APPENDIX F
Geotechnical Memorandum

McTaggart's Pond Dam
Seepage and Stability Evaluation

TO: Dan Buttrick
FROM: Dan Gnatek
COPY: File
DATE: November 4, 2019

This technical memorandum presents the results of the subsurface exploration program and seepage and stability analyses performed on a section of McTaggart's Pond Dam in Fitchburg, Massachusetts. A Site Locus is presented as Figure 1 of Appendix A. Elevations presented in this memorandum reference the North American Vertical Datum of 1988 (NAVD88). The existing conditions described in this memorandum are based on an Existing Conditions Plan prepared by Sherman & Frydryk, LLC, dated August 7, 2019. No bathymetric survey was performed as part of this scope.

Common terms used in this memorandum when discussing the orientation of the dam are defined as follows:

- Upstream – the side of the dam that borders the impoundment
- Downstream – the high side of the dam (i.e. the side opposite the upstream side)
- Right – the area to the right when facing the downstream direction
- Left – the area to the left when facing the downstream direction

Site Conditions

Existing – McTaggart's Pond Dam is an Intermediate-size, Significant-hazard dam rated in Poor condition based on the Office of Dam Safety's rating guidelines. The dam is an approximately 430-foot-long earth and concrete/stone-masonry embankment dam with a primary spillway and a low-level outlet structure. The embankment crest is approximately 20 feet wide with an approximately 150-foot-long concrete retaining wall at the downstream edge of the crest to the right of the gatehouse structure. The wall has a maximum height of approximately 16 feet. Previous inspections have identified areas of active seepage downstream of this wall. Historical drawings of the dam are included in Appendix B.

Subsurface Conditions

The generalized subsurface conditions described in the text below summarize trends observed in the explorations. The boundaries between soil strata are approximate and are based on interpretations of widely spaced explorations and samples. Actual conditions could be more variable.

Test Borings – Three geotechnical test borings (B-1 through B-3) were drilled by Seaboard Drilling, Inc. of Chicopee, Massachusetts on November 7 and 8, 2018. An additional boring (B-3A) was drilled by Seaboard Drilling, Inc. on March 18, 2019. The borings were drilled along a cross-section through the dam embankment near the maximum section, just right

of the spillway. Boring B-1 was drilled on the upstream side of the dam crest, boring B-2 was drilled on the downstream side of the dam crest, and borings B-3 and B-3A were drilled at the downstream toe of the dam. Test borings were advanced with 4-inch-inner-diameter flush-joint casing, using drive-and-wash methods to depths of between 7.5 and 17.5 feet below the existing ground surface. Split-spoon sampling and Standard Penetration Tests (SPTs) were conducted continuously through the dam embankment and existing fill soils at the toe of the dam. Test borings were terminated upon casing refusal, except for boring B-1, which was terminated within the embankment fill at a depth of 15 feet. A 5-foot rock core was obtained in test boring B-3A in accordance with ASTM D2113 using an NX-sized double-wall core barrel. Rock core recovery and rock quality designation (RQD) were logged for the core run, and recovered soil and rock samples were visually classified in the field.

Groundwater monitoring wells were installed in test borings B-1 and B-2 upon completion of drilling. The monitoring wells were constructed using a 10-foot-long section of 2-inch-diameter Schedule 40 PVC slotted screen below sections of PVC riser pipe of varying lengths. The annulus between the borehole and the PVC pipe was backfilled with filter sand to a height of approximately 2 feet above the top of the screened section, and an approximately 2-foot-thick bentonite seal was installed above the filter sand. The remaining annulus was grouted via tremie methods to grade to limit surface water from infiltrating the well. Protective steel flush-mounted well caps were installed at each well location. Groundwater elevation readings were taken periodically during the explorations and additional readings were taken following the completion of drilling activities. A borehole permeability test was attempted in boring B-2, but the embankment fill was deemed too permeable to provide reliable results. Test borings B-3 and B-3A were grouted via tremie methods upon completion of drilling.

Boring locations are shown on Figure 2, of Appendix A. Test boring logs are included in Appendix C.

Laboratory Testing – Laboratory tests were performed to aid in soil classifications and estimation of strength and permeability properties. Three mechanical Particle Size Analysis tests (ASTM D6913) were performed on samples taken during the explorations. Laboratory test results are included in Appendix D.

Summary of Subsurface Conditions – In general, subsurface conditions observed in the explorations performed within the dam embankment consisted of approximately 6 inches of topsoil, overlying approximately 18 feet of existing embankment fill, overlying bedrock. Subsurface conditions observed in the explorations performed at the downstream toe of the dam generally consisted of approximately 6 inches of topsoil, overlying approximately 5 to 7 feet of existing fill, overlying gneissic bedrock. Organic material (fibrous peat) was observed to be intermixed near the bottom of the existing fill stratum. Table 1 below presents the general stratigraphy encountered during the subsurface exploration program in descending depth from the ground surface.

Groundwater was encountered approximately 4.5 to 6.5 feet below the existing ground surface within the dam embankment, corresponding to elevations 631.5 to 633.5 feet. Groundwater was encountered approximately 2.5 feet below the existing ground surface at the downstream toe of the dam, corresponding to elevation 622.5 feet. Water levels can fluctuate with season, precipitation, and nearby construction or other below grade activities, such as excavation, dewatering, wells, infiltration basins, etc.

Table 1
Description of Subsurface Conditions Encountered

Strata (In Descending Depth)	General Description[1]
TOPSOIL	Loose, brown, fine to medium SAND and SILT, trace Gravel, trace Organic Matter
EMBANKMENT FILL	Loose to medium dense, brown, little to some Silt, trace to some Gravel, trace Brick, trace Cinders; varying to loose, brown, fine to coarse SAND and SILT, trace Gravel; varying to medium dense, brown, GRAVEL and fine to coarse SAND, some Silt; varying to very loose to very dense, GRAVEL, little to some fine to coarse Sand, trace to some Silt, trace Brick
FILL (at downstream toe)	Loose to medium dense, dark brown, fine to coarse SAND, little to some Silt, little to some Gravel; varying to medium, dark brown, SILT and GRAVEL, little fine to coarse Sand, little Fibrous Peat, trace Glass, trace Brick, trace Cinders; varying to very dense, dark brown, fine to coarse SAND, some Silt, little to some Gravel, little Fibrous Peat, trace Brick
BEDROCK	Hard to very hard, slight to very slightly weathered, moderately fractured to sound, grey/black, fine- to coarse-grained GNEISS, close to moderately close, shallow fractures REC[2] = 56"/60" = 93.3%; RQD[3] = 46"/60" = 76.7%

[1] Definition of Soil Description Terms: "trace" = 0-10%, "little" = 10-20%, "some" = 20-35%, "and" = 35-50%, by weight
[2] Rock core recovery (REC) is defined as the length of all core pieces recovered divided by the total core run length.
[3] Rock Quality Designation (RQD) is defined as the sum of all recovered sound rock pieces measuring 4 inches or more in length (for type NX, NQ, or PQ cores) divided by the total core run length. RQD is a relative indicator of rock quality

Seepage and Stability Analyses

The analyses and recommendations presented in this evaluation are based upon the data obtained from a limited number of subsurface explorations. Therefore, the nature and extent of variations of subsurface conditions may not become evident until commencement of corrective action (if recommended). If significant variations from these descriptions appear during construction, it will be necessary to re-evaluate these recommendations.

Development of Cross-Section for Seepage and Slope Stability – A cross-section was taken through the dam embankment at approximately the maximum section, just right of the spillway and near the recent subsurface explorations as shown on Figure 2 of Appendix A. The section geometry was developed based on the Existing Conditions Plan, historical record drawings for the dam, and information collected during the subsurface exploration program. Historical drawings, prepared by Howard Turner, dated Jan 31, 1956, which indicate that upstream and downstream walls bear on bedrock. The subsurface conditions observed in borings B-1 and B-2 (embankment fill over bedrock) support the bearing condition indicated on the historical drawings. The soil parameters used for the seepage and stability analyses are presented in Table 2 below.

Table 2
Soil Parameters for Seepage and Stability Analyses

Item	Total Unit Weight (PCF)	Cohesion (PSF)	Internal Friction Angle (Degrees)	Permeability (cm/s)
Vegetated Topsoil	105	100	28	3e-6
Fill	105	0	30	1e-5
Embankment Fill	120	0	32	1e-3
Stone Masonry	150	-	-	1e-7
Concrete	150	-	-	1e-10
Bedrock	165	-	-	1e-8
Sediment	110	0	30	3e-5

PCF = Pounds per Cubic Foot; PSF = Pounds per Square Foot

The material properties for soils were based on correlations with $(N_1)_{60}$ corrected blow counts presented in the California Department of Transportation (Caltrans) Geotechnical Manual, after Bowles (1977), typical properties of compacted fill presented in the Naval Facilities Engineering Command (NAVFAC) Design Manual 7.02 (1986), and engineering judgement. Bedrock, concrete, and stone masonry strength parameters were estimated using the Generalized Hoek-Brown method, which approximates the relationship between rock mass quality and material constants based on empirical data.

Seepage Analysis – A seepage analysis was performed near the maximum embankment section using the finite element groundwater capabilities of Slide 8.018 by Rocscience, Inc. The analysis was performed under two impoundment water surface conditions: normal storage pool elevation (635.3 feet) and maximum pool at the top dam elevation (638.9 feet). Soil permeability values were adjusted to generate a phreatic surface through the embankment that was in general agreement with the water surface observed in the groundwater monitoring wells.

Under the normal pool condition, the predicted phreatic surface (i.e. water table) generally flows horizontally through the dam embankment and drops steeply through the downstream retaining wall. This generally agrees with the groundwater measurements taken during the subsurface explorations and consistent with the relatively high permeability of the embankment soils. A more significant drop in the phreatic surface across the embankment would be observed if the embankment soils were less permeable and provided better seepage cutoff. Under the maximum pool condition, the predicted phreatic surface is similar to the normal pool condition, although higher in the embankment due to the increased impoundment level.

Exit gradients for the seepage model were predicted to be 0.2 and 0.3 for the normal pool and maximum pool conditions, respectively. Therefore, the potential for piping to occur is low, with factors of safety against piping of 3 and 2 for the normal pool and maximum pool conditions, respectively. Calculated discharge rates at Section A-A are generally small (approximately $1x10^{-6}$ gpm and $2x10^{-6}$ gpm per linear foot for the normal pool and maximum pool conditions, respectively) with the majority of the flow predicted through the bedrock layer.

Seepage cutoff appears to be adequate based on the results of the seepage analysis. However, areas of active seepage have been identified in past dam inspections, which may indicate specific defects that allow more seepage than is predicted. The above-referenced historical drawings indicate below-grade drain pipes penetrating through the downstream

retaining wall, which may be a contributing factor. Additionally, bedrock fractures may provide preferential seepage paths. If the downstream retaining wall is to remain and be buttressed, it is recommended that a chimney drain and blanket drain be installed to safely filter, collect, and discharge seepage flows.

Stability Analysis – A stability analysis was performed according to the requirements presented in Commonwealth of Massachusetts 302 CMR 10.00 Dam Safety, revised February 10, 2017. The guidelines provide minimum factors of safety for stability under specific loading conditions. The stability analyses were performed for the following conditions:

- Steady State – Assumes that the impoundment elevation (normal pool and maximum pool) remains constant for a sufficient period of time for seepage to reach equilibrium.

- Rapid Drawdown – Evaluates the stability of the dam if there is a rapid loss of water in the impoundment (normal pool and maximum pool) while leaving the upstream slope saturated. The rapid drawdown condition is a relative term that assumes that the impoundment will recede much quicker than the embankment soils can drain.

