Foth | Envirocon
Joint Venture

Technical Memorandum

101 International Drive, P.O. Box 16655
Missoula, MT 59808

March 30, 2015

TO: Scott Hansen, USEPA
John Robinson, WDNR

CC: Jamie Dunn, Jerry Winslow, Terry Coss, Chris Haack, Kristen Carney, Jennifer Casler, Ron French, Steve Laszewski

FR: Jim Hutchison
Denis Roznowski

RE: Technical Memorandum #AB-2
Breakwater Design
Ashland/NSP Lakefront Site

This technical memorandum is developed to provide the regulatory agencies with the Ashland Breakwater design progression that has occurred since the submittal of the *Preliminary Design for Ashland Breakwater* (*Preliminary Design*), dated January 23, 2015, and the Technical Memorandum #AB-1 (Memo #AB-1) dated March 16, 2015. Memo #AB-1 described the change in the proposed Breakwater footprint location and the proposed sediment removal depth based on Agencies input and field observations made during a geotechnical investigation performed through the ice over the time period of February 24, 2015 through March 4, 2015.

This memorandum presents findings obtained from the winter 2015 geotechnical investigation program and identifies subtle changes to the Breakwater design that are a result of these findings. Modeling of the Breakwater for foundation and slope stability is underway and results will be included in the upcoming Pre-Final Design submittal, along with the data presented in this memorandum.

Boring Data

Seven borings (AQ-BW-1 through AQ-BW-7) were performed in the area of the proposed Breakwater. Borings AQ-BW-1 through AQ-BW-5 were located along the approximate centerline of the proposed Breakwater from east to west, respectively, as shown on Figure 2-3 in Attachment 1. Please note that the boring locations shown are actual and that AQ-BW-01 was offset approximately 20 feet from the proposed location due to a deep snow bank located at the original proposed location. Borings AQ-BW6 and AQ-BW-7 were located to the north of the proposed Breakwater. Generally, the borings encountered approximately one foot of wood/silty sand at the surface along the west side of the site and up to 2.8 feet of wood/silty fine sand on the east side of the site. In all borings, a 6 to 9 foot layer of fine sand (SP) to

silty fine sand (SM) was found underlying the surface wood/fine sand layer. The surficial SP/SM layer overlies a layer of lean clay (CL), which is approximately 19.5 feet thick on the west side, tapering to 5 feet thick on the east side. The CL is very soft to medium stiff. Beneath the CL layer is a medium dense to dense silt (ML) which was generally encountered across the entire site. The soil stratum is shown in the cross section in Attachment2.

During drilling and coring, soil samples were obtained from split-spoon samplers, Shelby tubes, and for sediment, sediment sampling tubes. Split-spoon soil samples were observed by Foth during generation of the boring logs and certain split-spoon samples, and all Shelby tube samples were delivered to geotechnical laboratories for testing. The following laboratories were used:

Company	Testing Work
Coleman Engineering Company 635 Circle Drive Iron Mountain, MI	Soil characterization testing
Soil Engineering Testing, Inc. 2401 W. 66th Street Richfield, MN	Soil strength testing and consolidation testing

Results of the characterization tests (P_{200}, Atterberg Limits, dry and bulk density, specific gravity), permeability, and consolidation testing (initial void ratio, Compression Index [Cc], and Recompression Index [Cr]) are provided in the table in Attachment 3. The dry density, bulk density, and moisture content results are graphically depicted on the figure in Attachment 3. The consolidation test graphs are also provided in Attachment 3. The consolidation test results, the in-situ moisture content, and the Atterberg Limit results all indicate that the (CL) layer is not susceptible to large consolidation settlements due to loads imposed by the proposed Breakwater (1.2 to 1.3 tons per square feet). Compression of the CL layer is expected to be on the order of only 1-2%.

Results of the soil strength tests (Consolidated Undrained [CU], Unconsolidated Undrained [UU], as well as the field vane shear tests) are tabulated and graphically presented in Attachment 4. A foundation and slope stability analysis is currently underway. Results will be provided in the Pre-Final Design.

Coleman Engineering Company is currently performing testing on bulk samples of sediment, obtained from within the proposed Breakwater footprint during sediment coring, to evaluate sediment dewatering with and without amendment. The results will indicate the effectiveness of bulk sediment dewatering and conditioning that may be required to allow effective sediment management with respect to free-liquid control. The results will be included in the Pre-Final Design.

Design Considerations After Geotechnical Analysis

The results of the 2015 field observations, field tests, boring data (blow counts), and laboratory analysis indicate only minor changes to the Breakwater *Preliminary Design* assumptions are required at this time, described as follows:

1. The wood at the mudline surface is lying on top of and mixing with fine sand, with the mixing zone a few inches to a few feet in depth. The proposed sediment removal thickness in the footprint of the Breakwater remains the same as stated in memo #AB-1, namely 5 feet along the first 350 feet of Breakwater footprint, beginning at the tie-in to the east peninsula, then to a depth of 1 foot along the remaining 950 feet of Breakwater footprint to its west terminus. The physical characteristics of the sediment to be removed prior to Breakwater construction will affect the dewatering processes for these materials and;

2. Due to the presence of fine sand at the proposed Breakwater rock/subgrade interface (which could be prone to liquefaction force if not confined), a bedding layer of stone will be placed as the first layer of the Breakwater construction on the north (lakeside) edge of the Breakwater. This initial bedding layer will be placed, following excavation of the surficial wood/sand layer, for support of the core (C) stone, filter (B) stone, and armor (A) layers (see Attachment 5 for plan and cross section views of the design revision). The bedding layer will act as a filter for the fine sand subgrade and the other stone layers. Once confined, the fine sand will not be subject to liquefaction forces which can be associated with wave action.

Attachments

Attachment 1

Boring, Coring and Poling Grid Locations

LEGEND

- 29N16E / 590.6 / 1.0' WOOD — EXISTING SEDIMENT SAMPLING LOCATION WITH TOP OF SEDIMENT ELEVATION AND WOOD/SEDIMENT THICKNESS
- AQ–BW–05 — SUBGRADE BORING LOCATIONS
- X — PROPOSED POLING TRANSECT POINT LOCATION
- AQ–SED–1 — SEDIMENT BORING LOCATION
- APPROXIMATE LOCATION OF PROPOSED BREAKWATER
- 595 — TOP OF LAKE BED ELEVATION CONTOUR

NOTES:

1. COORDINATE SYSTEM – WISCONSIN STATE PLANE, NORTH ZONE. U.S FEET. HORIZONTAL DATUM IS NAD83, VERTICAL DATUM IS NAVD88.
2. AERIAL MAP MODIFIED FROM OCTOBER 12, 2012 IMAGERY. FEATURES ALTERED TO REFLECT ANTICIPATED CONDITIONS POST–PHASE 1 RA.

