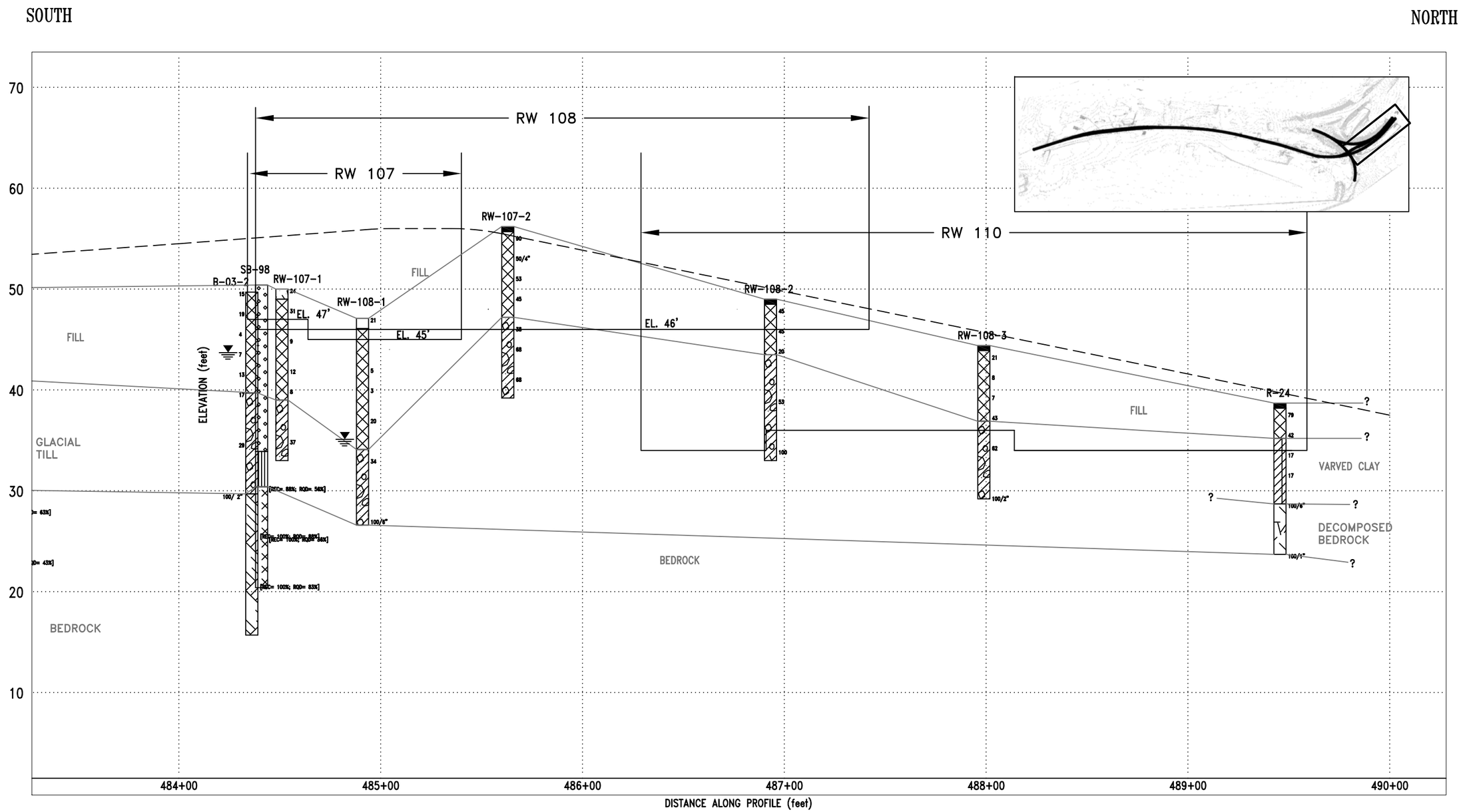
DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FILE NO. 331-14
SCALE 1" = 80'
DATE 4-8-09
FIGURE NO. 108-1

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of2-24-09)



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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

File No.: 0331-014.0 | Figure No.: 108-2

M:\CL\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

INSERT TAB
109
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Retaining Wall 109

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 109

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 1
6.3 Subsurface Summary at Retaining Walls 1
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 2
7.4.1 Design of Proprietary Retaining Wall 2
7.4.2 Design of Cast-in-Place Retaining Wall 2
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 3
7.9 Utilities 3
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 4
8.4 Temporary Lateral Support 4

Attached Figures:

109-1 Boring Location Plan
109-2 Subsurface Profile

RETAINING WALL 109
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 109 is shown on Figure 109-1 (attached).

This retaining wall will extend from SB Station 480+00 to 482+55 (Left). Elevated to the north of this wall is I-84 EB off-ramp to Asylum Street. The existing grade is at about El. 49 feet and slopes upward at about 3.3H:1V to El. 54 feet.

1.6 Existing Utilities

Not Applicable

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	SB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
109	480+00 to 482+55 L	255	10 to 13	42 to 44	Cut

*BFE = Bottom of Footing Elevation
L = Left (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata at this retaining wall are summarized below. Table 4 (Appendix 1) summarizes the strata by boring. Figure 109-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	SB Busway Stationing	Fill	Varved Clay	Glacial Till
109	480+00 to 482+55 L	4	0	15

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. However, at this location, a proprietary wall would require deep cuts into existing steep embankments, and is not economical and is therefore not recommended.

7.2 Bearing Pressures

Based our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 42 to 44 feet. We anticipated footing subgrade material to consist of loose to very dense Fill (3 to 10 ft), over dense Glacial Till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 4.0 ksf
Strength Limit State – 6.7_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

7.4.1 Design of Proprietary Retaining Wall

Not Applicable

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate that the maximum settlements will be less than one-half inch, and will occur rapidly (i.e. during construction). We estimate differential settlements along these walls to be negligible.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade. The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 109 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this wall will exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Not Applicable

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend over excavating 12-inches and proof compacting the exposed subgrade with at least 10 passes of a self propelled drum roller with a compaction force of at least 8 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

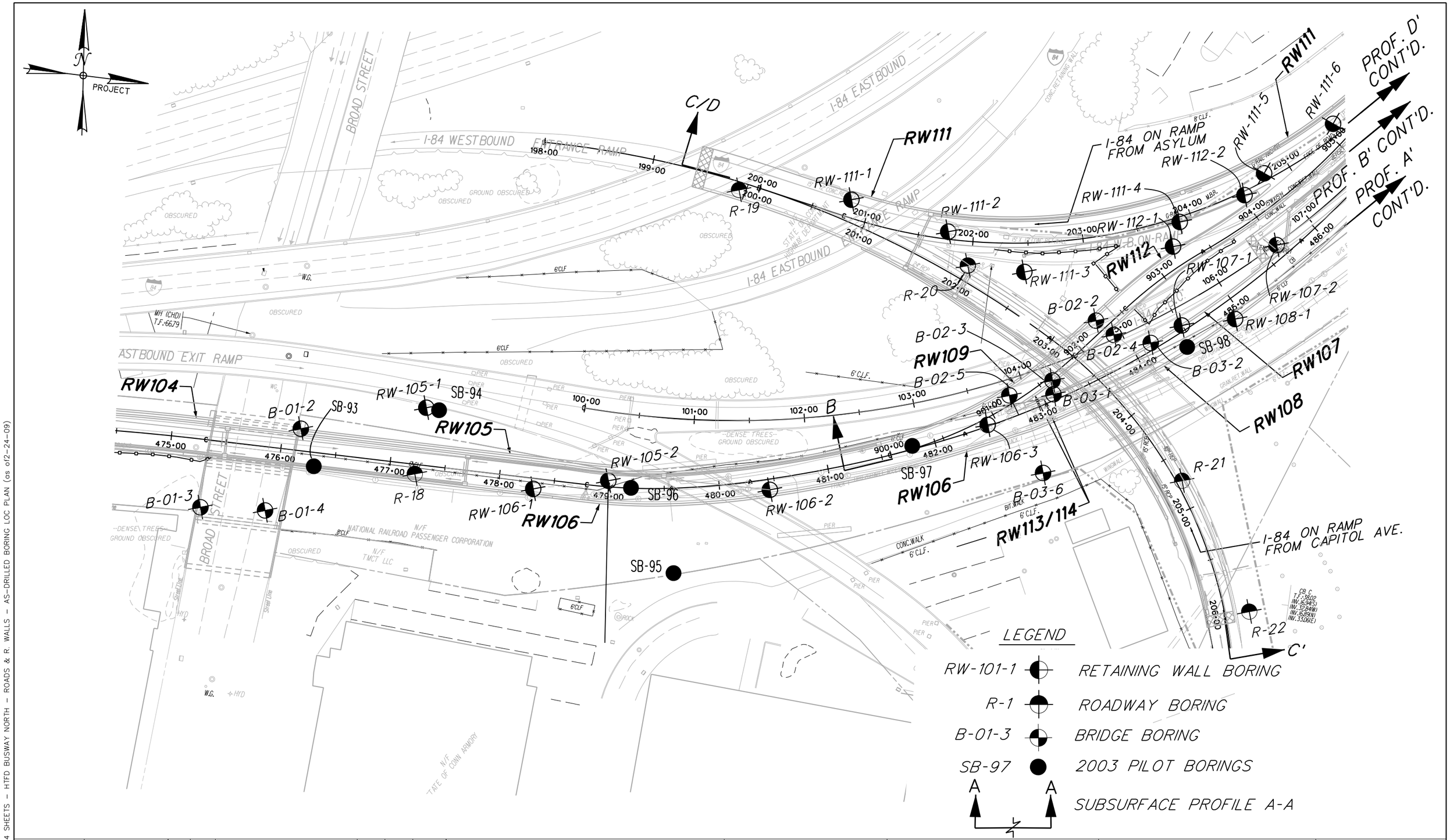
Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of “unsuitable” materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

We do not anticipate the presence of groundwater during construction of this wall. Although cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control surface water.