- Earthquake – Examines the stability of the dam during a seismic event. Maximum pool is not considered during this analysis as it is recognized that the probability of a flood and seismic event occurring at the same time is extremely low.

Slope stability software, Slide version 8.018, using the Spencer method, was used to analyze the conditions and determine the factor of safety against a global slope failure. The Spencer method is used to analyze slopes of varying geometries and is considered a rigorous method, as it satisfies both force and moment equilibrium.

Table 3 presents the results of our stability analysis and compares them to the minimum factors of safety (FOS) recommended by the DCR guidelines. Graphical output, illustrating the predicted failure planes, is included in Appendix E.

Table 3
Soil Parameters for Seepage and Stability Analyses

Condition	Steady State Seepage		Rapid Drawdown		Earthquake	
	Required FOS	Calculated FOS	Required FOS	Calculated FOS	Required FOS	Calculated FOS
Downstream Normal Pool	1.5	2.9	N/A	-	1.0	2.2
Downstream Max Pool	1.5	2.9	N/A	-	N/A	-
Upstream Normal Pool	1.5	3.2	1.2	2.3	1.0	2.8
Upstream Max Pool	1.5	4.5	1.1	2.1	N/A	-

Values in bold indicate the minimum FOS is not achieved. N/A = Not Applicable

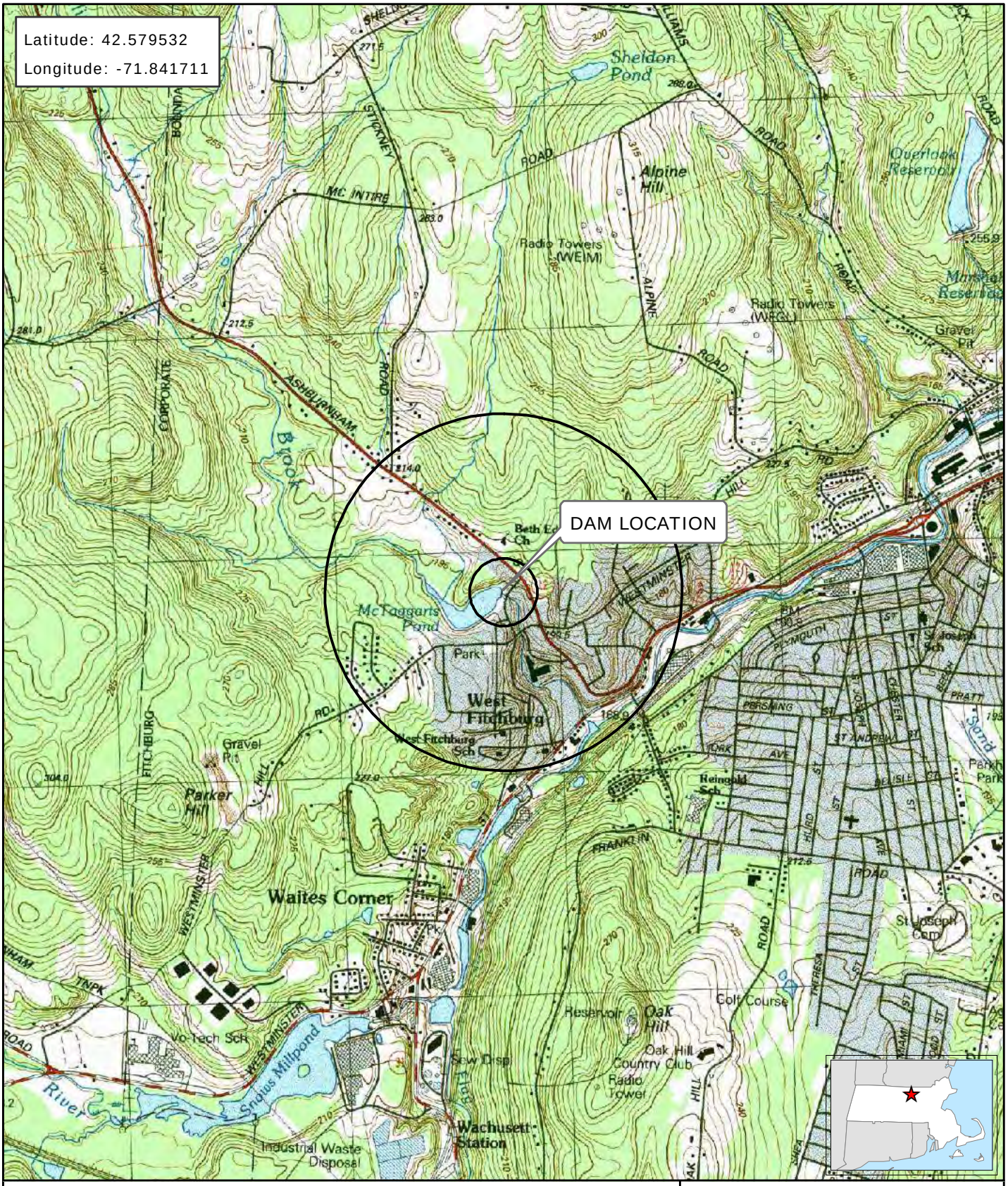
The upstream and downstream slopes of the dam embankment are generally stable and meet the required factors of safety for the loading conditions required by 302 CMR 10.00 Dam Safety. The global minimum factors of safety for the downstream slope are along

shallow failure planes, and failure along these planes would likely result in minor sloughing. The deeper-seated failure circles have factors of safety of greater than 5.

It should be noted that the Slide software does not evaluate the structural stability of the retaining walls. If the upstream and/or downstream retaining walls are to be re-used or re-purposed as part of the dam rehabilitation, it is recommended that they be evaluated by a Structural Engineer for stability with respect to sliding and overturning.

J:\F\F0079 Fitchburg\047 McTaggart's Pond Dam\Geotechnical\Report\Text\F-0079-047_Seepage and Stability.doc

Appendix A
Figures



Tighe&Bond
Engineers | Environmental Specialists

Image provided by MassGIS based on USGS Topographic Map for Fitchburg, MA. Revised 1988. Circles indicate 500-foot & half-mile radii Contour Interval: 3 Meters

1:24,000
0 1,000 2,000
Feet

N

FIGURE 1
SITE LOCUS &
DOWNSTREAM AREA MAP

McTaggarts Pond Dam
MA00879
Fitchburg, Massachusetts

March 2019

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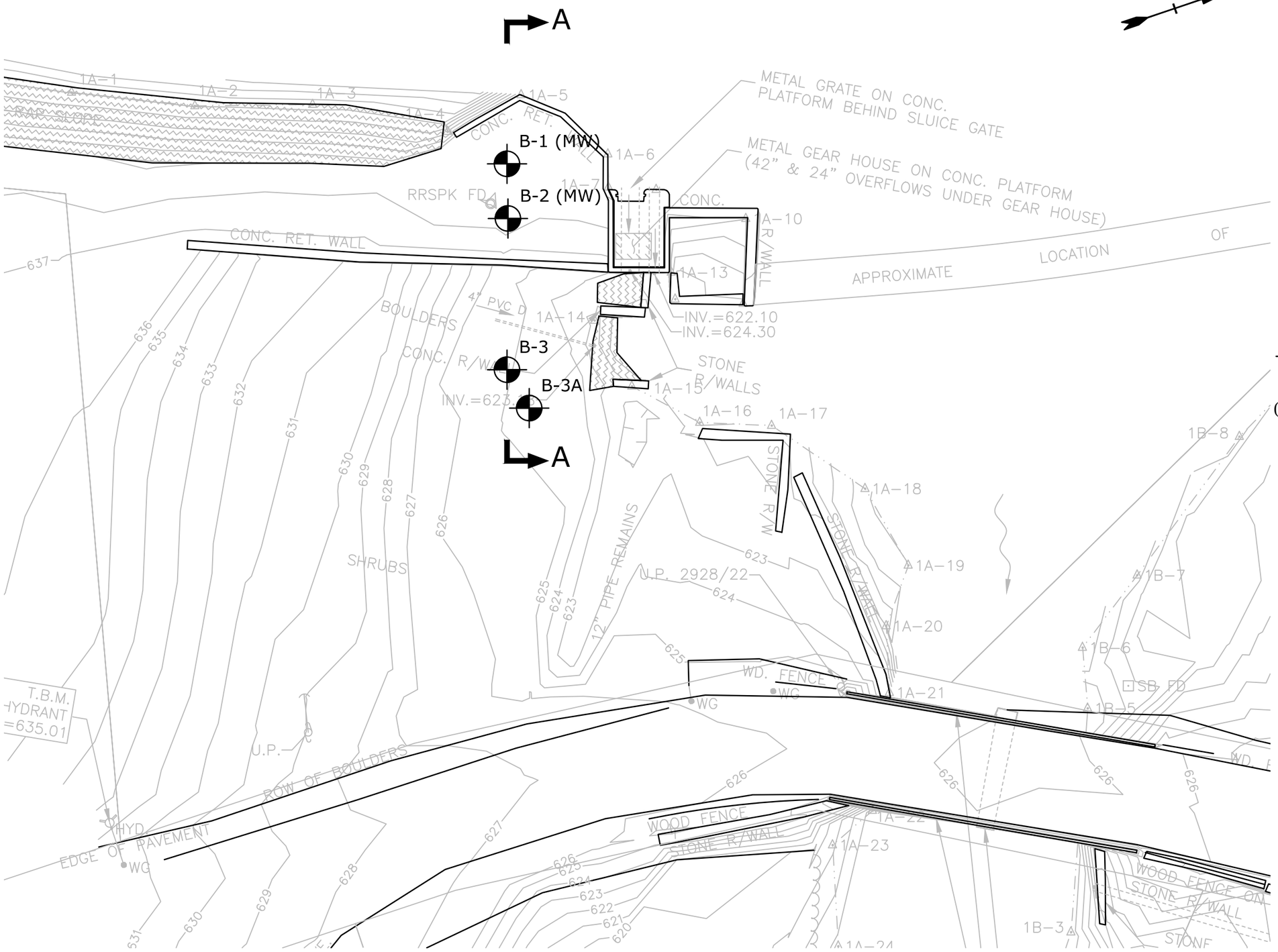
F-0079-047



GENERAL NOTES:

1. ELEVATIONS SHOWN HEREIN REFERENCE THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
2. BORING LOCATIONS LAID OUT BY TIGHE & BOND REPRESENTATIVES BY MEASURING OFF EXISTING FEATURES. LOCATIONS SHOULD BE CONSIDERED APPROXIMATE.
3. BORINGS DRILLED BY SEABOARD DRILLING, INC. OF CHICOPEE, MA ON NOVEMBER 7 AND 8, 2018. BORINGS WERE ADVANCED USING FLUSH-JOINT CASING USING DRIVE-AND-WASH METHODS.
4. DISTURBED SOIL SAMPLES WERE OBTAINED USING A STANDARD SPLIT-SPOON SAMPLER ADVANCED BY A 140-POUND HAMMER FREE FALLING FROM A HEIGHT OF 30 INCHES.
5. REFER TO BORING LOGS FOR DETAILED INFORMATION.