1,745,500 E

1,746,000 E

1,746,500 E

523,000 N

523,500 N

N

AQ–BW–05
AQ–SED–3
AQ–SED–2
AQ–SED–1
AQ–BW–07
AQ–BW–02
AQ–SED–5
AQ–BW–01
AQ–SB–07
592.2
9' SEDIMENT
AQ–SED–4
AQ–SED–6
AQ–BW–03
29N20E
590.2
1.0' WOOD
AQ–BW–04
AQ–BW–05
29N16E
590.6
1.0' WOOD
29N15E
590.6
1.0' WOOD

1,050'
TO WEST 1' OF SEDIMENT
TO EAST 9' OF SEDIMENT
450'
100'
50'
50'

PRELIMINARY DESIGN BREAKWATER LOCATION
PRELIMINARY DESIGN BREAKWATER STONE LOCATION (OPTION 1)
PRELIMINARY DESIGN BREAKWATER EXCAVATION LIMITS (OPTION 1)

590 591 592 593 594 595 596 597 598 599 601 602 603 605 606 607

DRAFT

X:\FOTH\IE\Xcel\15X001-00\cad\GeoTech-Breakwater_figures\15x001_Drwg-2-3_Breakwater_Sediment_boring_locations.dgn
3/27/2015 9:48:43 AM jrb2

Foth | Envirocon Joint Venture

Foth Infrastructure & Environment, LLC
2121 Innovation Court, Suite 300
P.O. Box 5126
De Pere, WI 54115-5126
Phone: 920-497-2500 Fax: 920-497-8516

GEOTECHNICAL WORK PLAN FOR ASHLAND/NSP LAKEFRONT SITE BREAKWATER

NORTHERN STATES POWER COMPANY

ASHLAND COUNTY WISCONSIN

REVISIONS NO.	BY	DATE	DESCRIPTION
1			
2			
3			
4			

RECORD DRAWING OF COMPLETED CONSTRUCTION BY: _____
RECORD DRAWINGS OF COMPLETED CONSTRUCTION CONFORMING TO CONTRACTOR AND/OR OWNERS RECORDS. DATE _____ BY _____

DATE OF PREPARATION

	BY	DATE
SURVEYED		
DRAWN		
DESIGNED		
CHECKED		

BORING, CORING AND POLING GRID LOCATIONS (REVISED)

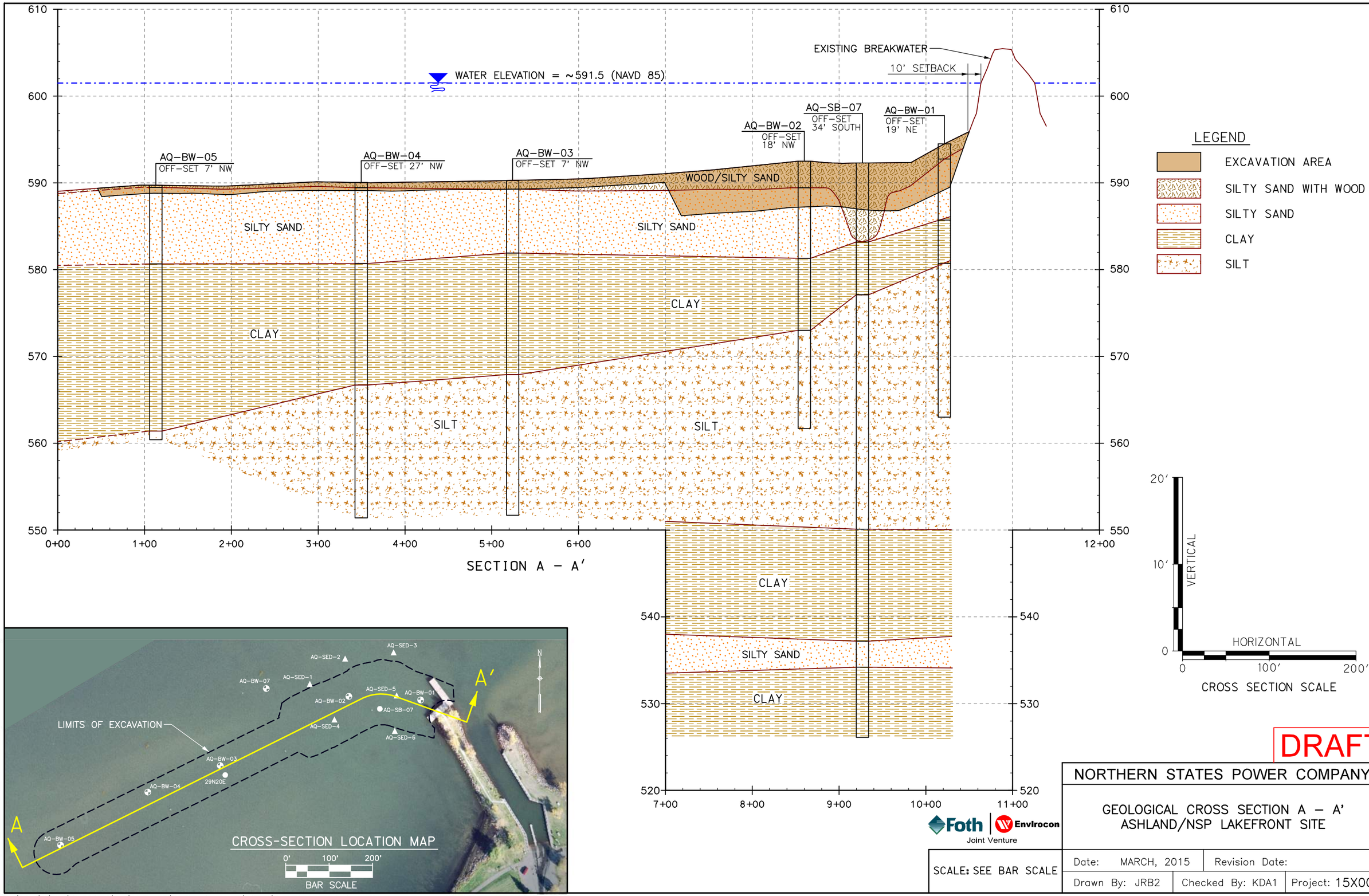
HORIZONTAL SCALE: 0 50' 100'

PROJECT ID: 15X001

2-3

Attachment 2

Geological Cross Section A-A’



DRAFT

NORTHERN STATES POWER COMPANY		
GEOLOGICAL CROSS SECTION A – A' ASHLAND/NSP LAKEFRONT SITE		
SCALE: SEE BAR SCALE	Date: MARCH, 2015	Revision Date:
	Drawn By: JRB2	Checked By: KDA1
		Project: 15X001

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X:\FOTH\IE\Xcel\15X001-00\cad\Breakwater\Geotechnical Report\Figures\Geologic Cross Section A-A.dgn
3/27/2015 8:13:34 AM jrb2