8.4 Temporary Lateral Support

Temporary lateral support will be required for construction of this retaining wall. Based on soil and groundwater conditions, and depth to bedrock, we recommend continuous steel sheet piling be used to provide the support of excavation. This wall will support sloped backfill (approximately 2H:1V). The effects of this sloped backfill must be considered in the support of excavation design. Due to the absence of traffic within the zone of influence of this wall, only construction surcharge loads need to be considered.



DESIGNED BY JWK							
DRAWN BY SMC							
CHECKED BY JWK							
APPROVED BY ULF		NO.	DATE		DRWN.	CHKD	APPVD
		REVISIONS					

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DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

FILE NO. 331-14

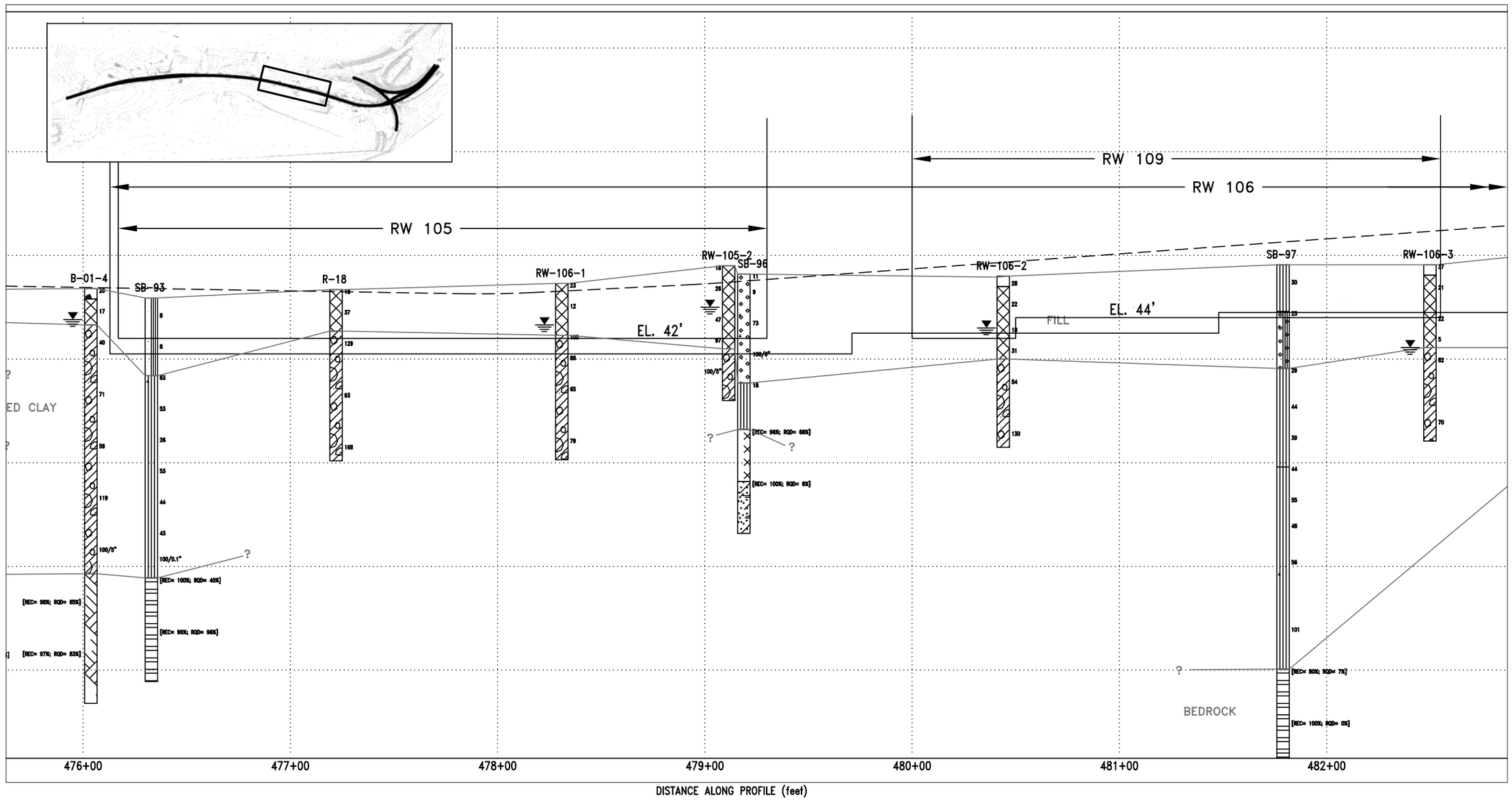
SCALE 1" = 80'

DATE 4-8-09

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FIGURE NO. 109-1

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of2-24-09)



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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

Date: 2-23-2009	Drawn By: MJV/DSF	Reviewed By: MGB	File No.: 0331-014.0	Figure No.: 109-2

M:\CL\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

INSERT TAB
110
HERE

Retaining Wall 110

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 110

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 1
6.3 Subsurface Summary at Retaining Walls 1
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 2
7.4.1 Design of Proprietary Retaining Wall 3
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 4
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 4
8.4 Temporary Lateral Support 4

Attached Figures:

110-1 Boring Location Plan
110-2 Subsurface Profile

RETAINING WALL 110
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 110 is shown on Figure 110-1 (attached).

This retaining wall will extend from I-84 WB On-Ramp Station 486+29 to 489+59 (Right). The proposed retaining wall will be located between the existing I-84 WB on-ramp from Asylum Street (at about El. 48 feet), and the existing I-84 EB off-ramp to Asylum Street (at about El. 37 feet).

1.6 Existing Utilities

Not Applicable

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	I-84 On-Ramp from Asylum Street Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
110	486+29 to 489+59 R	330	3 to 18	34 to 36	Fill

*BFE = Bottom of Footing Elevation
R = Right (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata summary at this retaining wall follows. Table 4 (Appendix 1) summarizes the strata by boring. Figure 110-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**I-84 On-Ramp from Asylum Street Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
110	486+29 to 489+59 R	< 2	0	9

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. However, at this location, a proprietary wall would require deep cuts into existing steep embankments, and is not economical and is therefore not recommended.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 35 feet. We anticipated footing subgrade material to consist of very dense Fill (less than 2 ft) over medium dense to very dense Glacial Till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 6.0 ksf
Strength Limit State – 11.7_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

Due to the proposed Busway behind the proposed retaining wall, earth pressure calculations should assume a surface surcharge of 24 inches soil depth or 250 psf.

7.4.1 Design of Proprietary Retaining Wall

Not Applicable

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate that the maximum settlements will be less than one-half inch, and will occur rapidly (i.e. during construction). We estimate differential settlements along these walls to be negligible.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems and six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade.

The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 110 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this wall will exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Not Applicable

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend excavating to subgrade and proof compacting the exposed subgrade with at least 4 passes of a compactor with a compaction force of at least 3 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

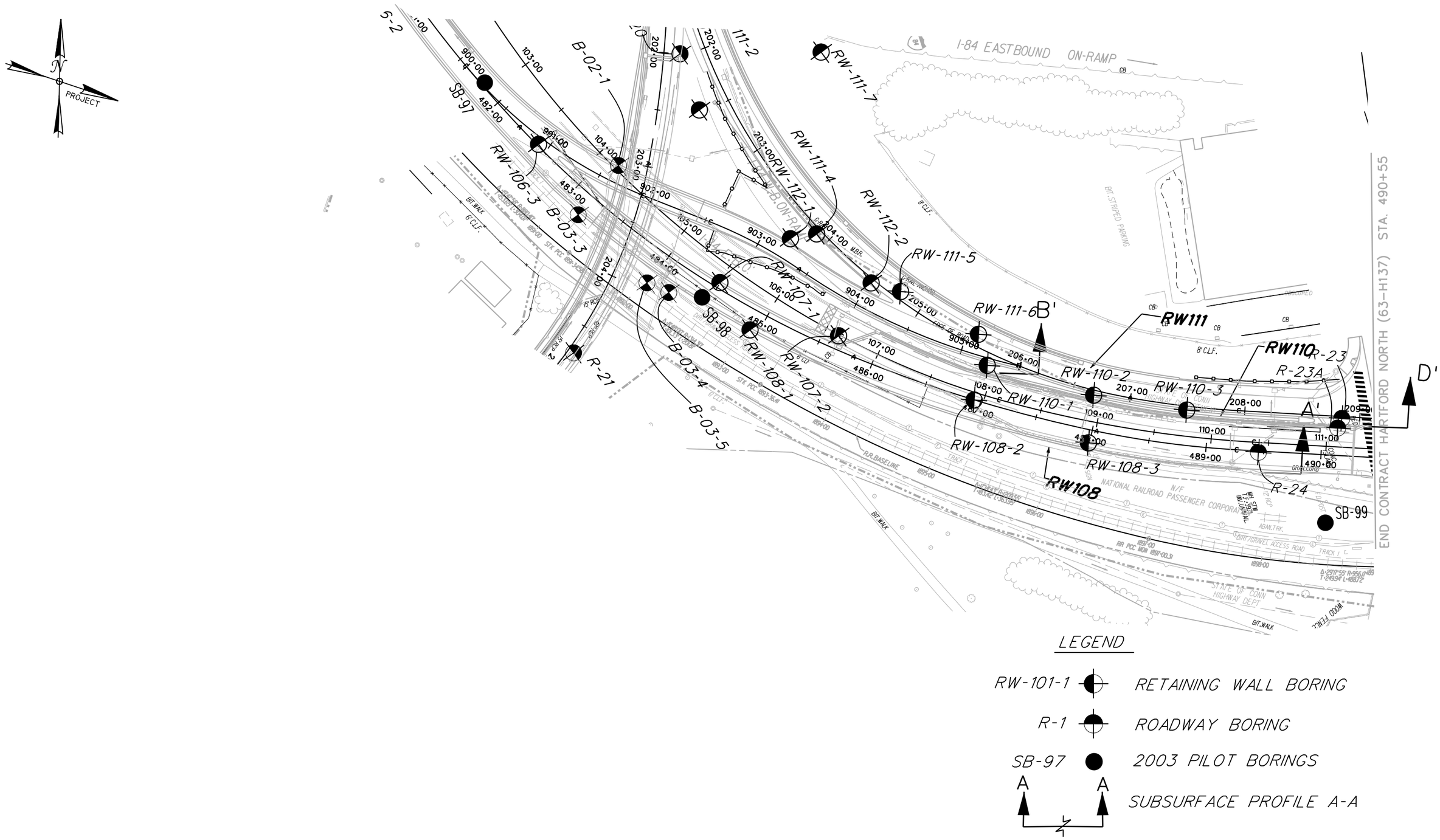
Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of “unsuitable” materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Shallow groundwater was observed near this retaining wall. Although cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control groundwater and surface water.