LEGEND:

B-# — APPROXIMATE BORING LOCATION

(MW) — DENOTES MONITORING WELL

0 10' 20' 40'

GRAPHIC SCALE

MCTAGGART'S POND DAM
FITCHBURG, MA

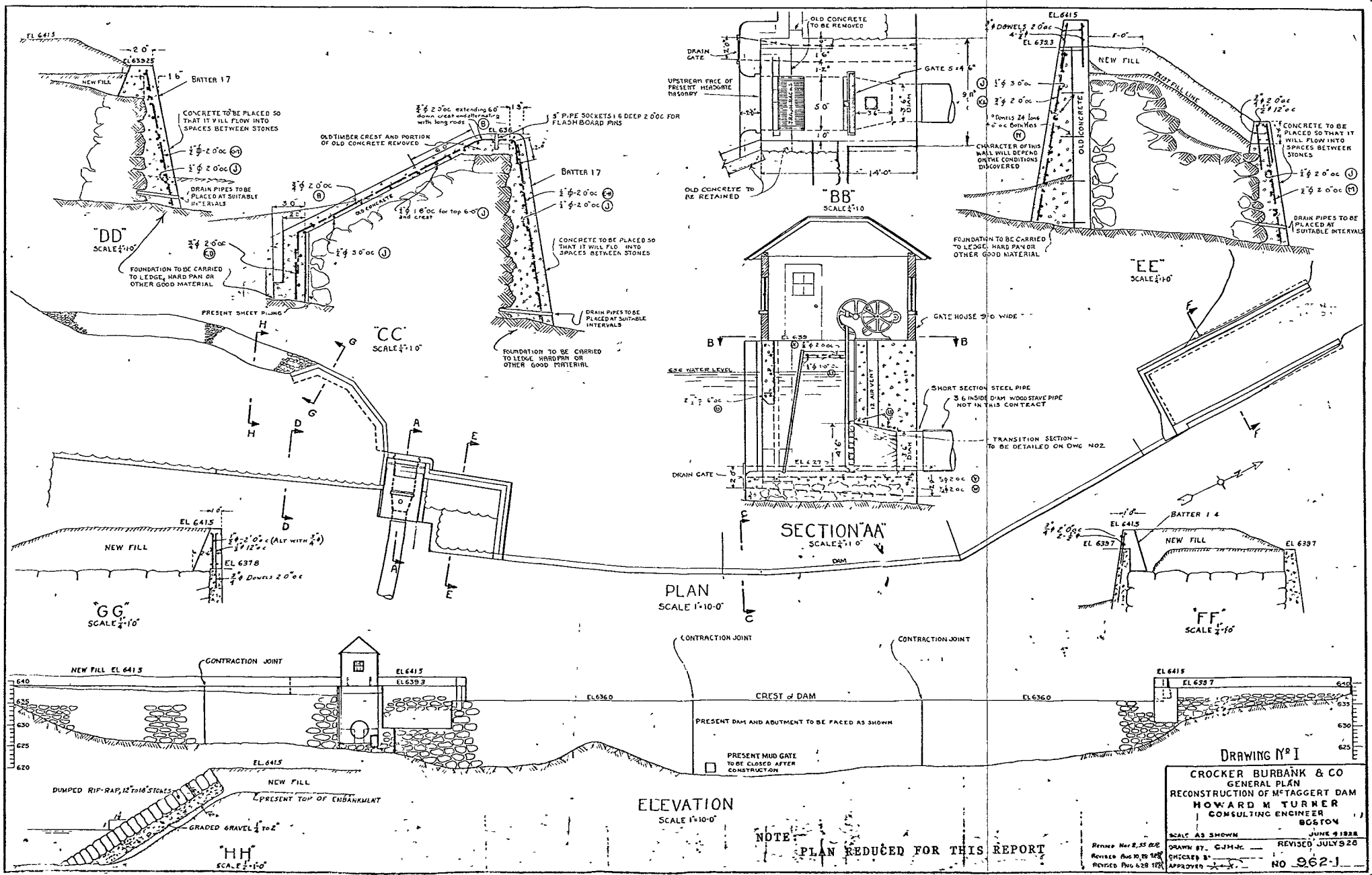
SUBSURFACE EXPLORATION PLAN

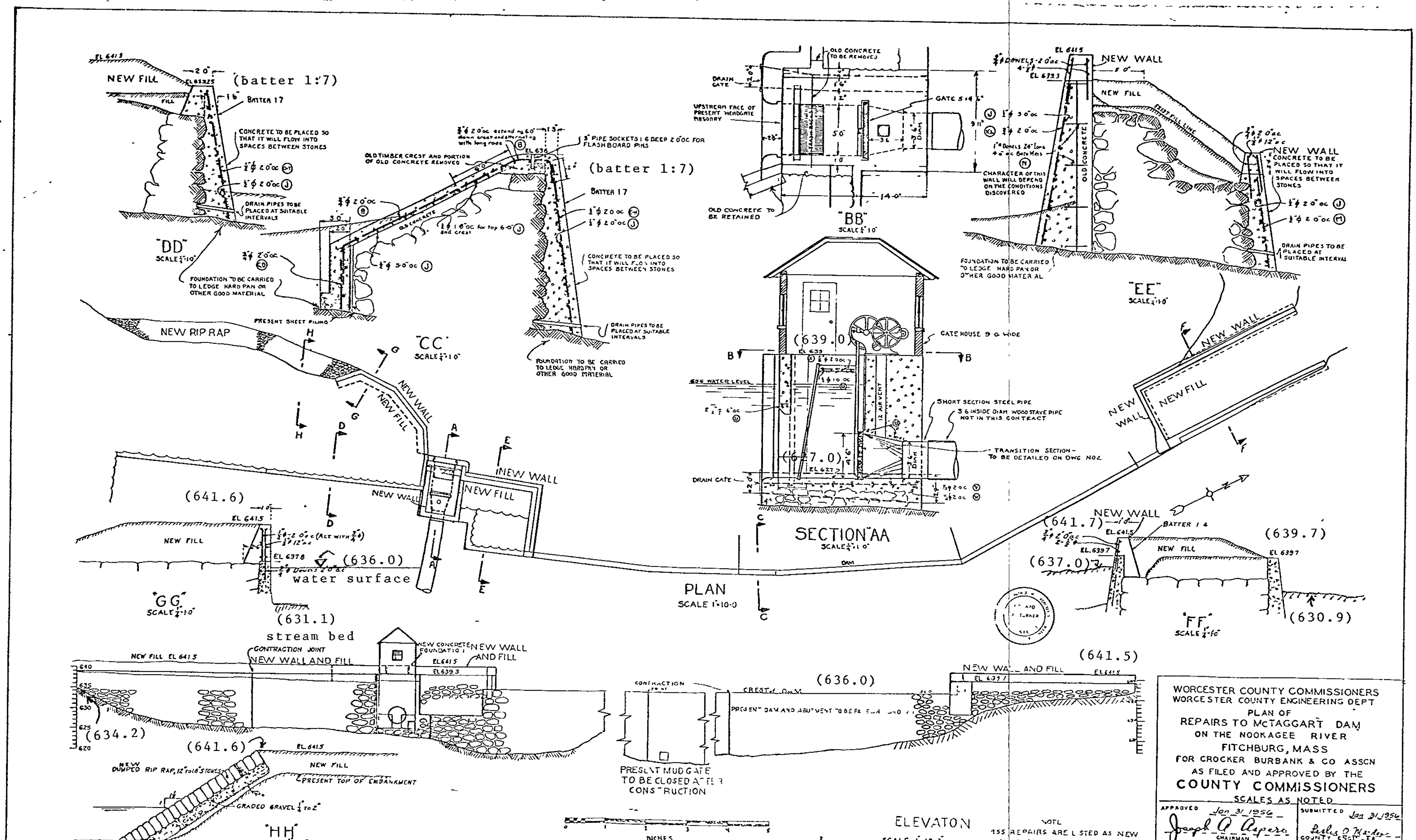
DATE: 02/07/2019
SCALE: 1" = 20'
FIGURE 2

Tighe&Bond
Engineers | Environmental Specialists

Mar 21, 2019-4:18pm Plotted By: dgnatek
Tighe & Bond, Inc. F:\Projects\F0079 Fitchburg\047 McTaggart's Pond Dam\Drawings_Figures\AutoCAD\Geotechnical\F-0079-047-B-BLP.dwg

Appendix B
Historical Drawings


"DD" SCALE 1/4"=1'0"
"CC" SCALE 1/4"=1'0"
"BB" SCALE 1/4"=1'0"
"EE" SCALE 1/4"=1'0"
"FF" SCALE 1/4"=1'0"
"GG" SCALE 1/4"=1'0"
"HH" SCALE 1/2"=1'0"
SECTION "AA" SCALE 1/4"=1'0"
PLAN SCALE 1"=10'-0"
ELEVATION SCALE 1"=10'-0"
NOTE PLAN REDUCED FOR THIS REPORT
DRAWING N° I
CROCKER BURBANK & CO
GENERAL PLAN
RECONSTRUCTION OF McTAGGERT DAM
HOWARD M TURNER
CONSULTING ENGINEER
BOSTON
SCALE AS SHOWN
JUNE 9 1928
DRAWN BY CJH-JC
CHECKED BY
APPROVED
REVISED JULY 928
NO 962-J
Revised Nov 8, 55 D.E.
Revised Aug 10, 55 D.E.
Revised Aug 6 28 1958
CONCRETE TO BE PLACED SO THAT IT WILL FLOW INTO SPACES BETWEEN STONES
DRAIN PIPES TO BE PLACED AT SUITABLE INTERVALS
FOUNDATION TO BE CARRIED TO LEDGE, HARD PAN OR OTHER GOOD MATERIAL
OLD CONCRETE TO BE REMOVED
OLD CONCRETE TO BE RETAINED
GATE HOUSE 9'0 WIDE
SHORT SECTION STEEL PIPE
3 6 INSIDE DIAM WOOD STAVE PIPE NOT IN THIS CONTRACT
TRANSITION SECTION — TO BE DETAILED ON DWG NO2
CONTRACTION JOINT
CREST of DAM
PRESENT DAM AND ABUTMENT TO BE FACED AS SHOWN
PRESENT MUD GATE TO BE CLOSED AFTER CONSTRUCTION
DUMPED RIP-RAP, 12" TO 18" STONES
GRADED GRAVEL 1/4" TO 2"
PRESENT TOP OF EMBANKMENT
NEW FILL
OLD CONCRETE
PRESENT SHEET PILING
DRAIN GATE
GATE 5'-4"
BATTER 1 7
BATTER 1 4



NOTES:

PLAN REDUCED FOR REPORT
ELEVATIONS IN PARENTHESIS VERIFIED IN FIELD
GATEHOUSE DIMENSIONS 5'x6.5'

McTAGGARTS POND DAM

FIGURE B-3

Appendix C
Exploration Logs

Tighe&Bond
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Project: McTaggart's Pond Dam
Location: Fitchburg, MA
Client: City of Fitchburg

Boring No. **B-1 (OW)**
Page 1 of 1
File No. F-0079-047
Checked by: D. Gnatek

Drilling Co. Seaboard Drilling, Inc.
Foreman: D. Feeley
T&B Rep.: M. Trovato
Date Start: 11/08/18 End: 11/08/18
Location See Exploration Location Plan
GS. Elev. 638± Datum: NAVD88

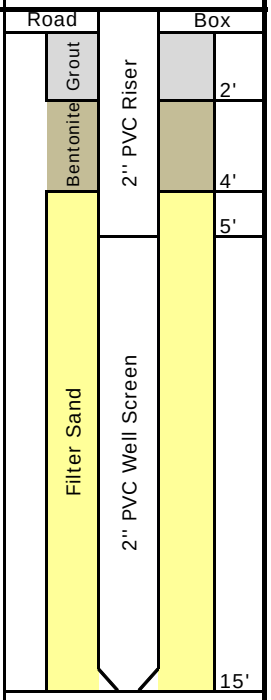
	Casing	Sampler
Type	Flush Joint	Split Spoon
I.D./O.D.	4''/4-1/2''	1-3/8"/2"
Hammer Wt.	-	140#
Hammer Fall	-	30"
Rig Make/Model	Diedrich D50 w/ auto hmr	

Groundwater Readings

Date	Time	Depth	Casing	Sta. Time
8-Nov	10:35	4.5'		0 hrs
23-Nov	8:10	10.65'		2 wks

Depth (ft.)	Casing Blows Per Ft.	Sample No. / Rec.(in)	Sample Depth (ft.)	Blows Per 6"	PID Reading (ppm)	Sample Description	General Stratigraphy	Notes
		S-1 / 16	0-2	2-1		Loose, light brown, fine to medium SAND, little Silt, trace Gravel	0.4' **TOPSOIL**	
				3-1				
		S-2 / 12	2-4	2-2		Loose, brown, fine to coarse SAND, little Silt, little Gravel, trace Cinders		
				2-3				
		S-3 / 4	4-6	2-2		Very loose, brown, GRAVEL, some fine to coarse Sand, some Silt		
5				1-1				
		S-4 / 14	6-8	3-3		10" Loose, brown, fine to coarse SAND, some Silt, little Gravel, trace Brick, over loose, light brown, fine to coarse SAND and SILT, trace Gravel	**EMBANKMENT FILL**	
				2-2				
		S-5 / 16	8-10	3-2		Loose, light brown, fine to coarse SAND and SILT, trace Gravel		
				4-5				
10		S-6 / 4	10-12	12-7		Medium dense, brown, GRAVEL and fine to coarse SAND, some Silt		
				4-4				
		S-7 / 7	12-14	5-3		Loose, brown, fine to coarse SAND, some Silt, trace Gravel		
				3-2				
15						End of boring at 15'		1
20								
25								
30								

Well Construction



Notes:
1. Groundwater monitoring well installed at the completion of drilling.