Attachment 3

Characterization Test Results

DRAFT

Summary of Soil Classification Laboratory Test Results - Breakwater

Ashland/NSP Lakefront Site
Ashland, Wisconsin

ASTM No.			D6913		D2216	D4318			D7263		D854	D2435	D2435	D2435	D2434	D2487/D2488
Soil Boring Number	Sample Interval	Sample[1] Depth (ft)	Grain Size Analysis %Fines <#200	Grain Size Analysis %Clay <.005	Sampled Water Content (%)	Atterberg Limits Liquid Limit	Atterberg Limits Plastic Limit	Atterberg Limits Plasticity Index	Dry Density (pcf)	Bulk Density (pcf)	Specific Gravity	Void Ratio (e_o)	Compression Index (Cc)	Recompression Index (Cr)	Permeability K @ 20°C (cm/sec)	U.S.C.S.
AQ-BW-01	A	12.2 - 14.2	7.9		24.1											SP
AQ-BW-01	A	14.7 - 16.7	38.0		22.6											SM/SC
AQ-BW-01	A	18.3 - 20.3			25.6	34.0	13.0	21.0	88.0	110.5						CL
AQ-BW-01	B	18.3 - 20.3			23.6	34.0	13.0	21.0								CL
AQ-BW-01	C	24.7 - 26.7			22.3											
AQ-BW-01	C	29.7 - 31.7			19.6			NP	104.0	124.4						
AQ-BW-01	D	34.7 - 36.7	98.2		22.8											ML/CL
AQ-BW-02	B	11.7 - 13.7	5.4		25.1											SP-SM
AQ-BW-02	A-D	16.7-18.7	5.8		21.3				107.3	130.2					5.0E-05	SP-SM/SP
AQ-BW-02	A	19.2 - 21.2	4.1		21.9											SP
AQ-BW-02	C	19.2 - 21.2			17.3	29.0	12	17								CL
AQ-BW-02	D	19.2 - 21.2			18.3											
AQ-BW-02	A	28 - 30			21			NP								
AQ-BW-02	B	33 - 34.5	61.3		19.2											ML/CL
AQ-BW-02	A	38 - 40	97.0		22.2											ML/CL
AQ-BW-02	C	38 - 40			22.4			NP	109.6	134.2						
AQ-BW-03	C	16.1 - 18.1	21.9		22.4						2.628					SM/SC
AQ-BW-03	C	18.6 - 20.6			17.3	32.0	13	19	110.3	129.4						CL
AQ-BW-03	A-D	23-25			17.8				111.3	131.1		0.509	0.18	0.02		CH/CL
AQ-BW-03	A	33 - 35			19.1	34.0	12	22			2.699					CL
AQ-BW-03	B	38 - 40	97.5		22.8											ML/CL
AQ-BW-03	D	43 - 45			24.1			NP								
AQ-BW-03	B	48 - 50	94.7		23.7											ML/CL
AQ-BW-03	C	48 - 50			25.1											
AQ-BW-04	B	14.3 - 16.3	10.0		22.9											SP-SM
AQ-BW-04	B	16.8 - 18.8	1.2		21.1											SP
AQ-BW-04	B	21.8 - 23.8			23.5	35.0	14.0	21.0	104.2	128.7						CL
AQ-BW-04	A	29.3 - 31.3			20.5	24.0	11.0	13.0	104.4	125.8						CL
AQ-BW-04	B	34.3 - 36.3			18.8	31.0	13.0	18.0								CL
AQ-BW-04	C	34.3 - 36.3	68.7		21.4											ML/CL
AQ-BW-04	B	39.3 - 41.3			25.8			NP								

DRAFT

Summary of Soil Classification Laboratory Test Results - Breakwater

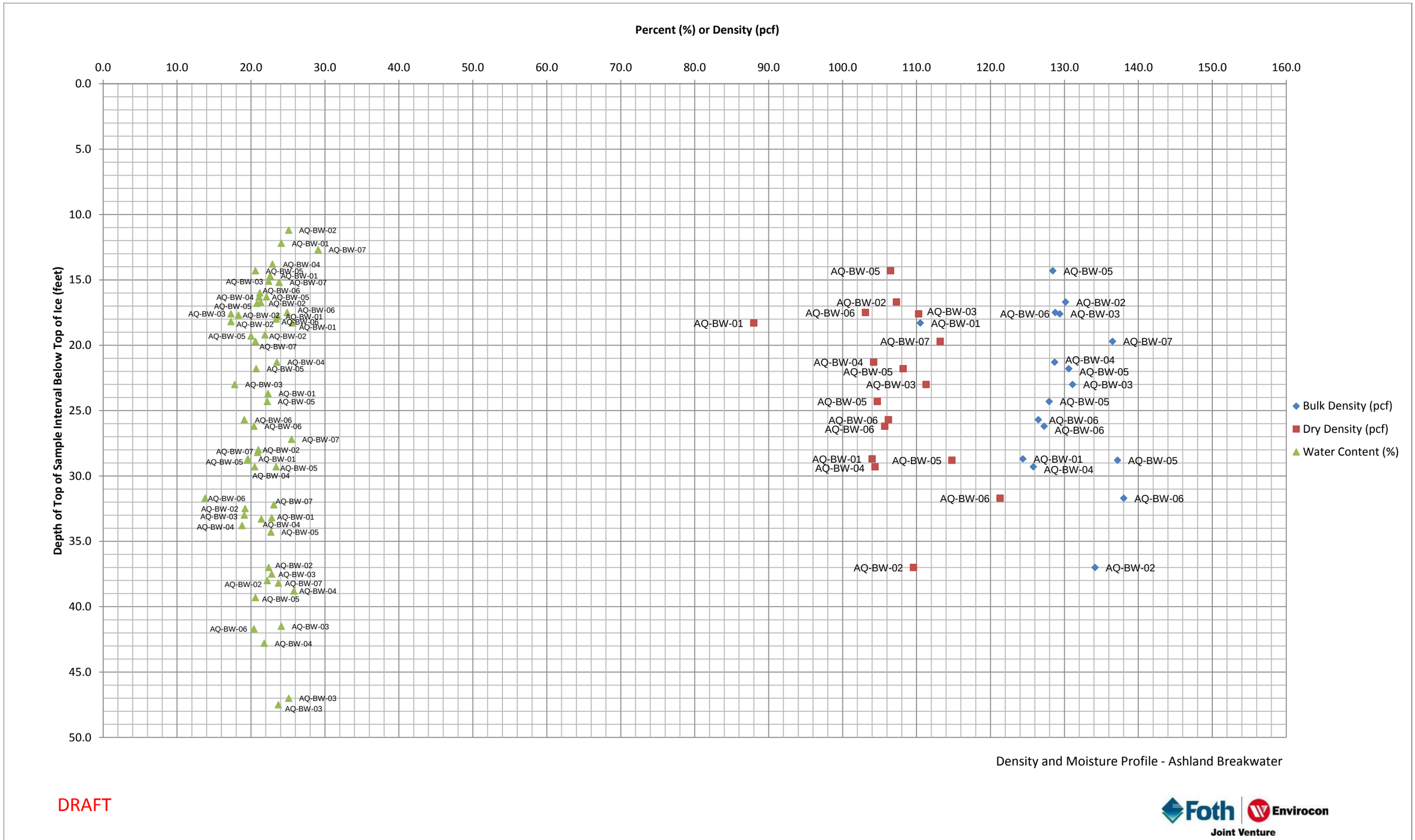
Ashland/NSP Lakefront Site
Ashland, Wisconsin