8.4 Temporary Lateral Support

Not Applicable



LEGEND

RW-101-1	RETAINING WALL BORING
R-1	ROADWAY BORING
SB-97	2003 PILOT BORINGS
A — A	SUBSURFACE PROFILE A-A

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of2-24-09)

DESIGNED BY	JWK
DRAWN BY	SMC
CHECKED BY	JWK
APPROVED BY	ULF

NO.	DATE		DRWN.	CHKD	APPVD

REVISIONS

PRIME DESIGNER:

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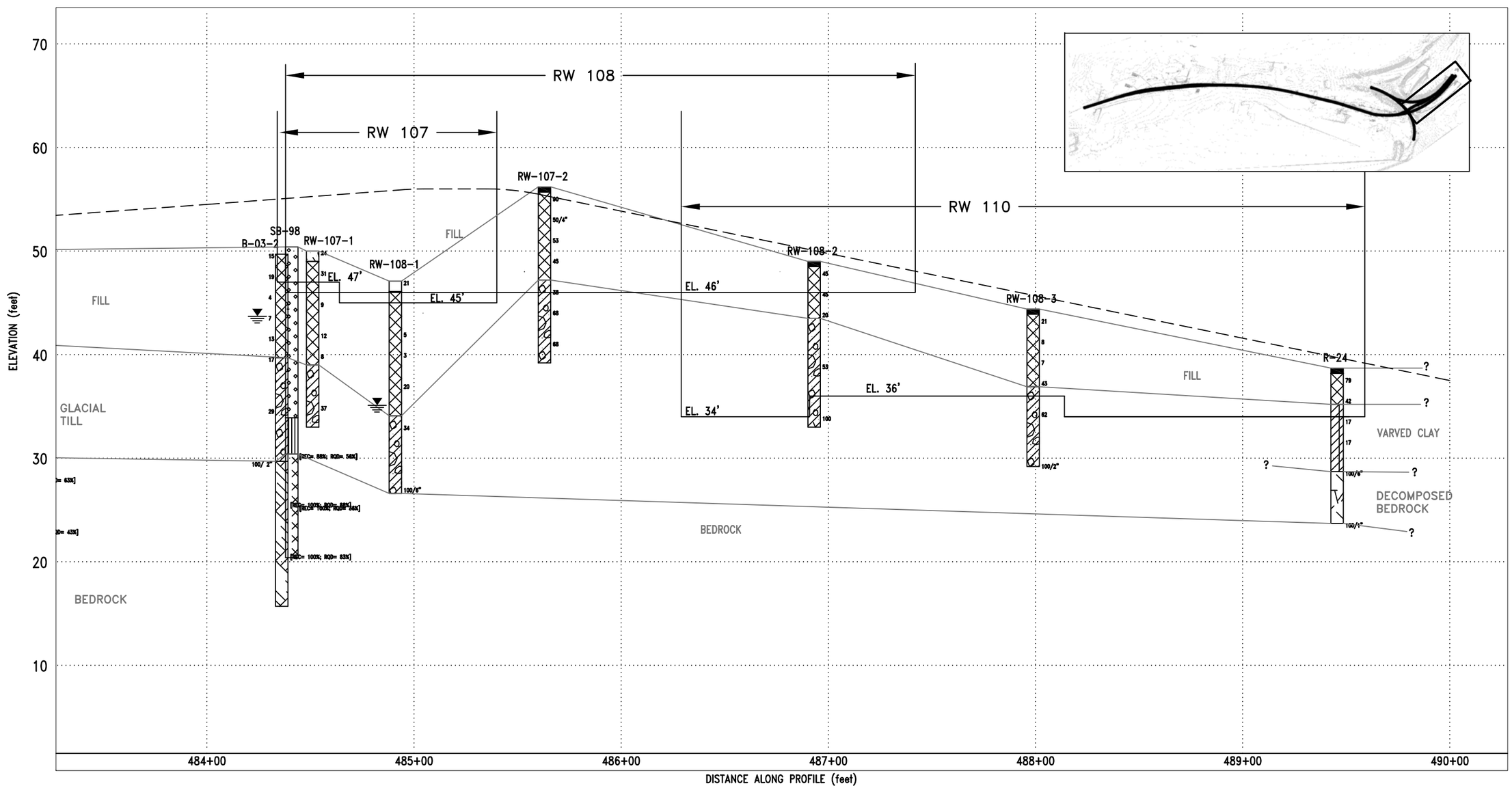
DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FILE NO. 331-14
SCALE 1" = 80'
DATE 4-8-09
FIGURE NO. 110-1



M:\CL\0331\14\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE A-A' (Roadway Figure 6A-F, Retaining Wall Figures 101-2 to 108-2 and 113-2 to 114-2)(West to East Sta. 443+00 -491+00) 1in.= 50ft. 5x Vert Ex.

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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE A-A'

New Britain / Hartford Busway
NB Busway 450+00 to 490+55

File No.: 0331-014.0 | Figure No.: 110-2

INSERT TAB
111
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Retaining Wall 111

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 111

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 1
6.3 Subsurface Summary at Retaining Walls 1
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 2
7.4.1 Design of Proprietary Retaining Wall 2
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 3
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 4
8.4 Temporary Lateral Support 4

Attached Figures:

111-1 Boring Location Plan
111-2 Subsurface Profile

RETAINING WALL 111
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 111 is shown on Figure 111-1 (attached).

This retaining wall will extend from I-84 WB On-Ramp Station 200+50 to 204+90 (Left). The proposed retaining wall will be located west of the existing I-84 WB on-ramp from Asylum Street. West of the on-ramp the grade slopes upward at 2H:1V for an approximate distance of 45 to 65 feet behind the proposed wall.

1.6 Existing Utilities

Not Applicable

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	I-84 On-Ramp from Asylum Street Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
111	200+50 to 204+90 L	440	10 to 15	21 to 34	Cut

*BFE = Bottom of Footing Elevation
L = Left (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata summary at this retaining wall follows. Table 4 (Appendix 1) summarizes the strata by boring. Figure 111-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	**I-84 On-Ramp from Asylum Street Stationing**	**Fill**	**Varved Clay**	**Glacial Till**
111	200+50 to 204+90 L	< 2	0	2 to 11

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. However, at this location, a proprietary wall would require deep cuts into existing steep embankments, and is not economical and is therefore not recommended.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 20.5 to 34.5 feet. We anticipated footing subgrade material to consist of very dense Fill (less than 3 ft) over medium dense to very dense Glacial Till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 6.0 ksf
Strength Limit State – 8.8_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

7.4.1 Design of Proprietary Retaining Wall

Not Applicable

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate that the maximum settlements will be less than one-half inch, and will occur rapidly (i.e. during construction). We estimate differential settlements along these walls to be negligible.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems or six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade. The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 111 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this wall will exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Not Applicable

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend excavating to subgrade and proof compacting the exposed subgrade with at least 4 passes of a compactor with a compaction force of at least 3 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

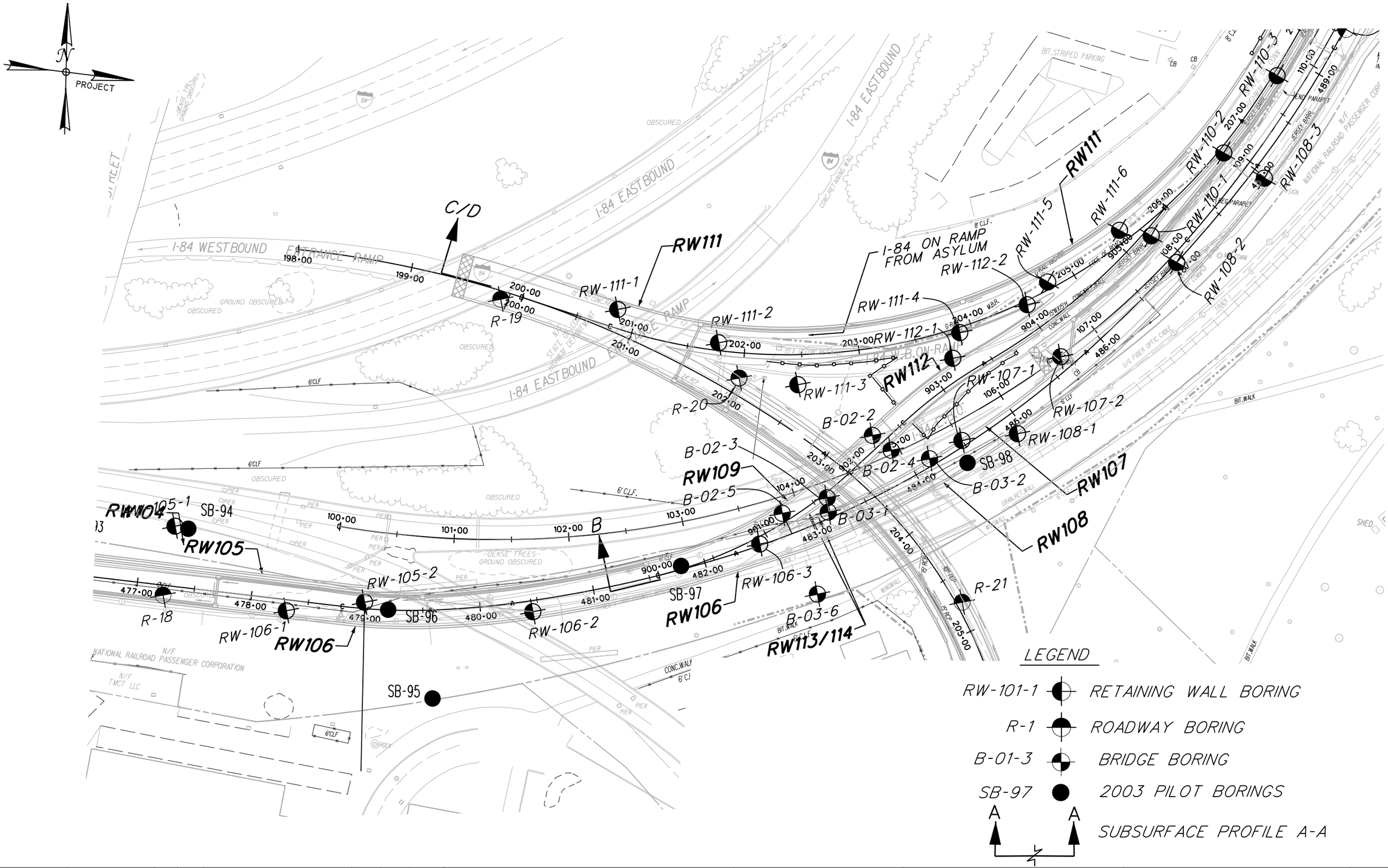
Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of “unsuitable” materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Shallow groundwater was observed as shallow near this retaining wall. Although cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control groundwater and surface water.