Proportions Used

TRACE (TR.)	0 - <10%
LITTLE (LI.)	10 - <20%
SOME (SO.)	20 - <35%
AND	35 - <50%

Density/Consistency

VERY LOOSE	0-4	VERY SOFT	<2
LOOSE	4-10	SOFT	2-4
MEDIUM DENSE	10-30	MEDIUM	4-8
DENSE	30-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	15-30
		HARD	>30

Tighe&Bond
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Project: McTaggart's Pond Dam
Location: Fitchburg, MA
Client: City of Fitchburg

Boring No. **B-2 (OW)**
Page 1 of 1
File No. F-0079-047
Checked by: D. Gnatek

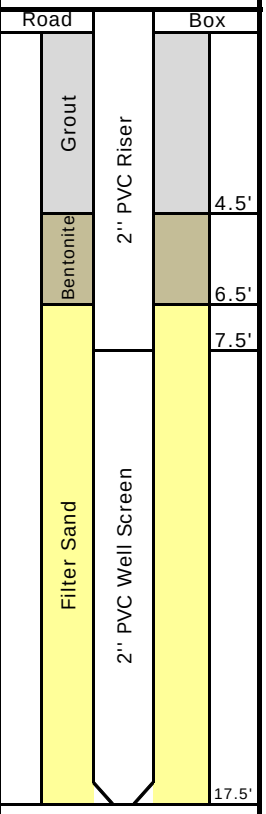
Drilling Co. Seaboard Drilling, Inc.
Foreman: D. Feeley
T&B Rep.: M. Trovato
Date Start: 11/08/18 End: 11/08/18
Location See Exploration Location Plan
GS. Elev. 638± Datum: NAVD88

	Casing	Sampler
Type	Flush Joint	Split Spoon
I.D./O.D.	4''/4-1/2''	1-3/8"/2"
Hammer Wt.	-	140#
Hammer Fall	-	30"
Rig Make/Model	Diedrich D50 w/ auto hmr	

Groundwater Readings

Date	Time	Depth	Casing	Sta. Time
8-Nov	14:10	6.5'		0 hrs
23-Nov	8:10	12.74'		2 wks

Depth (ft.)	Casing Blows Per Ft.	Sample No. / Rec.(in)	Sample Depth (ft.)	Blows Per 6"	PID Reading (ppm)	Sample Description	General Stratigraphy	Notes
		S-1 / 20	0-2	2-3		Loose, light brown, fine to coarse SAND, little Silt, trace Gravel	0.5' **TOPSOIL**	
				5-7				
		S-2 / 14	2-4	6-5		Medium dense, brown, fine to coarse SAND, little Silt, little Gravel, trace Cinders, trace Brick		
				6-4				
		S-3 / 10	4-6	4-4		Loose, brown, fine to coarse SAND, some Gravel, little Silt		
5				4-2				
		S-4 / 3	6-8	4-5		Medium dense, brown, fine to coarse SAND and GRAVEL, some Silt		
				7-5				
		S-5 / 3	8-10	4-2		Loose, brown, GRAVEL, little fine to coarse Sand, trace Silt	**EMBANKMENT FILL**	
				3-3				
10		S-6 / 9	10-10.8	23-50/4		Very dense, brown, GRAVEL, some fine to coarse Sand, little Silt, trace Brick		
		S-7 / 0	13-13.1	50/1		No Recovery		1
15								2
						End of boring at 17.5' due to casing refusal		3
20								
25								
30								



Notes:
1. Boulder encountered from approximately 13-13.5'.
2. Boulder encountered from approximately 15-17.5'.
3. Groundwater monitoring well installed at the completion of drilling.

Proportions Used

TRACE (TR.)	0 - <10%
LITTLE (LI.)	10 - <20%
SOME (SO.)	20 - <35%
AND	35 - <50%

Density/Consistency

VERY LOOSE	0-4	VERY SOFT	<2
LOOSE	4-10	SOFT	2-4
MEDIUM DENSE	10-30	MEDIUM	4-8
DENSE	30-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	15-30
		HARD	>30

Tighe&Bond
Engineers | Environmental Specialists

Project: McTaggart's Pond Dam
Location: Fitchburg, MA
Client: City of Fitchburg

Boring No. **B-3**
Page 1 of 1
File No. F-0079-047
Checked by: D. Gnatek

Drilling Co. Seaboard Drilling, Inc.
Foreman: D. Feeley
T&B Rep.: M. Trovato
Date Start: 11/07/18 End: 11/08/18
Location See Exploration Location Plan
GS. Elev. 625± Datum: NAVD88

	Casing	Sampler
Type	Flush Joint	Split Spoon
I.D./O.D.	4''/4-1/2''	1-3/8"/2"
Hammer Wt.	-	140#
Hammer Fall	-	30"
Rig Make/Model	Diedrich D50 w/ auto hmr	

Groundwater Readings

Date	Time	Depth	Casing	Sta. Time
7-Nov	14:00	2.6'		End of Boring

Depth (ft.)	Casing Blows Per Ft.	Sample No. / Rec.(in)	Sample Depth (ft.)	Blows Per 6"	PID Reading (ppm)	Sample Description	General Stratigraphy	Notes	Well Construction
		S-1 / 12	0-2	6-8		Medium dense, dark brown, fine to coarse SAND, some Silt, little Gravel	0.5' **TOPSOIL**		
				7-8					
		S-2 / 8	2-4	7-2		Medium, dark brown, SILT, some Gravel, little Fibrous Peat, little fine to coarse Sand, trace Glass			
				4-6			**FILL**		No Well Installed
		S-3 / 15	4-6	4-2		Medium, dark brown, SILT and GRAVEL, little fine to coarse Sand, little Fibrous Peat, trace Brick, trace Cinders			
5				5-14					
		S-4 / 9	6-8	20-48		Very dense, dark brown, fine to coarse SAND, some Gravel, some Silt, little Fibrous Peat, trace Brick			
				50/2				1	
						End of boring at 7.5' due to casing refusal			
10									
15									
20									
25									
30									

Notes:
1. Borehole grouted at the completion of drilling.

Proportions Used

TRACE (TR.)	0 - <10%
LITTLE (LI.)	10 - <20%
SOME (SO.)	20 - <35%
AND	35 - <50%

Density/Consistency

VERY LOOSE	0-4	VERY SOFT	<2
LOOSE	4-10	SOFT	2-4
MEDIUM DENSE	10-30	MEDIUM	4-8
DENSE	30-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	15-30
		HARD	>30

Tighe&Bond
Engineers | Environmental Specialists

Project: McTaggart's Pond Dam
Location: Fitchburg, MA
Client: City of Fitchburg

Boring No. **B-3A**
Page 1 of 1
File No. F-0079-047
Checked by: D. Gnatek

Drilling Co. Seaboard Drilling, Inc.
Foreman: D. Feeley
T&B Rep.: M. Trovato
Date Start: 03/18/19 End: 03/18/19
Location See Exploration Location Plan
GS. Elev. 625± Datum: NAVD88

	Casing	Sampler
Type	Flush Joint	Split Spoon
I.D./O.D.	4''/4-1/2''	1-3/8"/2"
Hammer Wt.	-	140#
Hammer Fall	-	30"
Rig Make/Model	Diedrich D50 w/ auto hmr	

Groundwater Readings

Date	Time	Depth	Casing	Sta. Time
3-Mar	9:45	2.4'		End of Boring

Depth (ft.)	Casing Blows Per Ft.	Sample No. / Rec.(in)	Sample Depth (ft.)	Blows Per 6"	PID Reading (ppm)	Sample Description	General Stratigraphy	Notes	Well Construction
		S-1 / 5	0-2	5-2		Loose, brown, fine to coarse SAND, some Silt, little Gravel	0.5' **TOPSOIL**	1	No Well Installed
				2-1					
		S-2 / 7	2-4	1-5		Medium dense, dark brown, fine to coarse SAND, some Silt, some Gravel	**FILL**		
				6-5					
		S-3 / 13	4-6	3-2		5" Loose, dark brown, fine to coarse SAND, some Gravel, little Silt, over medium, dark brown, fine to coarse SAND, some Fibrous Peat, little Silt, little Gravel			
5				50/4			5.4'		
		C-1 / 56	6-11	0:59		Hard to very hard, slight to very slightly weathered, moderately fractured to sound, grey/black, fine- to coarse-grained GNEISS, close to moderately close, shallow fractures		2	
				2:41			**GNEISS**		
				2:44					
				3:03		REC = 56"/60" = 93.3%			
10				4:42		RQD = 46"/60" = 76.7%			
						End of boring at 10.7'		3	
15									
20									
25									
30									

Notes:
1. Petroleum-like odor observed from 2-4'.
2. Fracture observed from approximaely 6-6.4'.
3. Borehole grouted at the completion of drilling.