ASTM No.			D6913		D2216	D4318			D7263		D854	D2435	D2435	D2435	D2434	D2487/D2488
Soil Boring Number	Sample Interval	Sample[1] Depth (ft)	Grain Size Analysis %Fines <#200	%Clay <.005	Sampled Water Content (%)	Atterberg Limits Liquid Limit	Plastic Limit	Plasticity Index	Dry Density (pcf)	Bulk Density (pcf)	Specific Gravity	Void Ratio (e_o)	Compression Index (Cc)	Recompression Index (Cr)	Permeability K @ 20°C (cm/sec)	U.S.C.S.
AQ-BW-04	D	44.3 - 46.3			21.8											
AQ-BW-05	A-D	14.3 - 16.8	38.3		20.6				106.5	128.4					2.8E-04	SM/SC
AQ-BW-05	A	16.8 - 18.8	14.6		20.8											SM/SC
AQ-BW-05	B	16.8 - 18.8	16.1		22.1						2.668					SM/SC
AQ-BW-05	A	19.3 - 21.3	5.4		20.0											SP-SM
AQ-BW-05	A	21.8 - 23.8			20.7	32.0	13.0	19.0	108.2	130.6						CL
AQ-BW-05	A-D	24.3 - 26.3			22.2				104.7	127.9		0.634	0.24	0.03		
AQ-BW-05	A	29.3 - 31.3			23.4											
AQ-BW-05	B	29.3 - 31.3			19.5	27.0	12.0	15.0	114.8	137.2	2.730					CL
AQ-BW-05	A	34.3 - 36.3			22.7	26.0	11.0	15.0								CL
AQ-BW-05	A	39.3 - 41.3			20.6			NP								
AQ-BW-06	B	16.5 - 18.5	8.2		21.2											SP-SM
AQ-BW-06	C	19 - 21			23.4											
AQ-BW-06	D	19 - 21			24.9	38.0	13.0	25.0	103.1	128.8						CL
AQ-BW-06	C	27.2 - 29.2			20.4	27.0	12.0	15.0	105.7	127.3						CL
AQ-BW-06	D	27.2 - 29.2	58.6		19.1				106.2	126.5						ML/CL
AQ-BW-06	B	32.2 - 34.2			13.8	23.0	17.0	6.0	121.3	138.0						CL-ML
AQ-BW-06	B	42.2 - 44.2	95.7		20.4											ML/CL
AQ-BW-07	B	13.2 - 15.2	3.0		29.1											SP
AQ-BW-07	B	15.7 - 17.7	20.3		23.8						2.648					SM/SC
AQ-BW-07	C	20.7 - 22.7			20.6	33.0	13.0	20.0	113.2	136.5	2.710					CL
AQ-BW-07	A	28.2 - 30.2			20.9											
AQ-BW-07	C	28.2 - 30.2			25.5	24.0	13.0	21.0			2.725					CL
AQ-BW-07	C	33.2 - 35.2	88.5		23.1											ML/CL
AQ-BW-07	A	38.2 - 40.2			23.7			NP								

Laboratory results from Coleman Engineering Company and Soil Engineering Testing, Inc.

1. Depth below top of ice.

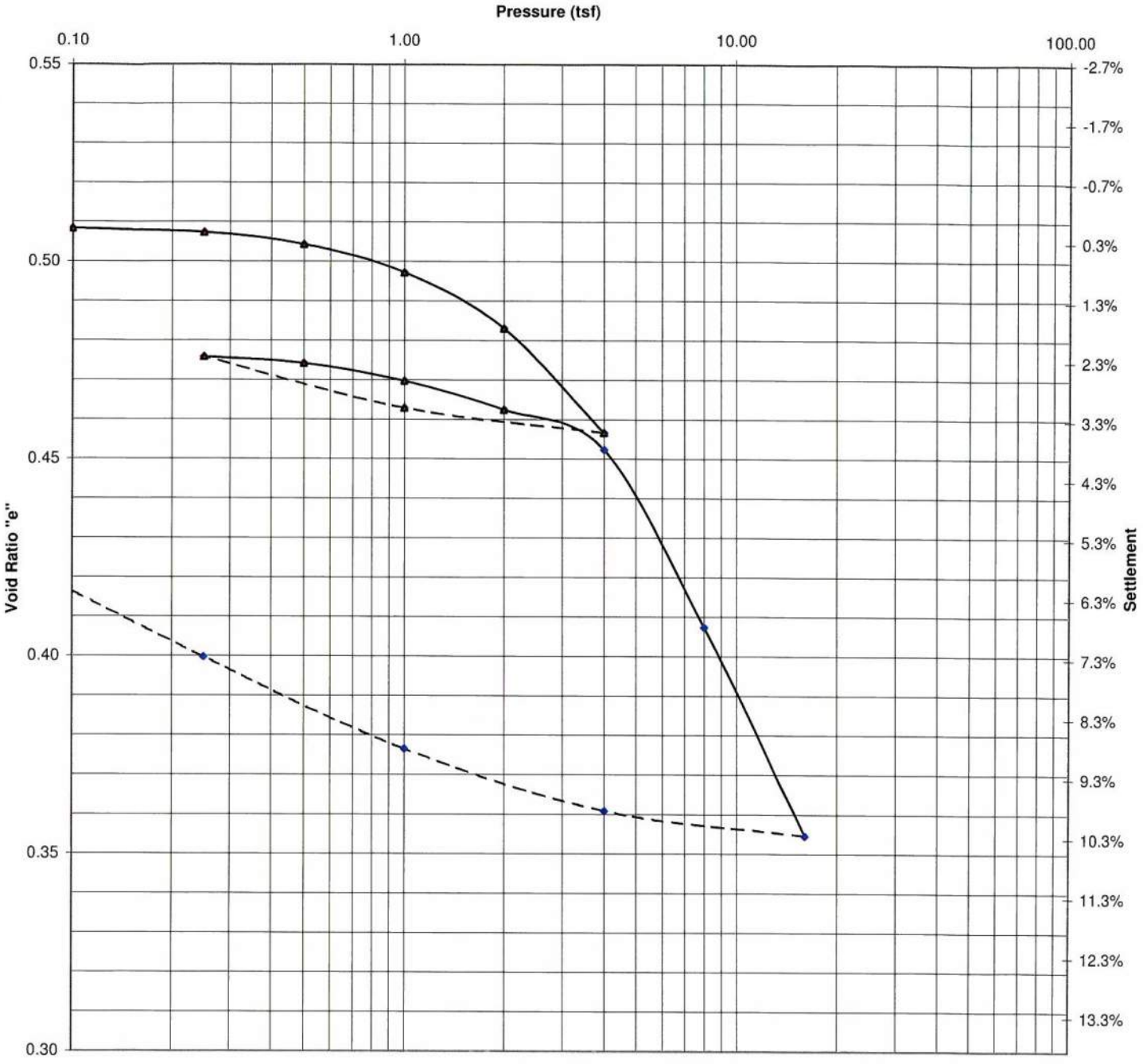
Prepared by: TMK1
Checked by: JBH1



X:\FOTH\IE\Xcel\15X001-00\10500 Support Data\Tech memo AB 2\Figures-plotted lab results 2015.xlsx density-Breakwater