8.4 Temporary Lateral Support

Temporary lateral support will be required for construction of this retaining wall. Based on soil and groundwater conditions, and depth to bedrock, we recommend continuous steel sheet piling be used to provide the support of excavation. This wall will support sloped backfill (approximately 2H:1V). The effects of this sloped backfill must be considered in the support of excavation design. Due to the absence of traffic within the zone of influence of this wall, only construction surcharge loads need to be considered.



DESIGNED BY JWK							
DRAWN BY SMC							
CHECKED BY JWK							
APPROVED BY ULF		NO.	DATE		DRWN.	CHKD	APPVD
		REVISIONS					

PRIME DESIGNER:

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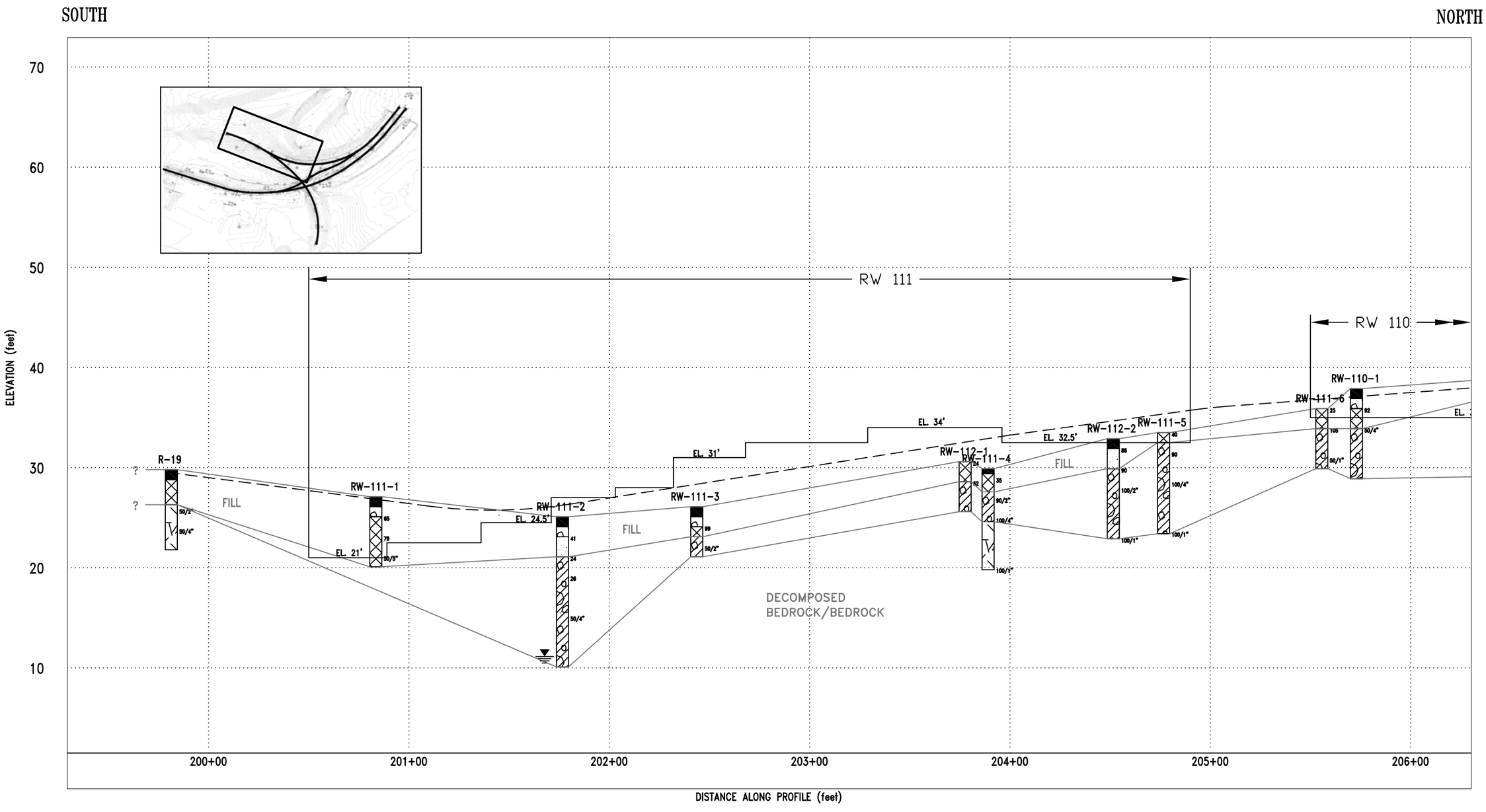
DWG. TITLE
AS-DRILLED EXPLORATION LOCATION PLAN

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FILE NO. 331-14
SCALE 1" = 80'
DATE 4-8-09
FIGURE NO. 111-1

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (os of2-24-09)



M:\CL\0331\CADD\Roadway and Retaining Walls\SUBSURFACE PROFILE D-D' (Roadway Figure 8A-B, Retaining Wall Figures 111-2 & 110-2) I-84 WB Onramp - Asylum Street (west to east sta. 200+00 -209+50) 1in.= 50ft. 5x vert ex

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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

Date: 2-23-2009	Drawn By: MJV/DSF	Reviewed By: MGB

SUBSURFACE PROFILE D-D'

New Britain / Hartford Busway
I-84 WB Onramp from Asylum Street

File No.: 0331-014.0 Figure No.: 111-2

INSERT TAB
112
HERE

Retaining Wall 112

Wall-Specific Information & Recommendations

Wall-Specific Table of Contents
for Retaining Wall 112

1.0 GENERAL INFORMATION 1
1.5 Existing Conditions 1
1.6 Existing Utilities 1
1.7 Proposed Retaining Wall 1
6.0 INTERPRETATION OF SUBSURFACE CONDITIONS 1
6.3 Subsurface Summary at Retaining Walls 1
7.0 ANALYSES AND DESIGN RECOMMENDATIONS 2
7.1 Foundation and Type 2
7.2 Bearing Pressures 2
7.3 Retaining Wall Backfill 2
7.4 Design Parameters 2
7.4.1 Design of Proprietary Retaining Wall 3
7.4.2 Design of Cast-in-Place Retaining Wall 3
7.5 Settlement Analysis 3
7.6 Drainage 3
7.7 Stability 3
7.8 Seismic Design 3
7.9 Utilities 4
8.0 CONSTRUCTION RECOMMENDATIONS 4
8.1 Subgrade Preparation 4
8.2 Reuse of Fill 4
8.3 Dewatering 4
8.4 Temporary Lateral Support 4

Attached Figures:

112-1 Boring Location Plan
112-2 Subsurface Profile

RETAINING WALL 112
Wall-Specific Information & Recommendations

This section (tab) should be used in conjunction with the proceeding section, which is common to all retaining walls.

1.0 GENERAL INFORMATION

1.5 Existing Conditions

The approximate location of proposed Retaining Wall 112 is shown on Figure 112-1 (attached).

This retaining wall will extend from SB Station 902+80 to 904+87 (Left). The proposed retaining wall will be located to the west of the elevated I-84 EB off-ramp to Asylum Street. North of Station 903+25 the proposed retaining will be built within the existing I-84 WB on-ramp from Asylum Street, at an existing grade of about El. 28 feet.

1.6 Existing Utilities

Not Applicable

1.7 Proposed Retaining Wall

Proposed details for this retaining wall are summarized below. Wall locations and dimensions were estimated from drawings and cut sections provided by Lochner.

Retaining Wall No.	SB Busway Stationing	Approx. Length (feet)	Approx. Height (feet)	Estimated BFE* (feet)	Type (Cut/Fill)
112	902+80 to 904+87 L	207	8 to 16	26 to 30	Fill

*BFE = Bottom of Footing Elevation
L = Left (Indicates retaining wall location relative to the Stationing)

6.0 INTERPRETATION OF SUBSURFACE CONDITIONS

6.3 Subsurface Summary at Retaining Walls

The subsurface strata summary at this retaining wall follows. Table 4 (Appendix 1) summarizes the strata by boring. Figure 112-2 depicts the generalized subsurface profile at this retaining wall.

		Approximate Thickness (feet)		
Retaining Wall No.	SB Busway Stationing	Fill	Varved Clay	Glacial Till
112	902+80 to 904+87 L	< 2	0	5 to 7

7.0 ANALYSES AND DESIGN RECOMMENDATIONS

Based on settlement analyses we recommend conventional spread shallow foundations and conventional wall backfill materials (e.g. 125 pcf fill), e.g. there is no need for special measures such as: light weight fill, waiting periods, wick drains, or Geofoam.

7.1 Foundation and Type

We recommend shallow foundations with bottom of footings constructed below frost depth, a minimum of 4.0 feet below final grades.

We understand that proprietary walls will be used wherever possible. This retaining wall will retain/protect the proposed Busway and proprietary walls are feasible.