Proportions Used

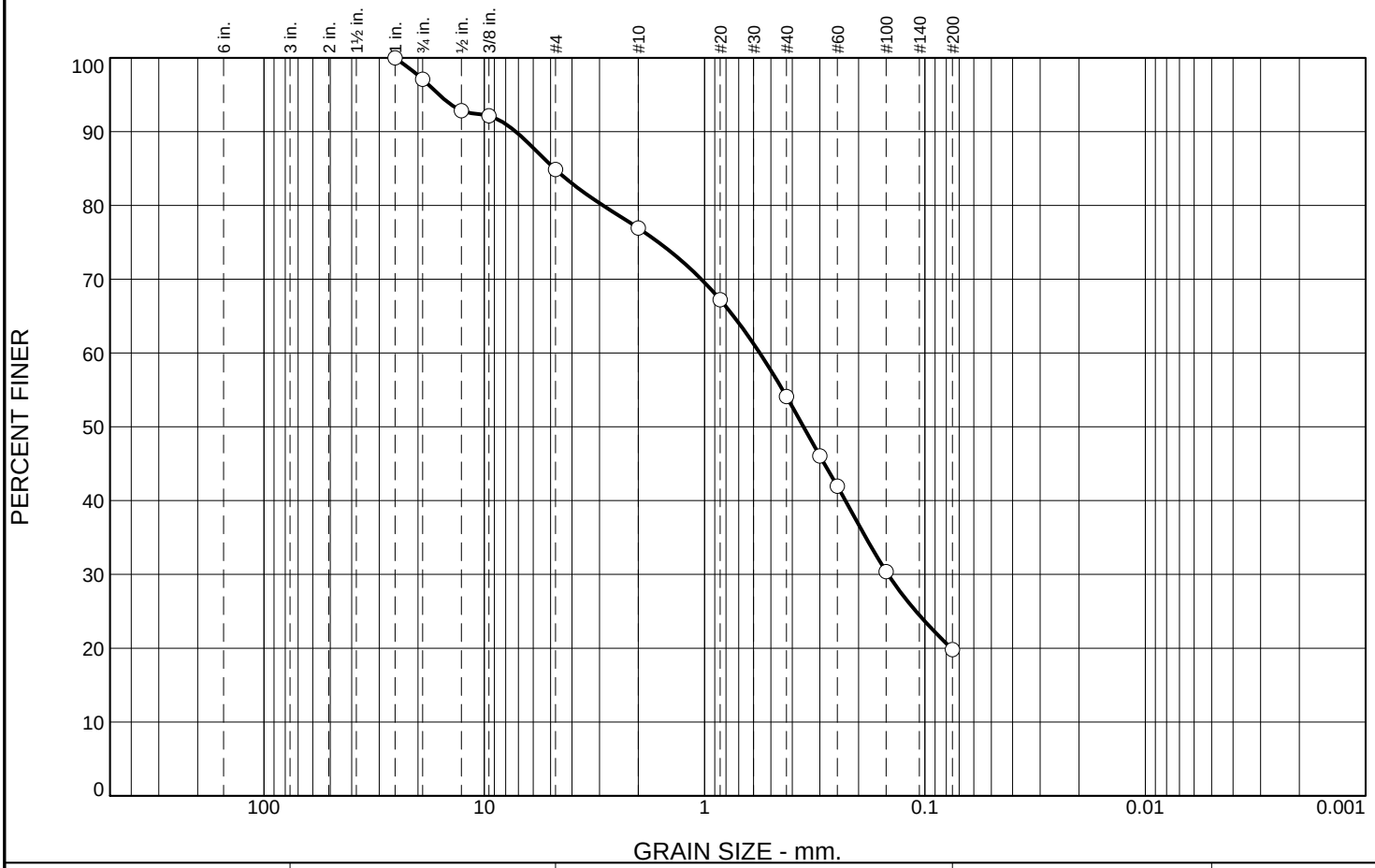
TRACE (TR.)	0 - <10%
LITTLE (LI.)	10 - <20%
SOME (SO.)	20 - <35%
AND	35 - <50%

Density/Consistency

VERY LOOSE	0-4	VERY SOFT	<2
LOOSE	4-10	SOFT	2-4
MEDIUM DENSE	10-30	MEDIUM	4-8
DENSE	30-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	15-30
		HARD	>30

Appendix D
Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	15.1	65.1	19.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	97.1		
1/2"	92.8		
3/8"	92.1		
#4	84.9		
#10	76.9		
#20	67.2		
#40	54.1		
#50	46.1		
#60	42.0		
#100	30.4		
#200	19.8		

* (no specification provided)

Material Description

Dark brown silty sand little gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 4.8020 D_{60}= 0.5618 D_{50}= 0.3557
D_{30}= 0.1471 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Boring jar sample submitted by client on 02/25/19

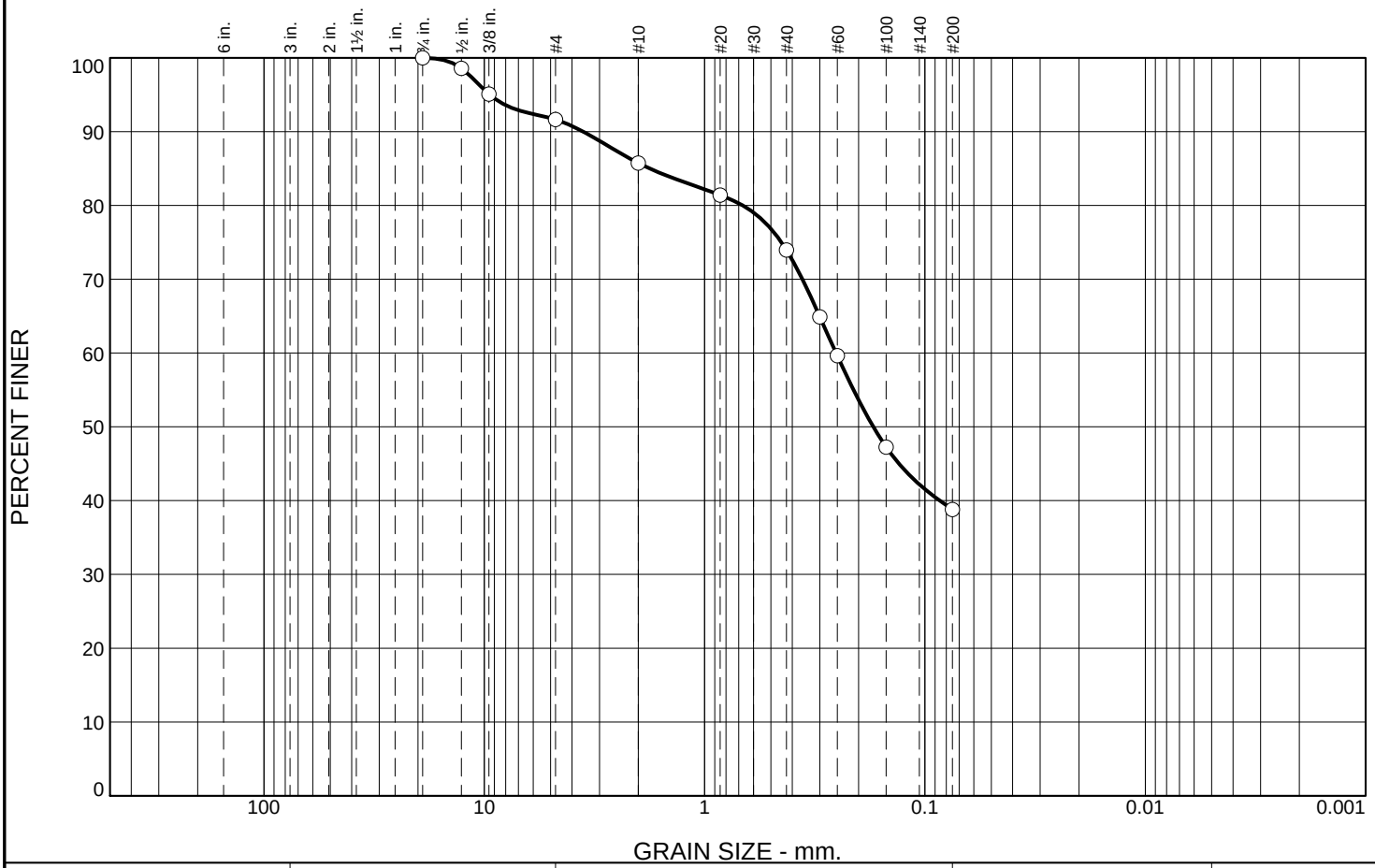
Sample No.: L-26858 **Source of Sample:** McTaggarts Pond Dam - Fitchburg MA **Date:** 02/26/19
Location: B-1 S-2 **Elev./Depth:** 2'- 4'

YANKEE ENGINEERING & TESTING, INC.

Client: Tighe & Bond Consulting Engineers
Project: Tighe & Bond - Various Sites
Worcester MA Office
Project No: 92047A

Tested By: AK/AH **Checked By:** WJP

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	8.4	52.8	38.8	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/4"	100.0		
1/2"	98.6		
3/8"	95.1		
#4	91.6		
#10	85.7		
#20	81.4		
#40	74.0		
#50	64.9		
#60	59.6		
#100	47.3		
#200	38.8		

* (no specification provided)

Material Description

Brown silty sand trace gravel
fines appeared to be non-plastic

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 1.7729 D_{60}= 0.2532 D_{50}= 0.1716
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-4(0)

Remarks

Boring jar sample submitted by client on 02/25/19

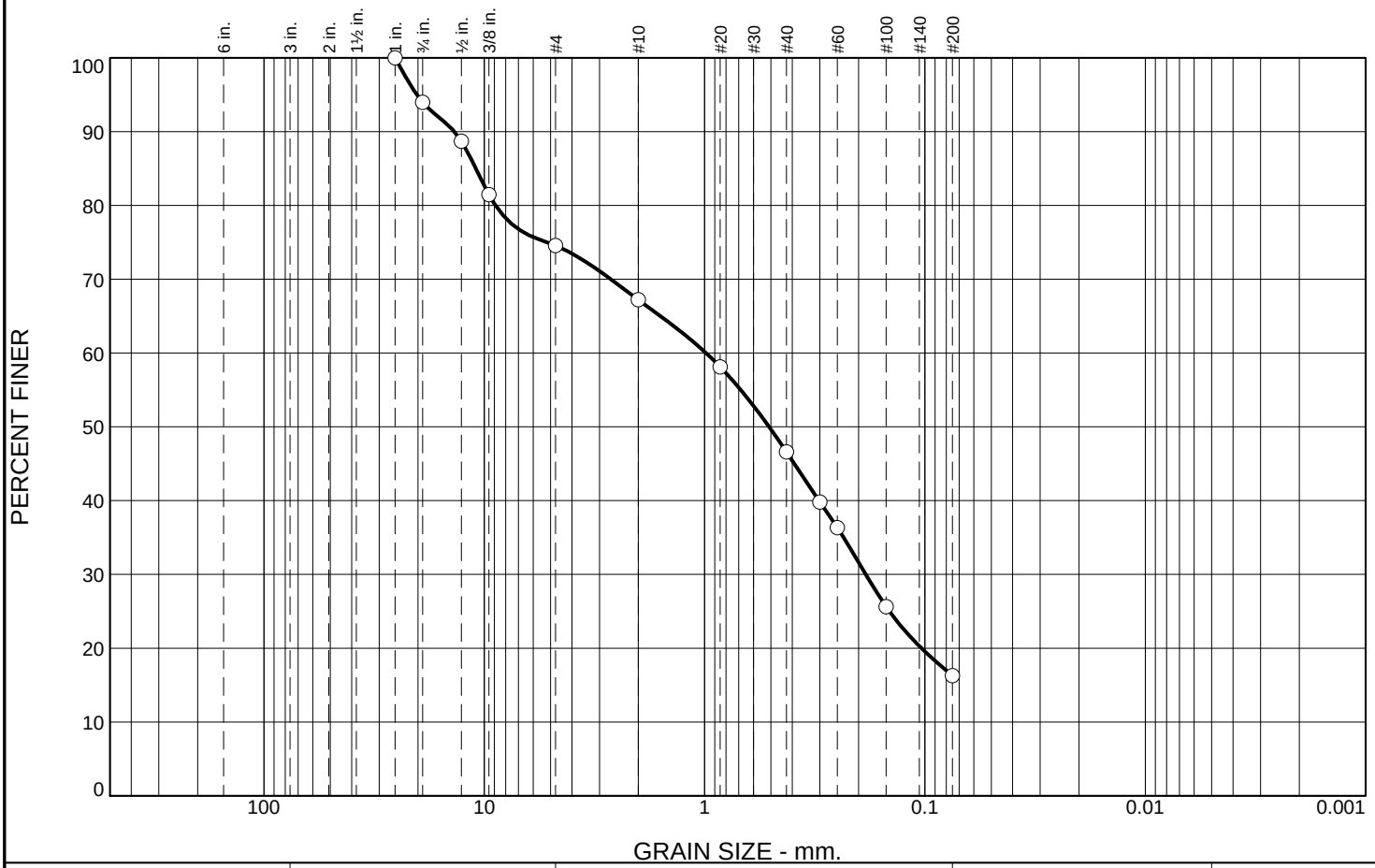
Sample No.: L-26859 **Source of Sample:** McTaggarts Pond Dam - Fitchburg MA **Date:** 02/26/19
Location: B-1 S-5 **Elev./Depth:** 8'- 10'

YANKEE ENGINEERING & TESTING, INC.