Consolidation Test Results

Void Ratio and % Settlement vs. Log of Pressure



Project: Ashland/NSP Lakefront Site - 15X001			Date: 3/20/15	
Sample #: ST-5	Boring #: AQ-BW-3	Depth ft: 23-25	Job #: 9783	
Soil Type: Sandy Fat Clay w/a little gravel (CH/CL)				
Initial W/C (%): 17.8	Dry Density (pcf): 111.3	LL: PL: PI:	Gs: 2.69	(Assumed)
Organic Content (%):	Initial Height (in.): 0.746	Diameter (in.): 2.506	e_o= 0.509	
Preconsolidation Pressure (Pc): 2.9 tsf	Compression Index (Cc): 0.18	Recompression Index (Cr): 0.02		

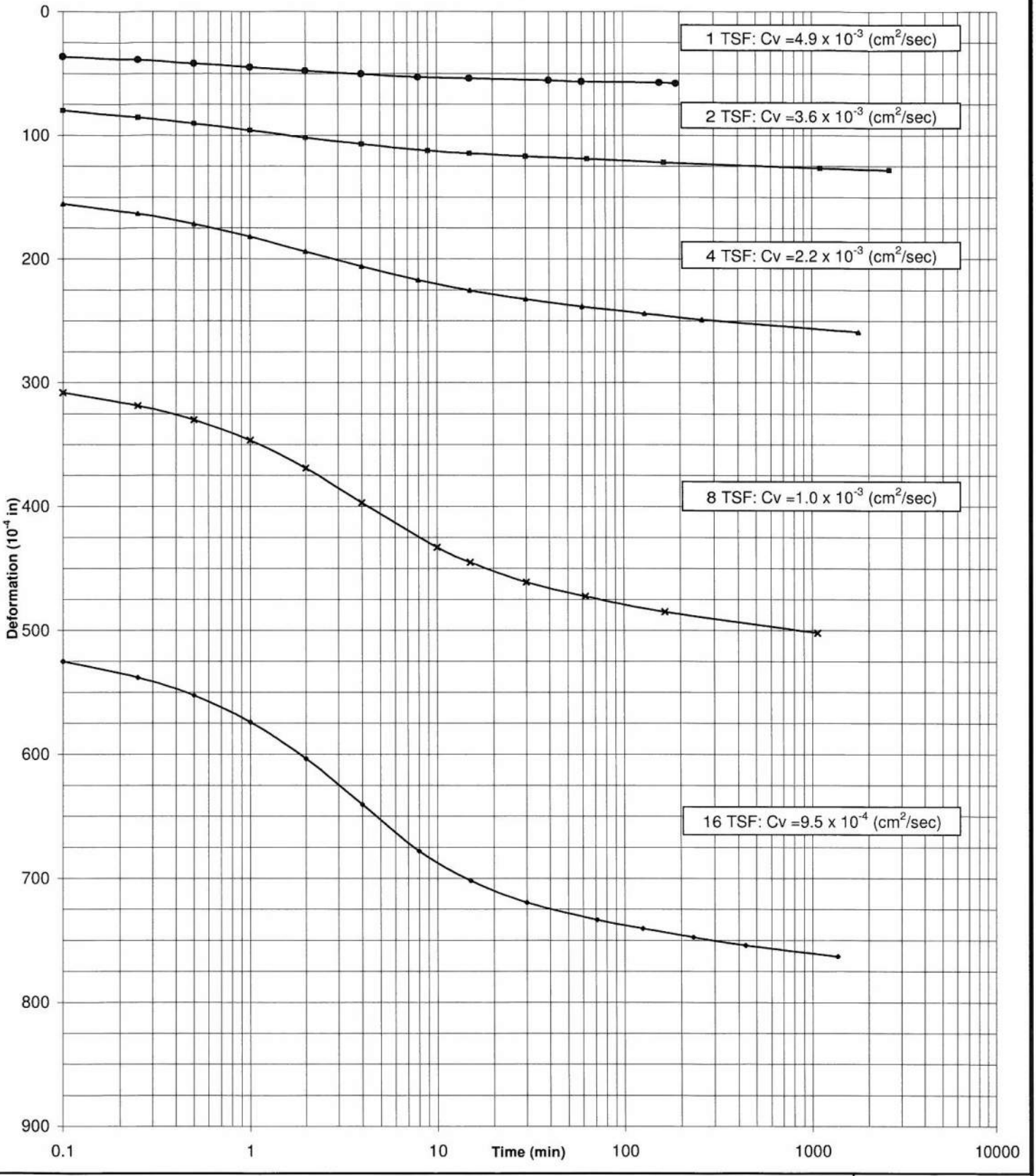
Remarks: Testing performed in general accordance with ASTM:D2435

2401 W 66th Street

SOIL ENGINEERING TESTING, INC.

Richfield, Minnesota 55423-2031

Consolidation Log of Time Curves



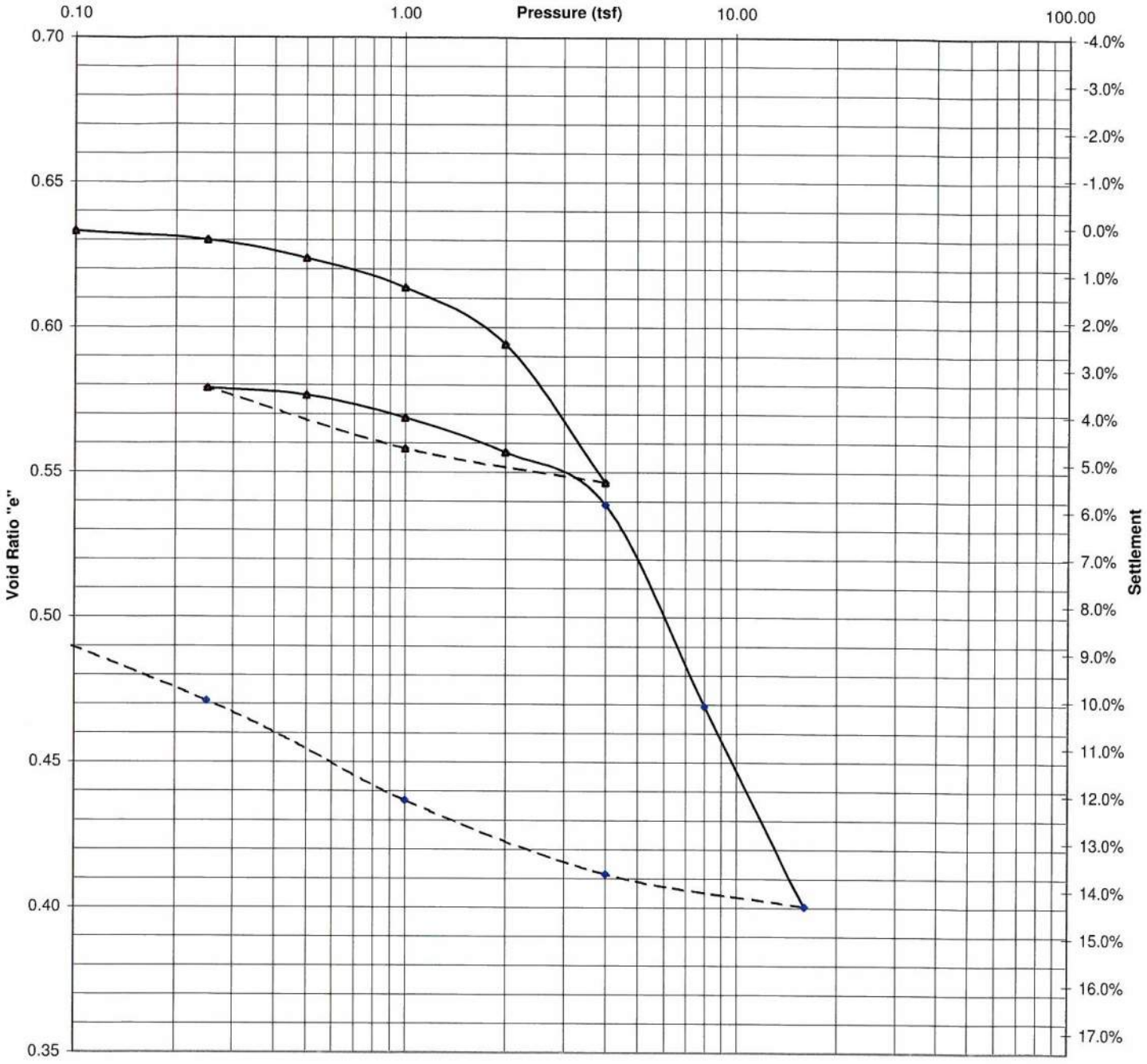
Project: Ashland/NSP Lakefront Site - 15X001			Date: 3/20/15
Sample #: ST-5	Boring #: AQ-BW-3	Depth ft: 23-25	Job #: 9783