7.2 Bearing Pressures

Based on our recommendation for the bottom of retaining wall footings to bear at least four feet below final grades, we understand the proposed bottom of wall footing elevation will be about El. 26 to 30 feet. We anticipated footing subgrade material to consist of very dense glacial till. For a cast-in-place wall with a minimum footing width of 4 feet, we recommend using the following Maximum Factored Bearing Resistances:

Service Limit State – 8.0 ksf
Strength Limit State – 15.2_ksf

Refer to the following design parameters (Section 7.4) and subgrade preparation (Section 8.1) recommendations.

7.3 Retaining Wall Backfill

Conventional 125 pcf backfill should be used behind this retaining wall.

7.4 Design Parameters

Due to the proposed Busway behind the proposed retaining wall, earth pressure calculations should assume a surface surcharge of 24 inches soil depth or 250 psf.

7.4.1 Design of Proprietary Retaining Wall

We understand a proprietary retaining wall will not be used at this location.

7.4.2 Design of Cast-in-Place Retaining Wall

We recommend the following static design parameters for cast-in-place walls backfilled with Conventional 125 pcf Fill. Load Factors should be selected from AASHTO LRFD Table 3.4.1-2

Unit Weight of soil above the water table, pounds per cubic foot (pcf)	125
Unit weight of soil below the water table, pounds per cubic foot (pcf)	62.6
Soil Angle of Internal Friction, φ	34
Nominal Bearing Resistance and Anticipated Subgrade	*See Section 7.2*
Bearing Resistance Factor (φ_b)	0.45
Coefficient of Friction for Sliding (AASHTO LRFD Table 3.11.5.3-1)	0.55
Coefficient of Friction for Soil against Wall (tan δ)	0.40
Coefficient of Passive Earth Pressure, K_P (to be neglected above frost depth)	3.5
Coefficient of Active Earth Pressure with level backfill, K_a	0.28
Coefficient of Active Earth Pressure with 2H:1V sloped backfill, K_a	0.42
Sliding Resistance Factor (φ_τ) (AASHTO LRFD Table 10.5.5.2.2-1)	0.8

The resistance factors provided in the previous table are for the Strength Limit State. In accordance with LRFD Section 10.5.5.1, resistance factors for the Service Limit State shall be taken as 1.0, except for global stability where the resistance factor shall be taken as 0.75. In accordance with LRFD Section 10.5.5.3.3, resistance factors for Extreme Limit State shall be taken as 1.0, except for uplift resistance of piles, where the resistance factor shall be taken as 0.80.

7.5 Settlement Analysis

We estimate settlement will be less than ¼ inch.

7.6 Drainage

Drainage details for retaining walls should be constructed in accordance with ConnDOT Bridge Design Manual specifications for walls and abutments. Specifically, bagged stone and weepholes should be utilized for wall stems and six-inch underdrains should be installed and connected to roadway drainage.

7.7 Stability

We performed a global stability analysis on Wall 105 (the highest proposed wall), assuming a height of 28 feet, level backfill, and footing embedment of at least four feet below final grade. The resulting safety factor against global slope failure exceeds 1.5. Since subgrade conditions of Retaining Wall 112 are similar to those at Retaining Wall 105, we have determined by inspection that the safety factors against global stability for this other wall will also exceed 1.5.

7.8 Seismic Design

Since the proposed retaining wall is in Seismic Zone 1, per Section 4.7.4.1 of AASHTO LRFD 2008 interim, seismic loads do not need to be analyzed. Thus, seismic parameters have not been provided.

7.9 Utilities

Not Applicable

8.0 CONSTRUCTION RECOMMENDATIONS

8.1 Subgrade Preparation

Based on the anticipated subgrade materials and conditions, we recommend excavating to subgrade and proof compacting the exposed subgrade with at least 4 passes of a compactor with a compaction force of at least 3 tons.

Disturbed subgrades and loose zones observed during proof compaction should be over-excavated to firm stable ground and replaced with Granular Fill (less than 24-inches), Compacted Granular Fill (24-inches or greater), or crushed stone wrapped in a non-woven filter fabric.

8.2 Reuse of Fill

Excavated materials are not anticipated to be suitable for re-use as Compacted Granular Fill, Granular Fill, or Pervious Structure Backfill due to their elevated Silt content. Topsoil and Subsoil may be stockpiled and reused to dress slopes.

Existing fill that is free of deleterious materials may be reused as embankment fill (ConnDOT Form 816 Section 2.02.03.5). Form 816 does not indicate an acceptable percentage of fines, however, generally more than 35 percent Silt will be difficult to place and compact.

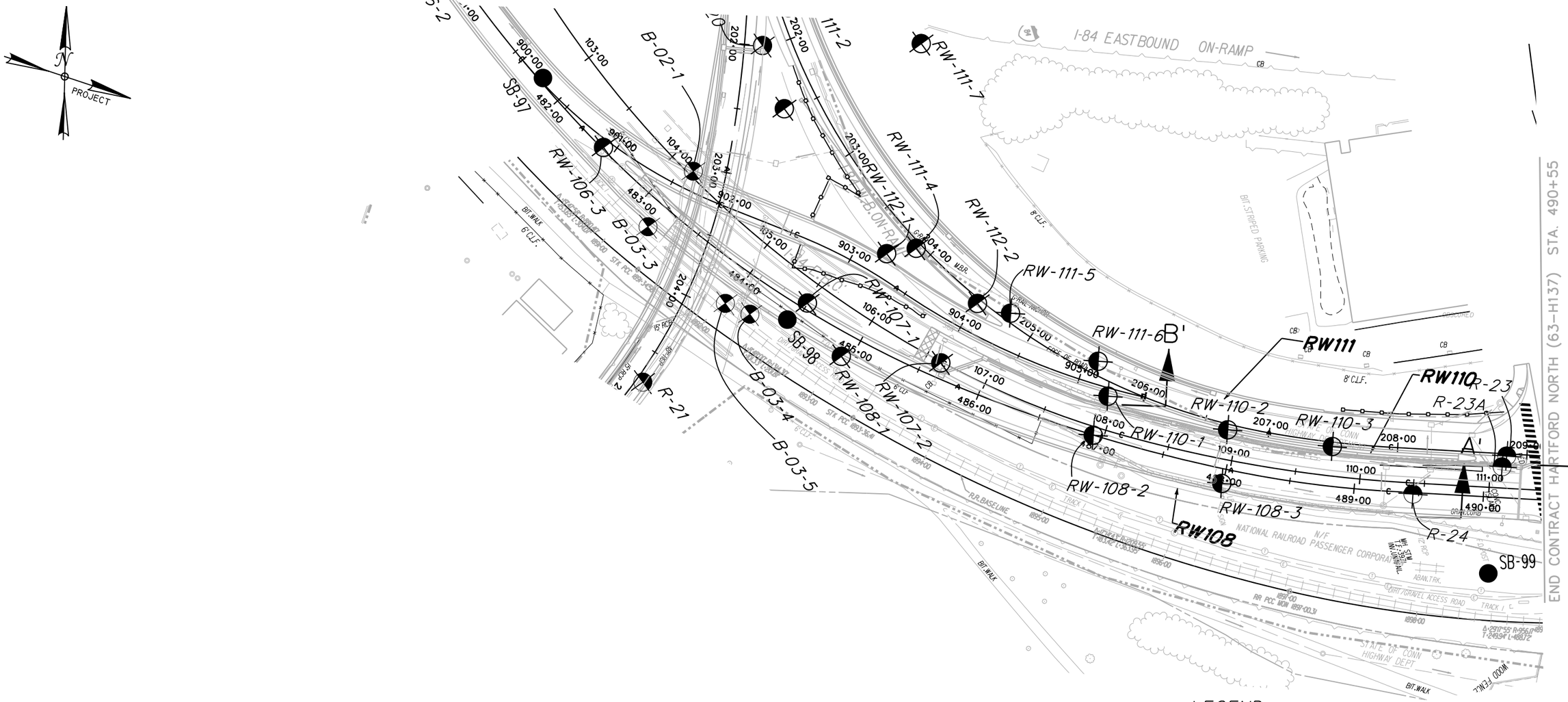
Fill with elevated fines content is not expected to be suitable for reuse on the project, except for placement of “unsuitable” materials in the outer slopes of an embankment as indicated on ConnDOT Standard Drawing No. 201.

8.3 Dewatering

Large volumes of groundwater are not anticipated during foundation construction. Although cofferdam and pumping is not expected to be required, contractors should be prepared with pumps to control surface water.

8.4 Temporary Lateral Support

Not Applicable



LEGEND

RW-101-1	RETAINING WALL BORING
R-1	ROADWAY BORING
SB-97	2003 PILOT BORINGS
A — A	SUBSURFACE PROFILE A-A

M:\CL\331\14\CADD\4 SHEETS - HTFD BUSWAY NORTH - ROADS & R. WALLS - AS-DRILLED BORING LOC PLAN (as of2-24-09)