Client: Tighe & Bond Consulting Engineers
Project: Tighe & Bond - Various Sites
Worcester MA Office
Project No: 92047A

Tested By: AK/AH **Checked By:** WJP

Particle Size Distribution Report



% +3"	% Gravel	% Sand	% Silt	% Clay
0.0	25.4	58.3	16.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100.0		
3/4"	94.0		
1/2"	88.7		
3/8"	81.5		
#4	74.6		
#10	67.2		
#20	58.1		
#40	46.6		
#50	39.8		
#60	36.3		
#100	25.6		
#200	16.3		

* (no specification provided)

Material Description

Brown silty sand some gravel

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 10.9237 D_{60}= 0.9856 D_{50}= 0.5098
D_{30}= 0.1857 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= SM AASHTO= A-1-b

Remarks

Boring jar sample submitted by client on 02/25/19

Sample No.: L-26860 **Source of Sample:** McTaggarts Pond Dam - Fitchburg MA **Date:** 02/26/19
Location: B-2 S-3 **Elev./Depth:** 4'- 6'

YANKEE ENGINEERING & TESTING, INC.

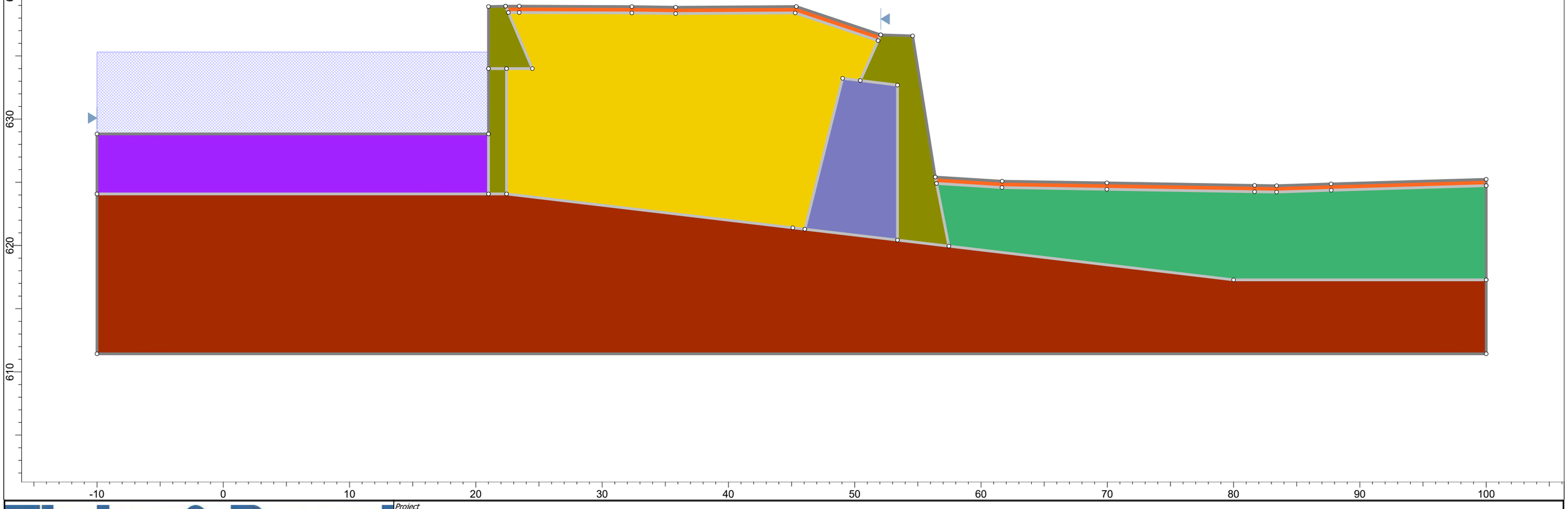
Client: Tighe & Bond Consulting Engineers
Project: Tighe & Bond - Various Sites
Worcester MA Office
Project No: 92047A

Tested By: AK/AH **Checked By:** WJP

Appendix E
Seepage and Stability Analyses Output

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		120	Mohr-Coulomb	0	32
Fill		105	Mohr-Coulomb	0	29
Vegetated Topsoil		105	Mohr-Coulomb	100	28
Stone Masonry		150	Generalized Hoek-Brown		
Concrete		150	Generalized Hoek-Brown		
Bedrock		165	Generalized Hoek-Brown		
Sediment		110	Mohr-Coulomb	0	30

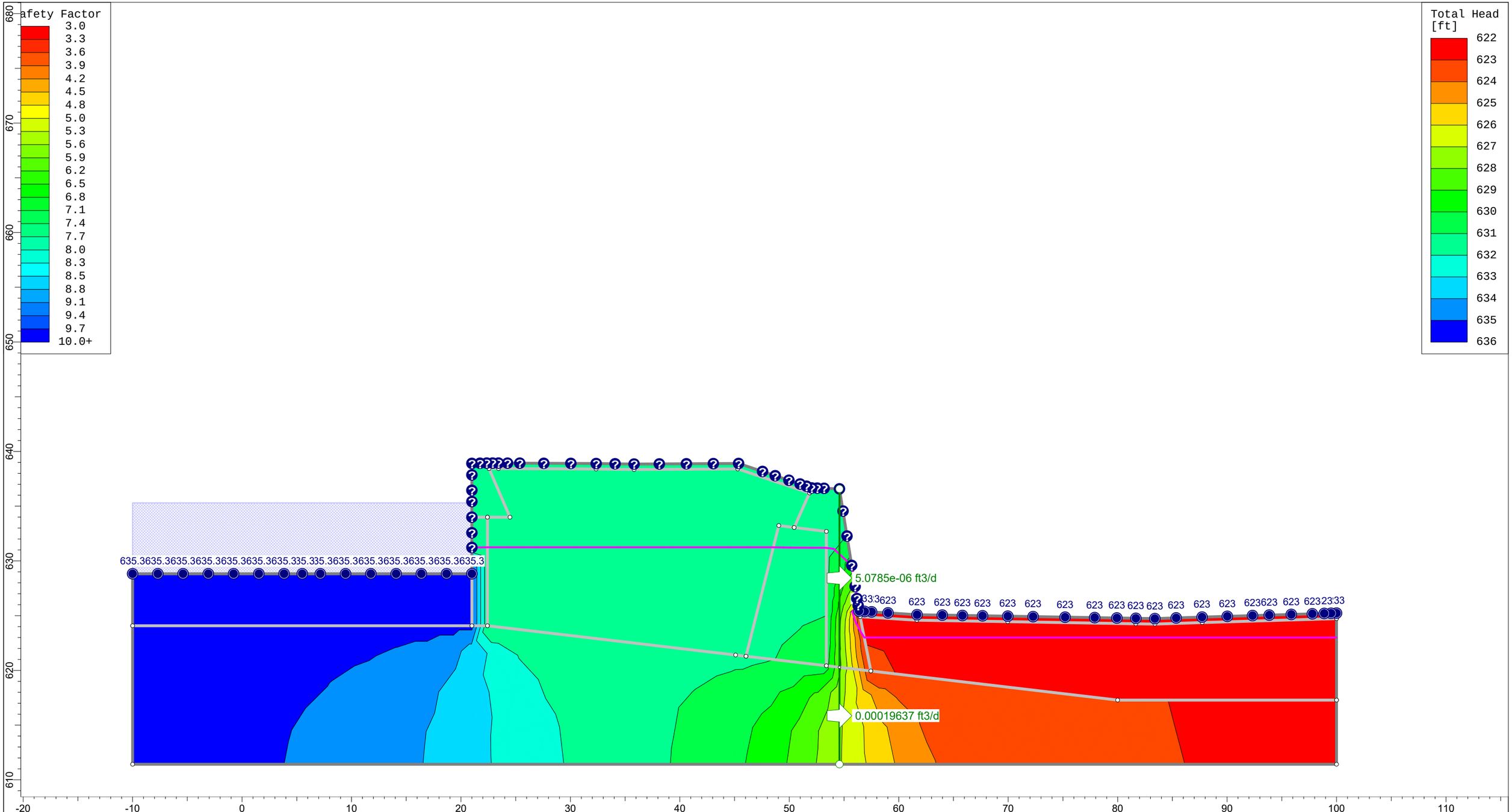
Material Name	Color	KS (cm/s)
Embankment Fill		0.001
Fill		1e-05
Vegetated Topsoil		3e-06
Stone Masonry		1e-07
Concrete		1e-10
Bedrock		1e-08
Sediment		3e-05



Tighe&Bond
Engineers | Environmental Specialists

Project	McTaggarts Pond Dam		
Analysis Description	Upstream - Normal Pool		
Drawn By D. Gnatek	*Scale* 1:90	*Company* Tighe & Bond, Inc.	
Date 2/18/2019, 2:11:28 PM		*File Name* F-0079-047 - Copy.slmd	