2401 W 66th Street

SOIL ENGINEERING TESTING, INC.

Richfield, Minnesota 55423-2031

Void Ratio and % Settlement vs. Log of Pressure



Project: Ashland/NSP Lakefront Site - 15X001				Date: 3/20/15
Sample #: ST-2	Boring #: AQ-BW-5	Depth ft: 24.3-26.3		Job #: 9783
Soil Type: Fat Clay w/sand (CH)				
Initial W/C (%): 22.2	Dry Density (pcf): 104.7	LL: PL: PI:		Gs: 2.74 (Assumed)
Organic Content (%):	Initial Height (in.): 0.745	Diameter (in.): 2.503	e_o= 0.634	
Preconsolidation Pressure (Pc): 2.4 tsf	Compression Index (Cc): 0.24	Recompression Index (Cr): 0.03		

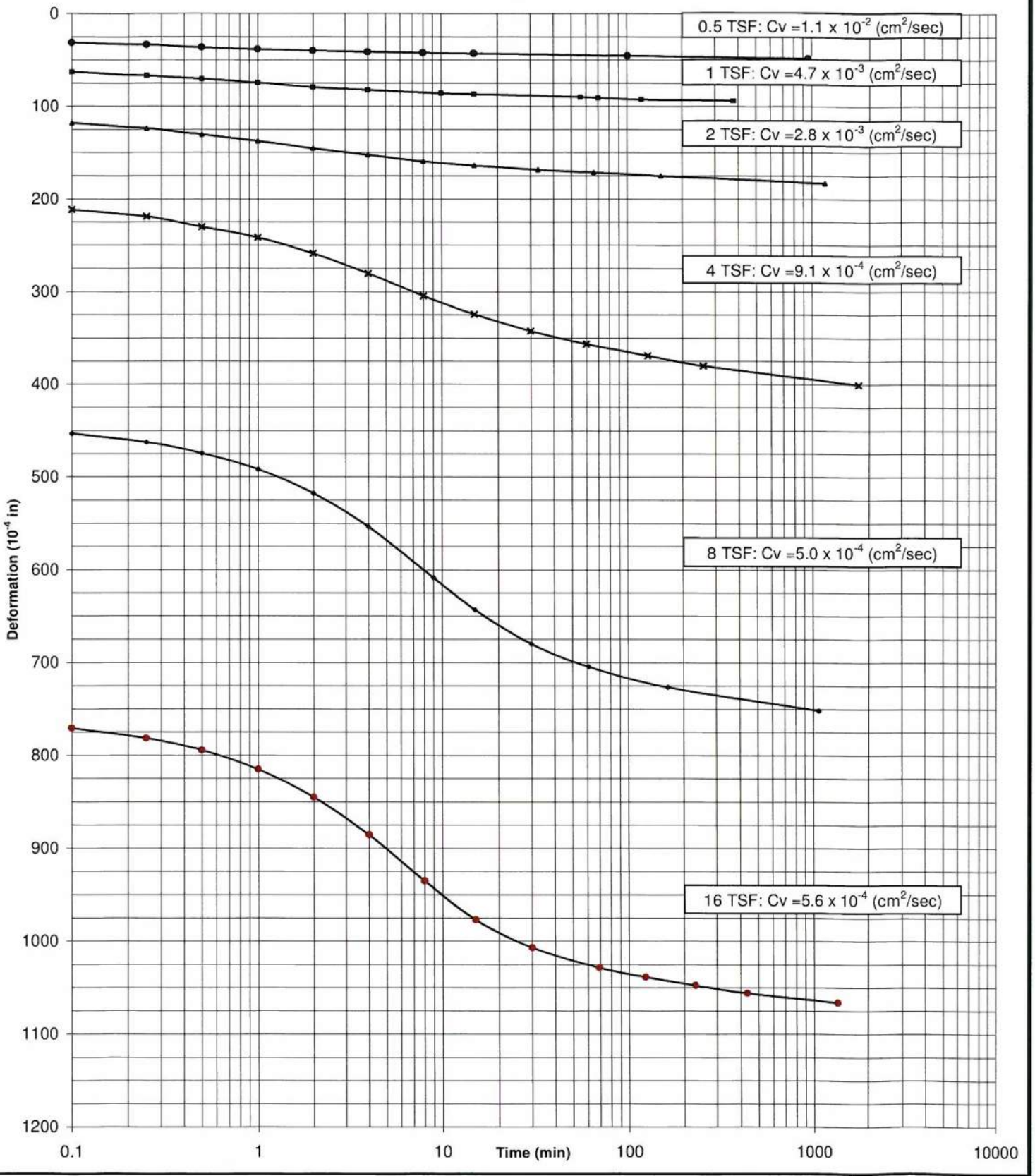
Remarks: Testing performed in general accordance with ASTM:D2435

2401 W 66th Street

SOIL ENGINEERING TESTING, INC.

Richfield, Minnesota 55423-2031

Consolidation Log of Time Curves



Project: Ashland/NSP Lakefront Site - 15X001			Date: 3/20/15
Sample #: ST-2	Boring #: AQ-BW-5	Depth ft: 24.3-26.3	Job #: 9783

2401 W 66th Street

SOIL ENGINEERING TESTING, INC.