DESIGNED BY	JWK
DRAWN BY	SMC
CHECKED BY	JWK
APPROVED BY	ULF

NO.	DATE		DRWN.	CHKD	APPVD
		REVISIONS			

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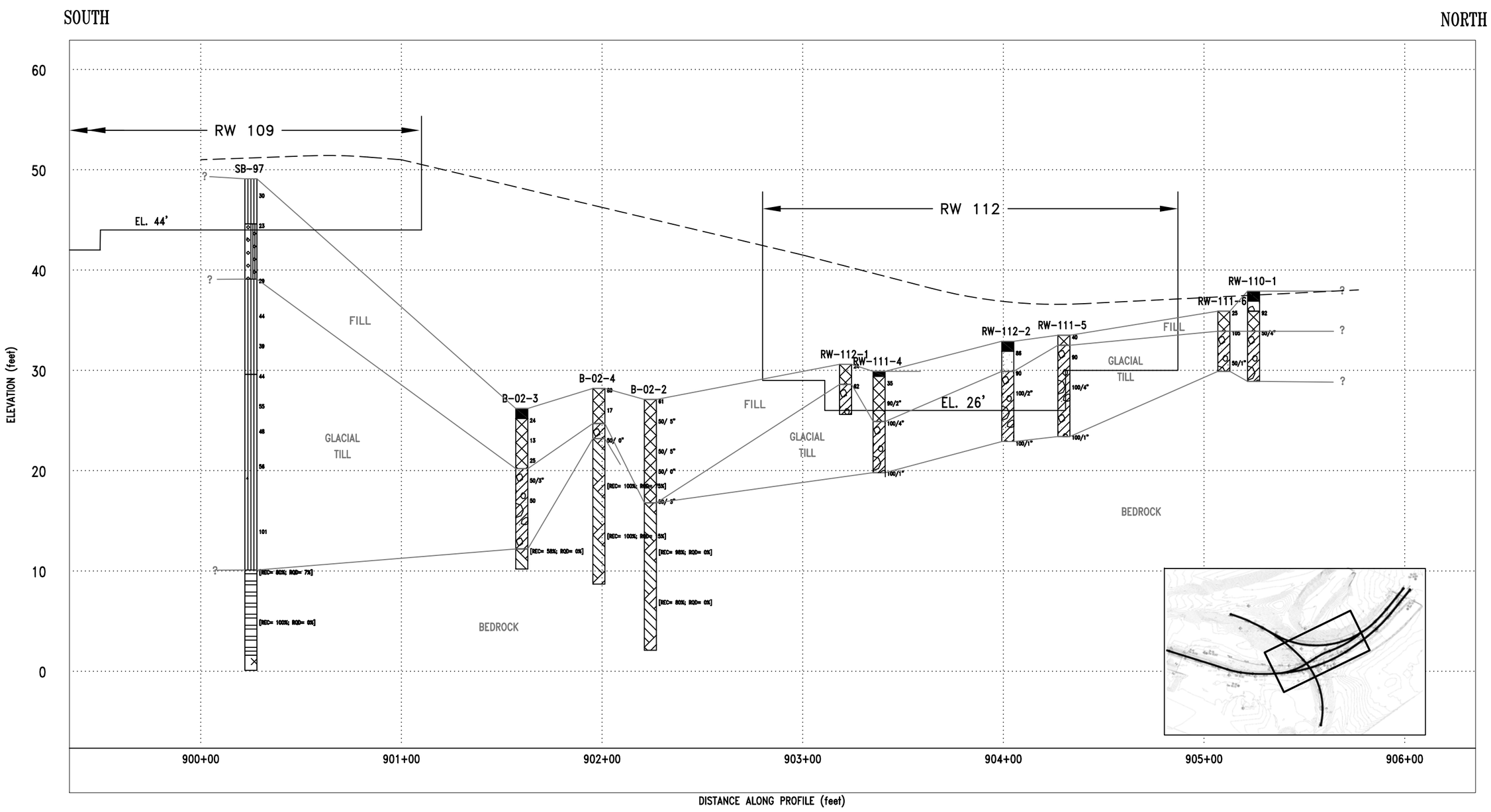
AS-DRILLED EXPLORATION LOCATION PLAN

PROJECT
STATE PROJECT NO. 63-H137
NEW BRITAIN - HARTFORD BUSWAY

FILE NO. 331-14
SCALE 1" = 80'
DATE 4-8-09
FIGURE NO. 112-1



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0 50
Horizontal Scale (feet)
Vertical Exaggeration: 5x

Notes:
1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown.
2. Refer to plan view for subsurface profile location. For strata details and symbol legend, see Subsurface Profile Legend and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval. Where coring was performed, numbers represent Recovery and RQD values.

Date: 2-23-2009 | Drawn By: MJV/DSF | Reviewed By: MGB

SUBSURFACE PROFILE B-B'

New Britain / Hartford Busway
SB Busway 900+00 to 906+00

File No.: 0331-014.0 | Figure No.: 112-2

M:\CL\0331\Roadway & Retaining Walls\CADD\SUBSURFACE PROFILE B-B' (Roadway Figure 7, Retaining Wall Figures 109-2 & 112-2)(East to West Sta. 900+00 - 906+50) 1in.= 50ft. 5x Vert Ex

INSERT TAB
APPENDIX 1
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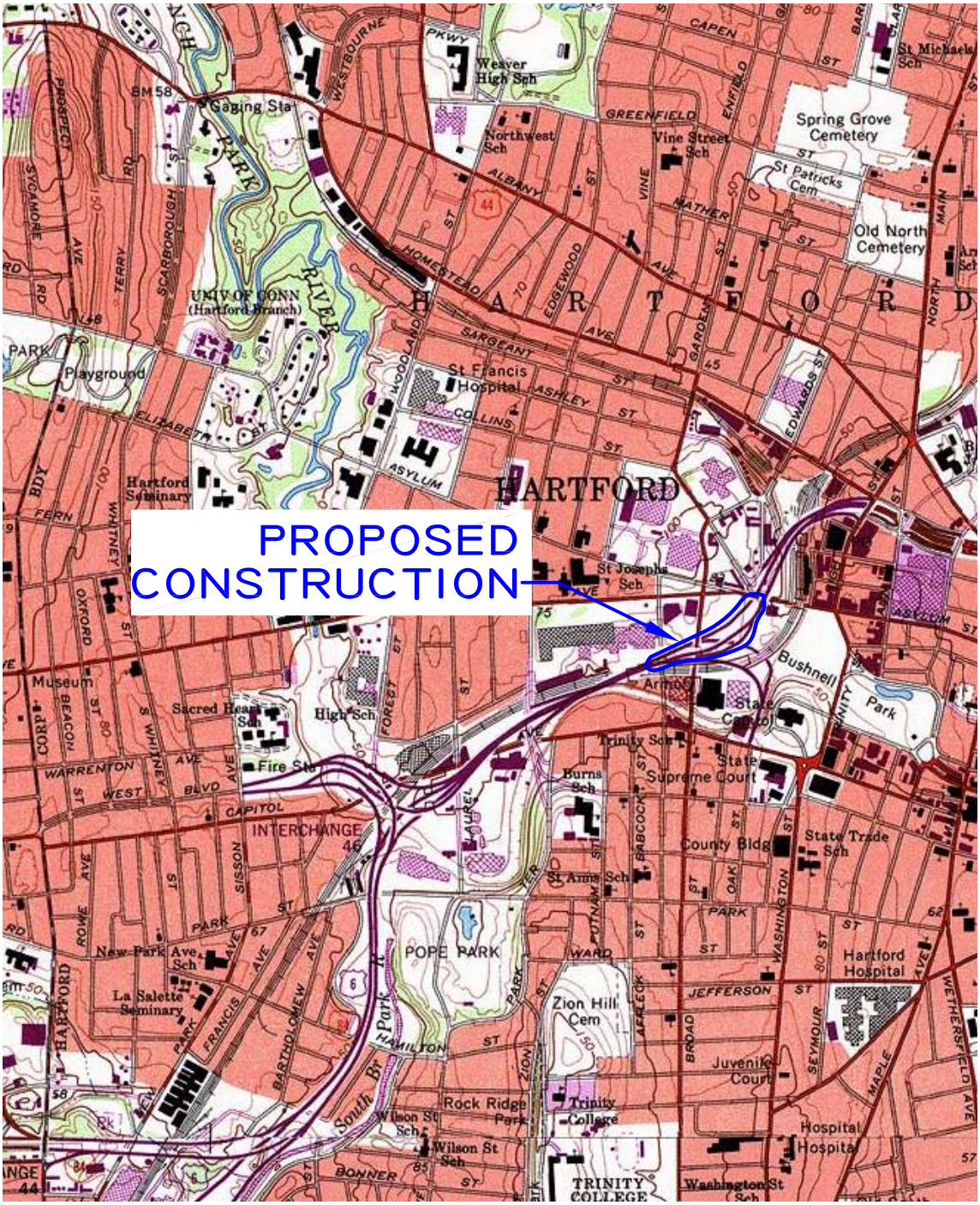
Appendix 1

Figures
&
Tables



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DRAWN BY: SMC | REVIEWED BY: MGB

CONNECTICUT

SCALE IN FEET
0 1000 2000 4000

PROJECT LOCATION PLAN
ROADWAY AND RETAINING WALLS
NEW BRITAIN-HARTFORD BUSWAY
STATE PROJECT NO. 63-H137

REFERENCE:
U.S.G.S. 7.5 MINUTE QUADRANGLE: HARTFORD, CT.
Figure was created using TOPO! 2003 software

PROJECT NO. 0331-14
DATE: 12-12-08
FIGURE NO. 1

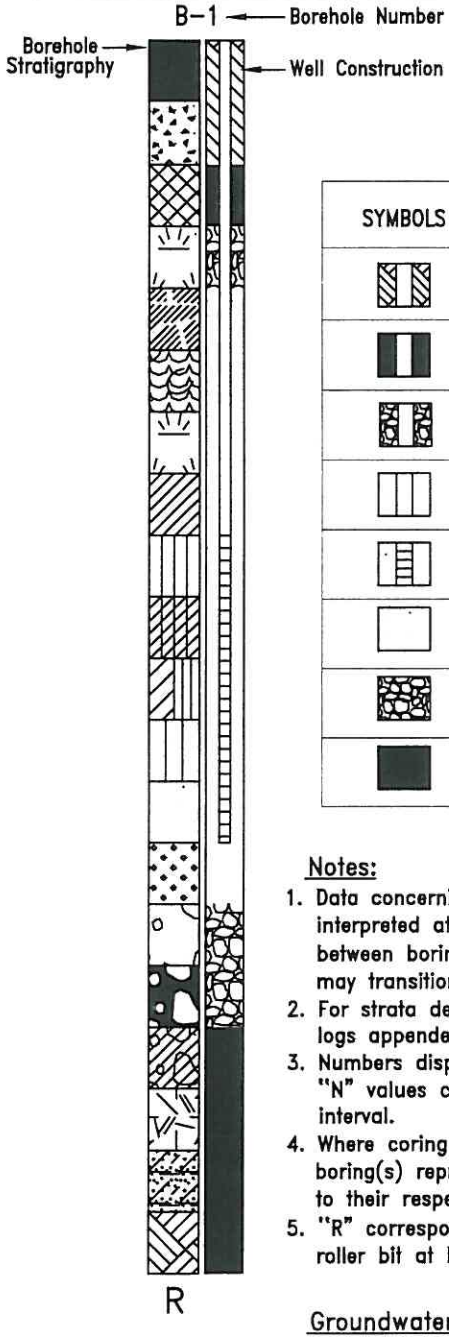
ACAD FILE No. M:\CL\331\14\CADD\Area Map - Broad Stover AAR.dwg