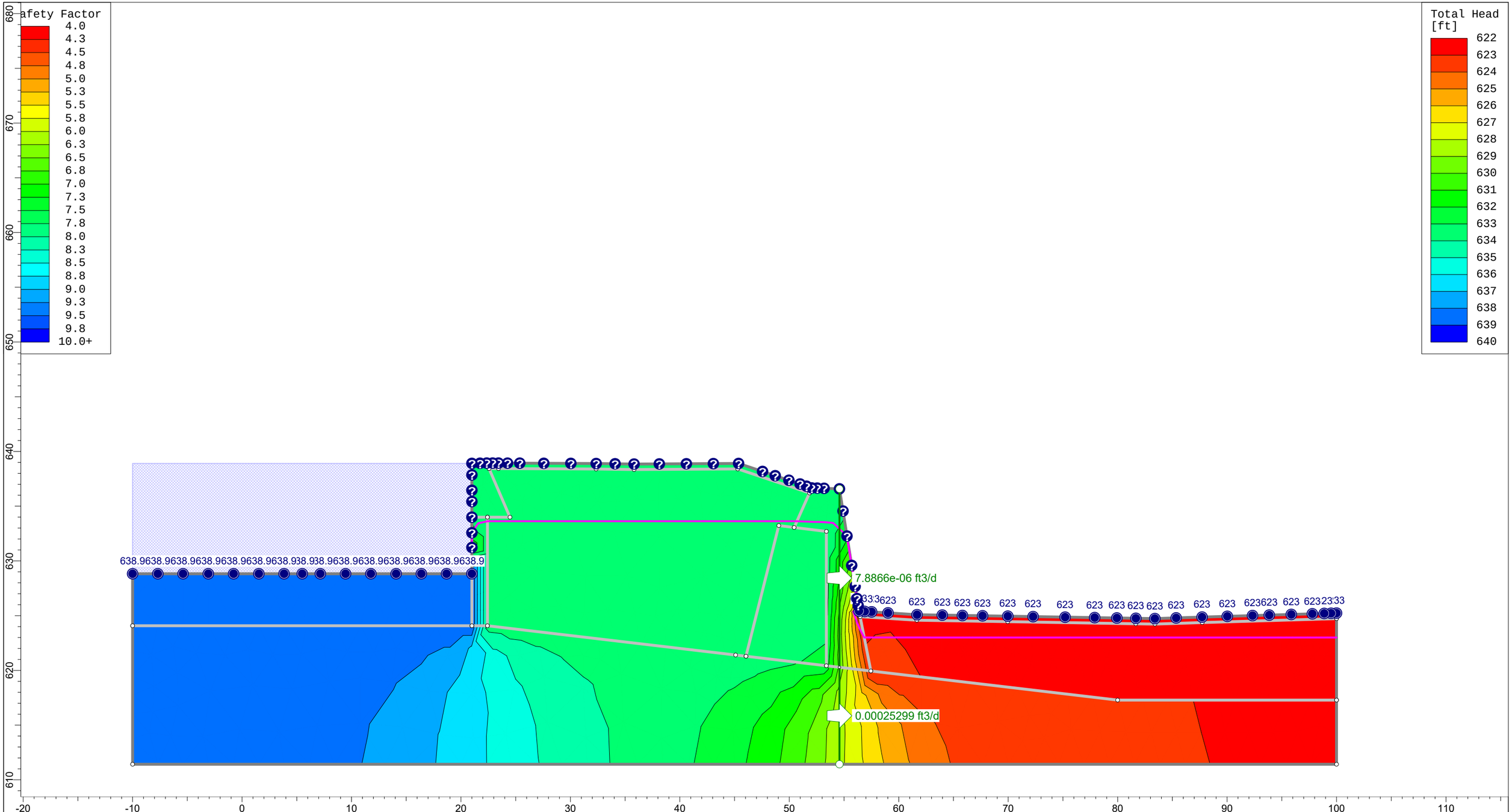
SLIDE 8.016



Tighe&Bond
Engineers | Environmental Specialists

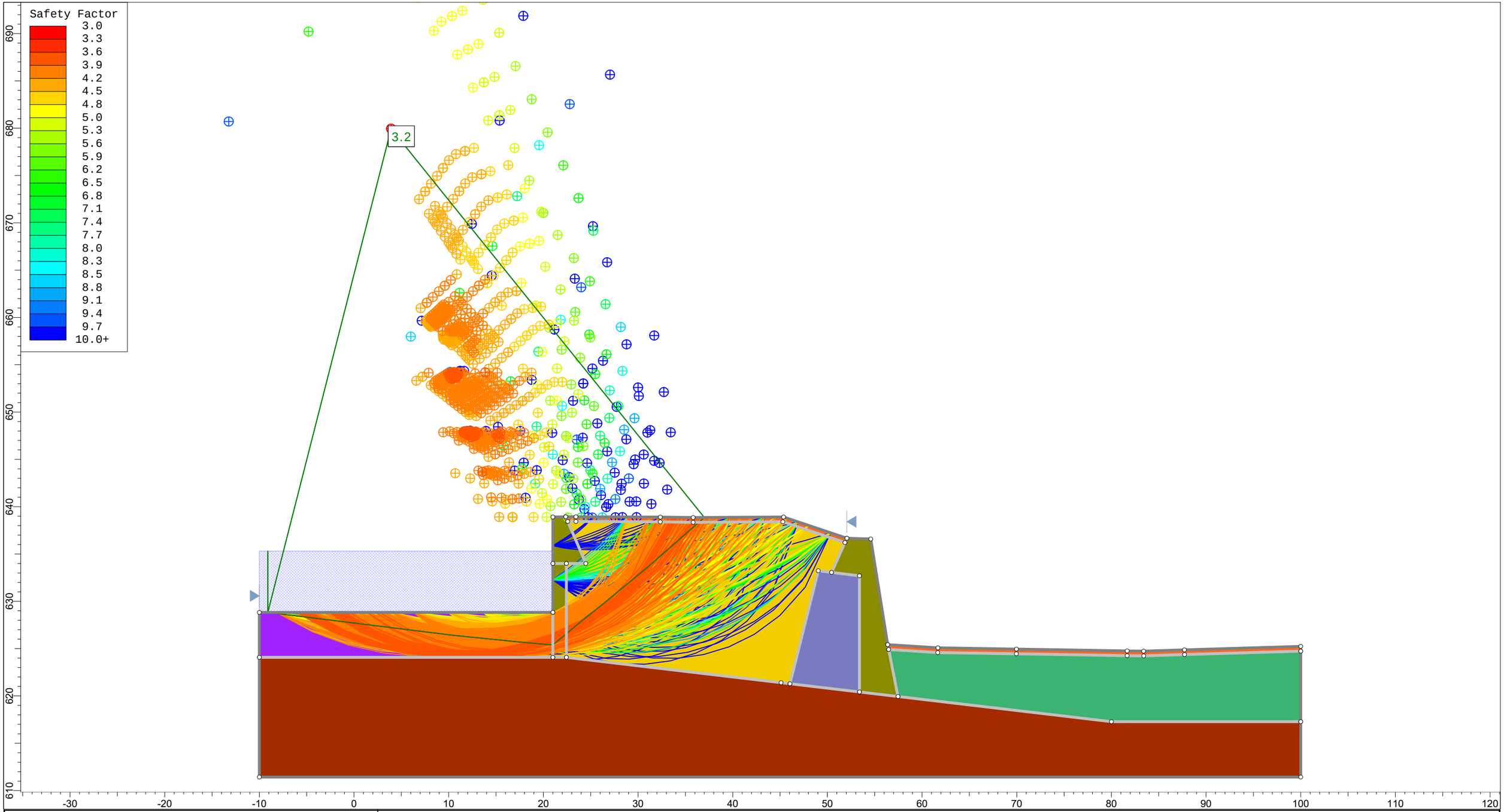
SLIDEINTERPRET 8.018

Project	McTaggarts Pond Dam		
Analysis Description	Upstream - Normal Pool		
Drawn By D. Gnatek	*Scale* 1:100	*Company*	Tighe & Bond, Inc.
Date 2/18/2019, 2:11:28 PM		*File Name*	F-0079-047 - Copy.slmd



Tighe&Bond Engineers | Environmental Specialists	*Project*	McTaggarts Pond Dam		
	Analysis Description	Upstream - Maximum Pool		
	Drawn By	D. Gnatek	*Scale* 1:100	*Company* Tighe & Bond, Inc.
	Date	2/18/2019, 2:11:28 PM		*File Name* F-0079-047 - Copy.slmd