Richfield, Minnesota 55423-2031

Attachment 4

Strength Results

DRAFT

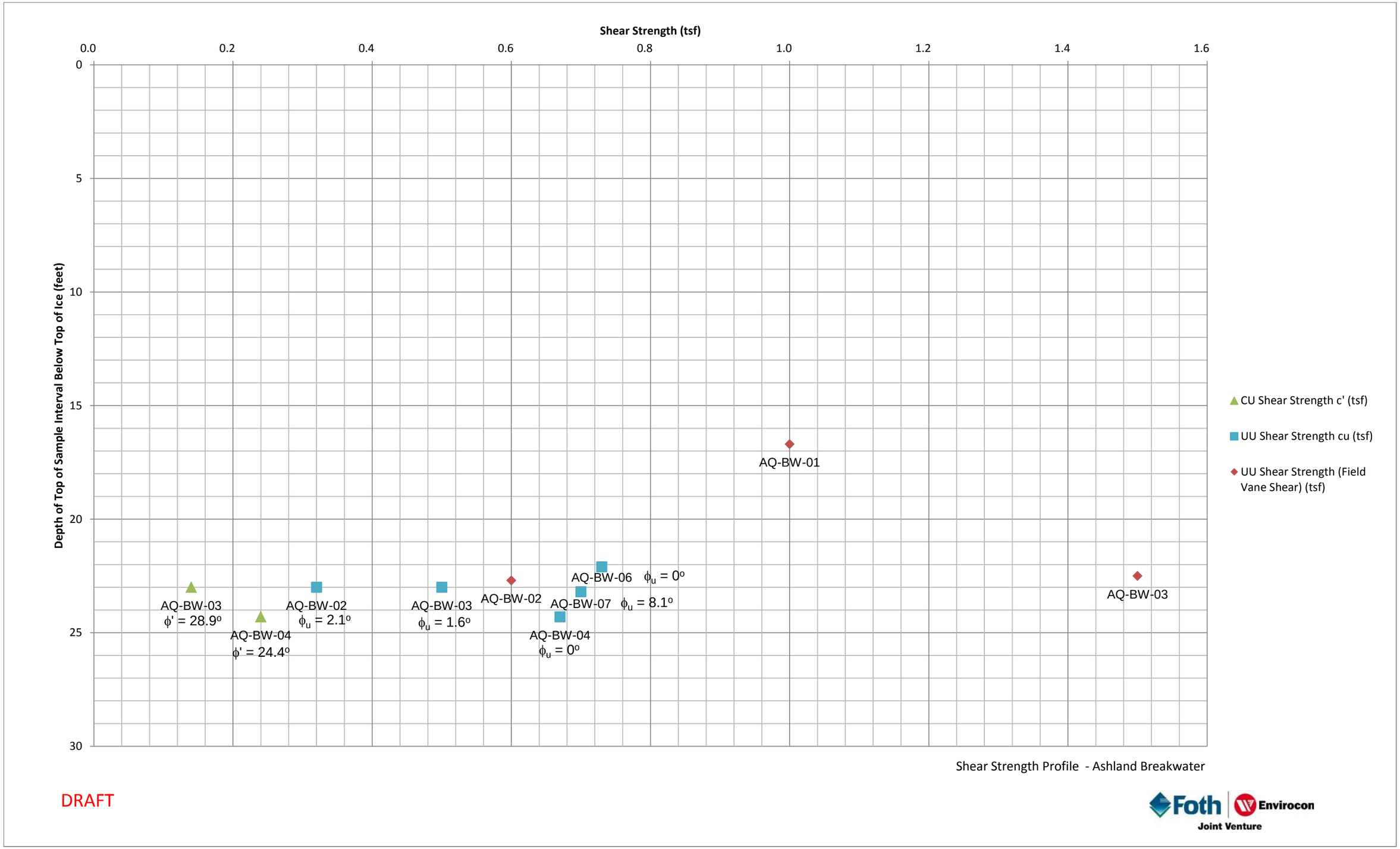
Summary of Strength Laboratory Test Results - Breakwater

Ashland/NSP Lakefront Site
Ashland, Wisconsin

ASTM No.		D4767	D4767	D2850	D2850			
Soil Boring Number	Sample[1] Depth (ft)	CU Angle of Friction φ' (degrees)	CU Shear Strength c' (tsf)	UU Angle of Friction φ_u (degrees)	UU Shear Strength c_u (tsf)		UU Shear Strength (Field Vane Shear) (tsf)	
AQ-BW-01	16.7						1.0	
AQ-BW-02	22.7						0.6	
AQ-BW-02	23 - 24.6			2.1	0.32			
AQ-BW-03	21.7					>	0.90	*
AQ-BW-03	22.5						1.50	
AQ-BW-03	23 - 25	28.9	0.14	1.6	0.50			
AQ-BW-04	24.3 - 26.3	24.4	0.24	0	0.67			
AQ-BW-06	22.1 - 24.1			0	0.73	>	1.0	*
AQ-BW-07	22.5					>	0.5	*
AQ-BW-07	23.2 - 25.2			8.1	0.70			

QU = Unconfined Compression Test yielding unconfined shear strength = 50% of the compressive strength
UU = Unconsolidated/Undrained Triaxial Compression Test yielding shear strength = 50% of the compressive strength
* Apparatus reached maximum without failing.
1. Depth below top of ice.

Prepared by: TMK1
Checked by: JBH1



Shear Strength Profile - Ashland Breakwater

DRAFT

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Attachment 5

Current Breakwater Design Figures

1,745,000 E
1,745,500 E
1,746,000 E
1,746,500 E
1,747,000 E
523,000 N
522,500 N
522,000 N

LAKE SUPERIOR

ROOT SECTION
TRUNK SECTION
HEAD SECTION

APPROXIMATE LIMITS OF BREAKWATER EXCAVATION (BY OTHERS)
TOE OF BREAKWATER
REMOVE EXISTING PIERS
PRESERVE AND PROTECT EXISTING STRUCTURE. BREAKWATER ROOT TERMINATION TO BE DETERMINED.
BEDDING STONE
BREAKWATER SURVEY CONTROL LINE (SCL)
TOE OF BREAKWATER
APPROXIMATE LIMITS OF BREAKWATER EXCAVATION (BY OTHERS)

1
2
3

NAVIGATION AID 1
NAVIGATION AID 2

BASIN

PRENTICE AVENUE
ST CLAIR ST
3RD AVENUE
U.S. HIGHWAY NO. 2
ELLIS AVENUE

NOTES:

1. COORDINATE SYSTEM - WISCONSIN STATE PLANE, NORTH ZONE. U.S. FEET. HORIZONTAL DATUM IS NAD83, VERTICAL DATUM IS NAVD88.

2. NAVD88 +601.0 = 0.0 LOW WATER DATUM (LWD).

PRE-FINAL DESIGN

NORTH

0 60' 180' 300'
GRAPHIC SCALE IN FEET

REV	T.I.	DESCRIPTION	DRN	DSN	APR	DATE
A	A	PRE-FINAL DESIGN	JLH	CDA	MJC	03/24/15

REVISIONS

TYPE OF ISSUE: (A) PRELIMINARY (B) FOR REVIEW (C) FOR APPROVAL (D) FOR INFORMATION (E) CONTRACT DOCUMENT (F) FOR CONSTRUCTION (G) AS BUILT (H) CANCELLED

PREPARED FOR:

DRAFT

PREPARED BY:

Baird
W.F. Baird & Associates Ltd.