\MISCELLANEOUS\LEGENDS\SUBSURFACE PROFILE LEGEND.dwg

STRATIGRAPHY SYMBOLS

SYMBOLS	TYPICAL DESCRIPTIONS OF PREDOMINENT MATERIAL TYPE
	ASPHALT
	CONCRETE
	FILL
	TOPSOIL
	SUBSOIL
	ORGANIC SILT OR CLAY WITH SHELLS
	PEAT
	CLAY
	SILT
	CLAY/SILT MIXTURE
	CLAY/SILT/SAND MIXTURE
	SILT/SAND MIXTURE
	SAND/SILT MIXTURE
	POORLY-GRADED SAND
	WELL-GRADED SAND
	SAND/GRAVEL MIXTURE
	SAND/GRAVEL/SILT MIXTURE
	BOULDERS AND/OR COBBLES
	GLACIAL TILL
	DECOMPOSED BEDROCK
	SANDSTONE
	BEDROCK

EXPLANATION OF BORING



WELL SYMBOLS

SYMBOLS	TYPICAL DESCRIPTIONS
	CEMENT SEAL: 1 PIPE
	BENTONITE SEAL: 1 PIPE
	SLOUGH BACKFILL: 1 PIPE
	FILTER PACK: 1 PIPE
	SLOTTED PIPE WITH FILTER PACK: 1 PIPE
	FILTER PACK AT BOTTOM OF HOLE
	SLOUGH AT BOTTOM OF HOLE
	BENTONITE AT BOTTOM OF HOLE

Notes:

1. Data concerning the various strata have been interpreted at boring locations only. The stratigraphy between borings may vary from that shown, and may transition more gradually within borings.
2. For strata details, see Report and boring logs appended to this report.
3. Numbers displayed beside boring(s) represent SPT "N" values corresponding to their respective sampling interval.
4. Where coring was performed, numbers displayed beside boring(s) represent Recovery and RQD values corresponding to their respective sampling interval.
5. "R" corresponds to refusal of sampler, casing and/or roller bit at bottom of boring.

Groundwater Observations (where applicable)

▽ Water Level Reading at time of drilling.

▼ Water Level Reading after completing drilling.

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Figure 11

SUBSURFACE PROFILE LEGEND

INSERT
GREEN SHEET
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New Britain - Hartford Busway
CT DOT State Project 63-H137
GeoDesign Project Number: 0331-14
Roadway and Retaining Walls

Table 1 : Atterberg Limits - New (2009) and Existing (2003) Results

Boring	Sample	From	To	Nat. Water Content	LL	PL	PI	Soil Consistency
RW-101-1	S-5	10	12	38	61	26	35	Very Stiff
RW-102-1	S-3	5	7	51	54	27	27	Stiff
RW-102-1	S-5	15	17	64	57	24	33	Very Soft
RW-102-3	S-7	20	22	60	59	27	32	Soft
RW-102-5	S-5	15	17	47	60	26	34	Medium
RW-102-7	S-4	10	12	37	41	20	21	Medium
RW-103-2	S-3	5	7	36	43	22	21	Stiff
SB-88	S-18	70	71.5	26.3	28	19		Very Soft
SB-88	S-6	16.5	18	33.9	57	28		Very Stiff
SB-88	S-12	40	41.5	49.7	36	24		Very Soft
SB-89	S-5	13.5	15	35.2	42	25		Stiff
SB-90	S-6	16.5	18	22.6	51	24		Very Stiff
SB-90	S-11	35	36.5	47	42	25		Very Soft
SB-91	S-3	7.5	9	8.5	18	15		Hard
SB-91	S-7	16.5	18	11.7	23	17		V. Dense
SB-92	S-2	4.5	6	30.8	45	24		Very Stiff
SB-93	S-4	10	11.5	9.1	23	14		V. Dense
SB-94	S-3	4.5	6	10.7	26	17		Dense
SB-95	S-2	4.5	6	11.5	20	19		M. Dense
SB-96	S-2	4.5	6	17.2	NP	NP		M. Dense
SB-97	S-8	25	26.5	9.9	23	14		V. Dense
SB-98	S-3	7.5	9	2.3	NP	NP		M. Dense
SB-99	S-9	25	26.5	37.4	35	20		Medium

New Britain - Hartford Busway
CT DOT State Project 63-H137
GeoDesign Project Number: 0331-14
Roadway and Retaining Walls

Table 2 - Existing Water Contents from Pilot Borings for Busway North

*Sorted by Strata, Water Content, then Depth

Depth	Boring	Water Content	Strata
22.5	RB-42	10.4	Clay
4.5	SB-94	10.7	Clay
16.5	SB-90	22.6	Clay
19.5	SB-99	23.2	Clay
7.5	SB-88	23.6	Clay
70	SB-88	26.3	Clay
22.5	SB-99	30.3	Clay
4.5	SB-92	30.8	Clay
16.5	SB-88	33.9	Clay
13.5	SB-89	35.2	Clay
25	SB-99	37.4	Clay
10.5	SB-90	40.3	Clay
16.5	RB-42	40.8	Clay
35	SB-90	47.0	Clay
40	SB-88	49.7	Clay
7.5	RB-42	10.6	Fill
16.5	SB-99	11.6	Fill
4.5	SB-96	17.2	Fill
7.5	SB-98	2.3	Sand
7.5	SB-91	8.5	Sand/Gravel/Silt
10	SB-93	9.1	Silt/Sand
13.5	SB-97	9.7	Silt/Sand
25	SB-97	9.9	Silt/Sand
28.5	SB-99	11.0	Till
16.5	SB-98	11.1	Sand
4.5	SB-95	11.5	Sand/Silt
16.5	SB-91	11.7	Sand/Gravel/Silt
19.5	SB-93	14.1	Silt/Sand

**Sorted by Strata, Depth, then Water Content

Depth	Boring	Water Content	Strata
4.5	SB-94	10.7	Clay
4.5	SB-92	30.8	Clay
7.5	SB-88	23.6	Clay
10.5	SB-90	40.3	Clay
13.5	SB-89	35.2	Clay
16.5	SB-90	22.6	Clay
16.5	SB-88	33.9	Clay
16.5	RB-42	40.8	Clay
19.5	SB-99	23.2	Clay
22.5	RB-42	10.4	Clay
22.5	SB-99	30.3	Clay
25	SB-99	37.4	Clay
35	SB-90	47.0	Clay
40	SB-88	49.7	Clay
70	SB-88	26.3	Clay
4.5	SB-96	17.2	Fill
7.5	RB-42	10.6	Fill
16.5	SB-99	11.6	Fill
4.5	SB-95	11.5	Sand/Silt
7.5	SB-98	2.3	Sand
7.5	SB-91	8.5	Sand/Gravel/Silt
10	SB-93	9.1	Silt/Sand
13.5	SB-97	9.7	Silt/Sand
16.5	SB-98	11.1	Sand
16.5	SB-91	11.7	Sand/Gravel/Silt
19.5	SB-93	14.1	Silt/Sand
25	SB-97	9.9	Silt/Sand
28.5	SB-99	11.0	Till

New Britain - Hartford Busway
CT DOT State Project 63-H137
GeoDesign Project Number: 0331-14
Roadway and Retaining Walls

Table 3: Summary of Sieve/Hydrometer Testing

Boring	Sample	From	To	Strata	Sieve/Hyd	Gravel	Sand	Silt/Clay	Silt	Clay
R-01	S-1	1	3	Fill	Sieve	22.6	57.8	19.6	19.6	
R-03	S-1	1	3	Fill	Sieve	11.7	71.2	17.1	17.1	
R-04	S-2	2	4	Fill	Hyd	9.2	64.2	26.6	19.6	7
R-05	S-1	0	2	Fill	Sieve	9.3	64	26.7	26.7	
R-06	S-1	1	3	Fill	Sieve	11	49.2	39.8	39.8	
R-07	S-1	1.5	3.5	Fill	Sieve	4.2	66.1	29.7	29.7	
R-14	S-1	0	2	Fill	Sieve	10.8	60.8	28.4	28.4	
R-16	S-1	0.5	2.5	Fill	Sieve	11.5	66.4	22.1	22.1	
R-18	S-1	0	2	Fill	Sieve	17.5	66.8	15.7	15.7	
R-20	S-2	2	4	Fill	Sieve	5.2	59.3	35.5	35.5	
R-21	S-2	2	4	Fill	Hyd	13.6	39.6	46.8	33.8	13
R-22	S-2	2	4	Fill	Sieve	6	36.5	57.5	57.5	
R-23	S-1	1	3	Fill	Sieve	18.5	61.4	20.1	20.1	
R-24	S-1	1	3	Fill	Sieve	10.7	62.1	27.2	27.2	
RW-101-1	S-2	2.5	4.5	Fill	Sieve	0.8	27.1	72.1	72.1	
RW-101-1	S-1	0.5	2.5	Fill	Sieve	2.3	14.8	82.9	82.9	
RW-103-2	S-1	0	2	Fill	Sieve	6.8	63	30.2	30.2	
RW-103-2	S-3	5	7	Fill	S/H		10	90	60	30
RW-105-2	S-1	0	2	Fill	Hyd	3.5	33.7	62.8	39.8	23
RW-106-1	S-1	0	2	Fill	Sieve	10.1	53.8	36.1	36.1	
RW-106-2	S-2	2.5	4.5	Fill	Sieve		95.8	4.2	4.2	
RW-107-2	S-4	7	9	Fill	Sieve	7.2	69.7	23.1	23.1	
RW-108-2	S-1	1	3	Fill	Sieve	10.3	76.1	13.6	13.6	
RW-108-2	S-2	3	5	Fill	Sieve	16.1	60.7	23.2	23.2	
RW-108-3	S-1	1	3	Fill	Sieve	16.9	60.9	22.2	22.2	
RW-108-3	S-3	5	7	Fill	Hyd	18.5	45.9	35.6	22.6	13
RW-106-3	S-4	7	9	GT	Sieve	5.8	69.4	24.8	24.8	
RW-111-4	S-2	3	4.3	GT	Sieve	10.8	60.5	28.7	28.7	
RW-110-2	S-1	1	3	GT	Sieve	16.2	55	28.8	28.8	
RW-110-3	S-1	1	3	GT	Sieve	11.8	58.8	29.4	29.4	
RW-106-1	S-3	5	7	GT	Hyd	10.7	35.7	53.6	33.6	20
RW-110-2	S-3	5	7	GT	Hyd	6.2	32.5	61.3	41.3	20
RW-103-2	S-6	15	16.3	GT	Sieve		2.8	97.2	97.2	

New Britain - Hartford Busway
CT DOT State Project 63-H137
GeoDesign Project Number: 0331-14
Roadway and Retaining Walls

Table 3: Summary of Sieve/Hydrometer Testing

Boring	Sample	From	To	Strata	Sieve/Hyd	Gravel	Sand	Silt/Clay	Silt	Clay
RW-112-2	S-1	1	3	Sand Fill	Sieve	12.5	63	24.5	24.5	
RW-102-5	S-5	15	17	VC	S/H			100	30	70
RW-102-1	S-3	5	7	VC	Hyd		1.5	98.5	38.5	60
RW-102-3	S-7	20	22	VC	S/H			100	40	60
RW-101-1	S-5	10	12	VC	S/H			100	45	55
RW-102-7	S-4	10	12	VC	Hyd		2.8	97.2	47.2	50
RW-102-1	S-5	15	17	VC	S/H			100	50	50

	FILL		
	Full Range	Remove Top and Bottom Outliers	Remove Top and Bottom Two Outliers
Gravel Range	0 to 22.6%	0 to 19%	1 to 18%
Sand Range	10 to 95.8%	15 to 75%	27 to 71 %
Silt/Clay Range:	4.2 to 90%	14 to 83%	16 to 72%

	Glacial Till	
	Full Range	Remove Top and Bottom Outliers
Gravel Range	0 to 16%	6 to 12%
Sand Range	3 to 70%	33 to 60%
Silt/Clay Range:	25 to 97%	29 to 61%

	Varved Clay	
	Full Range	Remove Top and Bottom Outliers
Gravel Range	0%	0%
Sand Range	1.5 to 2.8%	0%
Silt	30 to 50%	39 to 47%
Clay	50 to 70%	50 to 60%

New Britain - Hartford Busway

CT DOT State Project 63-H137
GeoDesign Project Number: 0331-14
Roadway and Retaining Walls

Table 4 - Summary of Soil Strata

Boring	Approximate Strata Thickness (feet)								Refusal Depth (feet)	Refusal (Inferred Rock) Elevation	Rock Core	Groundwater Depth (feet)	Groundwater Elevation (feet)	Well
	Asphalt/ Concrete	Topsoil	Crushed Stone	Fill	Sand	Clay	Glacial Till	Weathered Bedrock						
R-01	1			2.5		14+						n/a		
R-02	1			4.5		12+						n/a		
R-03	1			15		1+						n/a		
R-04				10		7+						n/a		
R-05				10		9+						14	54.7	
R-06	1.5			2.5		13+						n/a		
R-07	1			4.5		12+						9	59.9	
R-08				10		7+						8	52.6	
R-09	1			4.5		12+						15	37.7	
R-10				2		15+						9	47.6	
R-11				4		13+						n/a		
R-12				6		11+						n/a		
R-13			1.5	2.5		3.5	10+					14	33.9	
R-14				4.5		10.5	5+					5	43.5	
R-15	1			2.5		7	5.5+					n/a		
R-16	1			6.5		6.5	3.5+					5	43.3	
R-17	1			3.5		3	5		12	35		n/a		
R-18				4			12.5+					n/a		
R-19	1			2.5				4.5	8	22		n/a		
R-20				5			9.5	1	15.2	10		n/a		
R-21				9				6.5	15.4	16		n/a		
R-22				24+?					24	17		17	24.1	
R-23	1		1.5	7		2	4+		15.2	23		9	29.7	Yes
R-24	1			4		8		6.5	15.1	24		n/a		
RW-101-1	0.5			7		9.5+						n/a		
RW-102-1			1.5	2		14+						3	49.9	
RW-102-2				3		14+						3	49.8	
RW-102-3				3		26+						3	49.4	
RW-102-4				5		12+						n/a		
RW-102-5			1	1.5		14+						n/a		
RW-102-6			1	2		15+						n/a		
RW-102-7			1	1.5		14+						3	47.1	
RW-103-1				7		7	2+					5	43.9	

New Britain - Hartford Busway

CT DOT State Project 63-H137
GeoDesign Project Number: 0331-14
Roadway and Retaining Walls

Table 4 - Summary of Soil Strata

Boring	Approximate Strata Thickness (feet)								Refusal Depth (feet)	Refusal (Inferred Rock) Elevation	Rock Core	Groundwater Depth (feet)	Groundwater Elevation (feet)	Well
	Asphalt/ Concrete	Topsoil	Crushed Stone	Fill	Sand	Clay	Glacial Till	Weathered Bedrock						
RW-103-2				11			5+					4.5	44.5	
RW-104-1				3			24		27.5	20		4	44	
RW-104-2	1			4			12+					16	47	
RW-105-1				10			6+					7	56.8	Yes
RW-105-2				8			5		13	36		4	45	
RW-106-1				5			12+					4	43.3	
RW-106-2			1	7			8.5+					5	43	
RW-106-3			1	7			9+					8	41.1	
RW-107-1		1		10			6+					n/a		
RW-107-2	1			8			8+					n/a		
RW-108-1			1	12			7.5		20.5	26		12	35.1	
RW-108-2	1			5			10.5+					n/a		
RW-108-3	1			7			7.5	0.2	15.2	29		n/a		
RW-110-1	1		1	2			5		9	29		n/a		
RW-110-2	1		1				8		10.1	29		n/a		
RW-110-3	1		1				8		10.1	29		n/a		
RW-111-1	1		1	1.5			3		7	20		n/a		
RW-111-2	1		1	1.5			11		15	10		14	11.1	
RW-111-3	1		1	1			2		5	21		n/a		
RW-111-4	1		2				2	5	10.1	20		n/a		
RW-111-5				1			9		10.1	23		n/a		
RW-111-6				2			5		6	30		n/a		
RW-112-1				2			3		5	26		n/a		
RW-112-2	1			2			7		10.1	23		n/a		
B-01-3				2.5	5.5	7	12			19	Yes	2.5	44.2	
B-01-4			1.5	2.5			23			19	Yes	3	43.8	
B-02-1				2						20	Yes	13	14.5	
B-02-2				10						17	Yes	n/a		
B-02-3	1			9			4			12	Yes	n/a		
B-02-4				5						23	Yes	n/a		
B-03-1			1.5	7.5			11			30	Yes	7.5	42.6	
B-03-2				10			10			30	Yes	6	43.7	Yes

New Britain - Hartford Busway
CT DOT State Project 63-H137
GeoDesign Project Number: 0331-14

Table 5 - Groundwater Data Summary

Boring*	Approximate Ground Surface Elevation (ft)	Approximate Groundwater Depth (ft)	Approximate Ground Water Elevation	Well
RW-102-1	52.9	3	49.9	
RW-102-2	52.8	3	49.8	
RW-102-3	52.4	3	49.4	
R-09	52.7	15	37.7	
RW-102-4	51.9	10	41.9	
R-08	60.6	8	52.6	
R-10	56.6	9	47.6	
RW-102-7	50.1	3	47.1	
RW-103-1	48.9	5	43.9	
RW-103-2	49.0	4.5	44.5	Yes
R-13	47.9	14	33.9	
R-14	48.5	5	43.5	
R-16	48.3	5	43.3	
RW-104-1	48.0	4	44.0	
RW-104-2	63.0	16	47.0	
B-01-2	70.1	15.5	54.6	
B-01-3	46.7	2.5	44.2	
B-01-4	46.8	3	43.8	
RW-105-1	63.8	7	56.8	Yes
RW-106-1	47.3	4	43.3	
RW-105-2	49.0	4	45.0	
RW-106-2	48.0	5	43.0	
RW-106-3	49.1	8	41.1	
B-03-06	50.2	10	40.2	
B-03-1	50.1	7.5	42.6	
B-03-2	49.7	6	43.7	
RW-108-1	47.1	12	35.1	
R-23	38.7	9	29.7	Yes

*Borings are approximately listed from south to north along the NB & SB Busway Alignments
Refer to boring logs for details including date of readings

INSERT TAB
APPENDIX 2
HERE

Appendix 2

Limitations

GEOTECHNICAL LIMITATIONS

Explorations

1. The analyses and recommendations submitted in this report are based in part upon the data obtained from widely spaced subsurface explorations. The nature and extent of variations between these explorations may not become evident until further explorations are made and construction occurs. If variations then appear evident, it will be necessary to reevaluate the recommendations of this report.

2. The generalized soil and bedrock profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized and have been developed by interpretations of widely spaced explorations and samples; actual soil and bedrock transitions are probably more erratic. For specific information, refer to the boring logs.

3. The geologic and geomorphologic settings at this site are complex and the uncertain historic site usage has resulted in the varied distribution and stress history of compressible soils across the site. Limited spacing of borings and lab testing can at best, only allow for estimates to be developed for duration and magnitude of consolidation settlements.

4. Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in river levels, rainfall, temperature, and other factors occurring since the time measurements were made.

Review

5. In the event that any changes in the nature, design or location, of the proposed retaining walls the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of these reports modified or verified in writing by Geo**Design**, Inc. It is recommended that this firm be provided the opportunity for a general review of design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications.

Use of Report

6. This report has been prepared for the exclusive use H.W. Lochner, Inc., the Connecticut Department of Transportation (ConnDOT), and other members of the design team for specific application to the construction of the Busway Retaining Walls for the New Britain - Hartford Busway located in Hartford, Connecticut, in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made.

7. This final design Soil and Foundation Engineering Report has been prepared for this project by Geo**Design**. This report is for design purposes only and is not sufficient to prepare an accurate bid. Contractors wishing a copy of this report may secure it with the understanding that their scopes are limited to design considerations only.