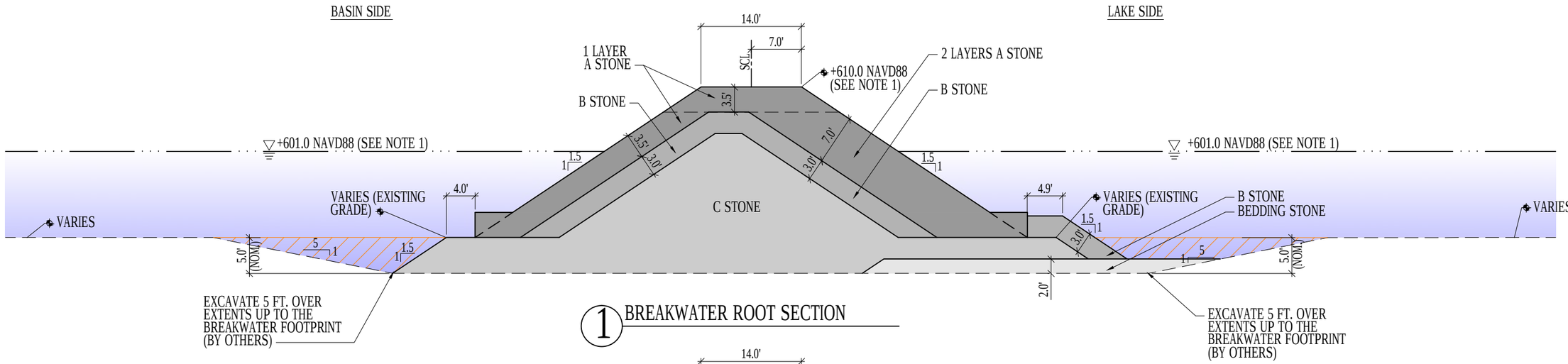
IN ASSOCIATION WITH:

ASHLAND BREAKWATER

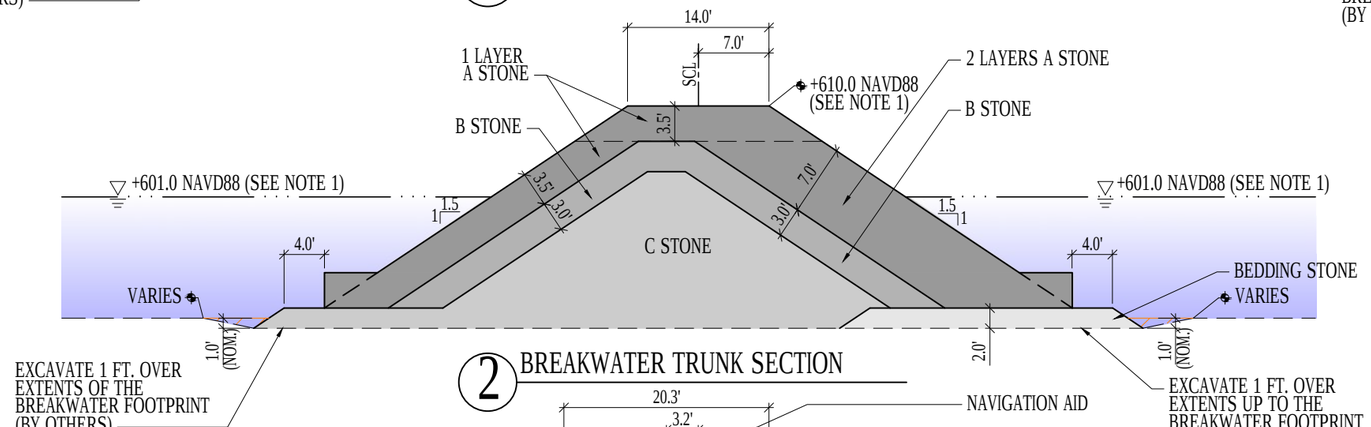
FIGURE A
PLAN VIEW, BEDDING MATERIAL AREA

DRAWING NUMBER: 12361 — PF — 010
REV: A
DATE: 03/24/15

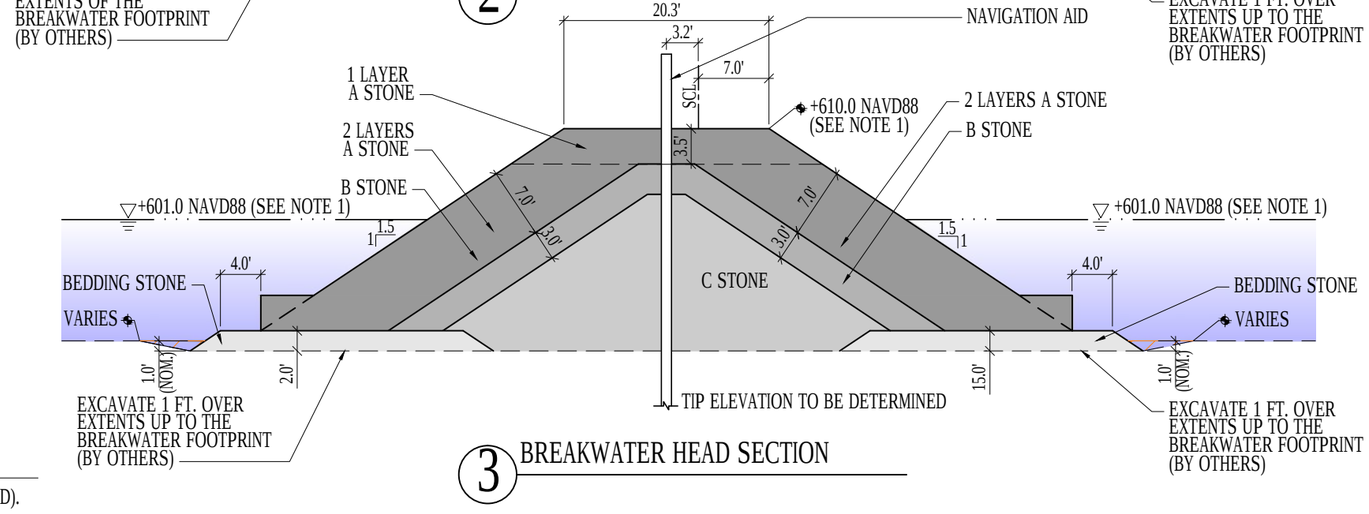
Date Plotted: 3/25/2015 11:09:41 AM



1 BREAKWATER ROOT SECTION



2 BREAKWATER TRUNK SECTION



3 BREAKWATER HEAD SECTION

NOTES:

1. NAVD88 +601.0 = 0.0 LOW WATER DATUM (LWD).

PRE-FINAL DESIGN

GRAPHIC SCALE IN FEET (0, 5, 10, 20)

REV	T.I.	DESCRIPTION	DRN	DSN	APR	DATE
A	A	PRE-FINAL DESIGN	JLH	CDA	MJC	03/24/15

REVISIONS

(T.I.) TYPE OF ISSUE: (A) PRELIMINARY (B) FOR REVIEW (C) FOR APPROVAL (D) FOR INFORMATION (E) CONTRACT DOCUMENT (F) FOR CONSTRUCTION (G) AS BUILT (H) CANCELLED

PREPARED FOR:

DRAFT

PREPARED BY: Baird, W.F. Baird & Associates Ltd.

ASHLAND BREAKWATER

FIGURE B
CROSS SECTION, BEDDING MATERIAL AREA

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Date Plotted: 3/25/2015 11:02:39 AM