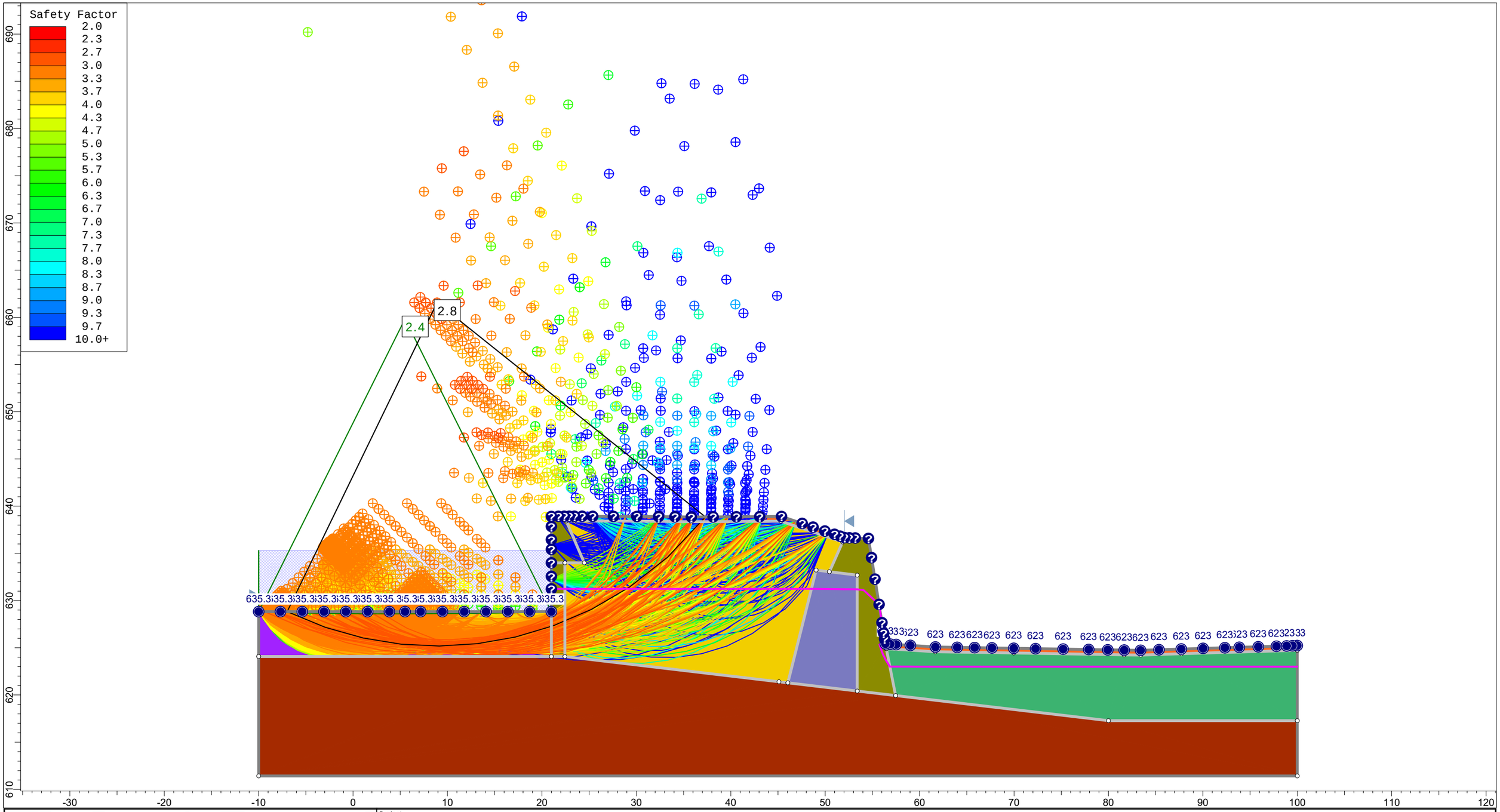
SLIDEINTERPRET 8.018



Tighe&Bond
Engineers | Environmental Specialists

SLIDEINTERPRET 8.018

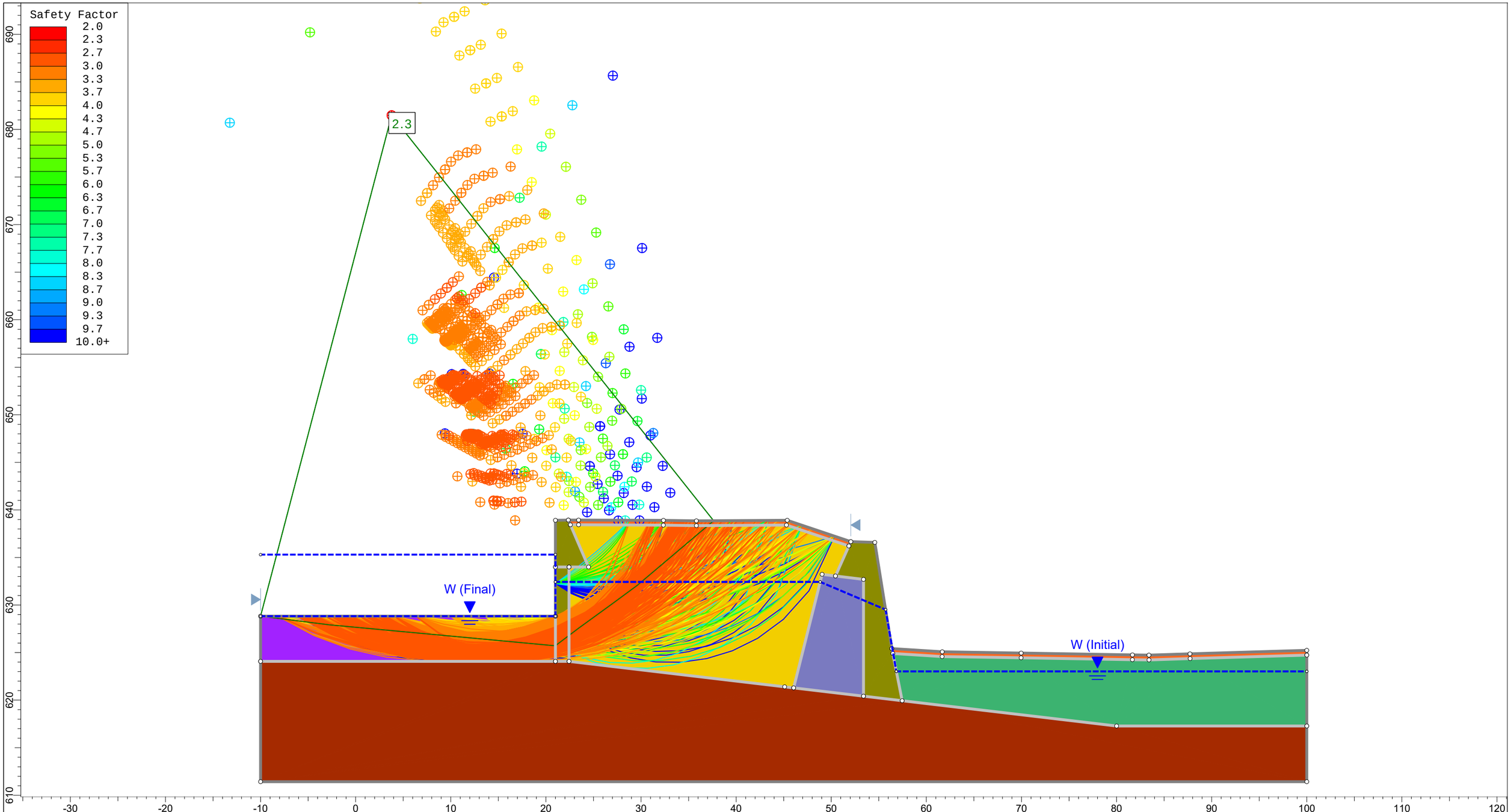
Project	McTaggarts Pond Dam				
Analysis Description	Upstream - Normal Pool				
Drawn By	D. Gnatek	*Scale*	1:115	*Company*	Tighe & Bond, Inc.
Date	2/18/2019, 2:11:28 PM			*File Name*	F-0079-047 - Copy.slmd



Tighe&Bond
Engineers | Environmental Specialists

Project	McTaggarts Pond Dam				
Analysis Description	Upstream - Normal Pool (Seismic)				
Drawn By	D. Gnatek	*Scale*	1:115	*Company*	Tighe & Bond, Inc.
Date	2/18/2019, 2:11:28 PM			*File Name*	F-0079-047 - Copy.slmd

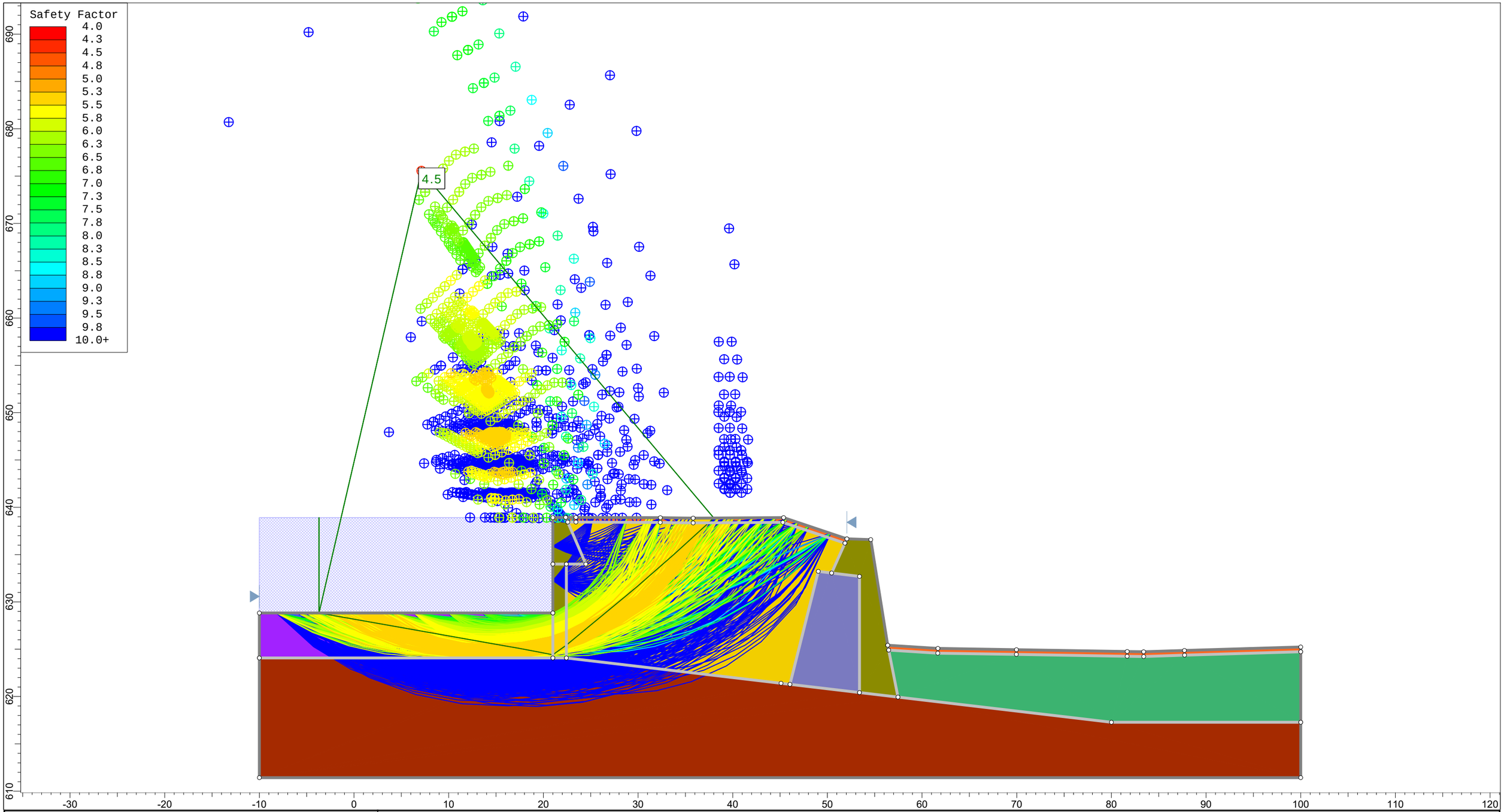
SLIDEINTERPRET 8.018



Tighe&Bond
Engineers | Environmental Specialists

SLIDEINTERPRET 8.018

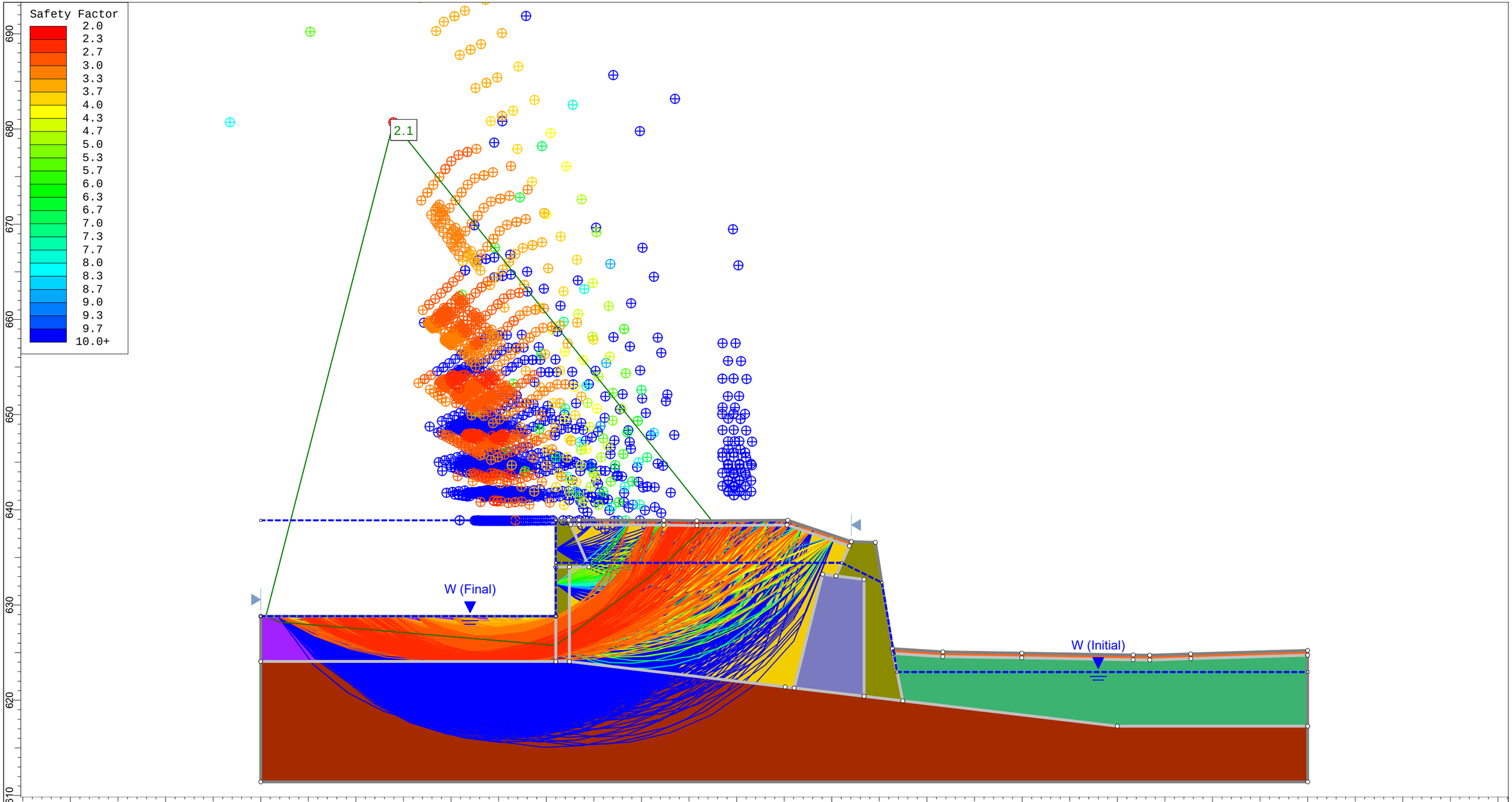
Project	McTaggarts Pond Dam				
Analysis Description	Upstream Normal Pool (Rapid Drawdown)				
Drawn By	D. Gnatek	*Scale*	1:115	*Company*	Tighe & Bond, Inc.
Date	2/18/2019, 2:11:28 PM			*File Name*	F-0079-047 - Copy.slmd



Tighe&Bond
Engineers | Environmental Specialists

Project	McTaggarts Pond Dam				
Analysis Description	Upstream - Maximum Pool				
Drawn By	D. Gnatek	*Scale*	1:115	*Company*	Tighe & Bond, Inc.
Date	2/18/2019, 2:11:28 PM			*File Name*	F-0079-047 - Copy.slmd

SLIDEINTERPRET 8.018

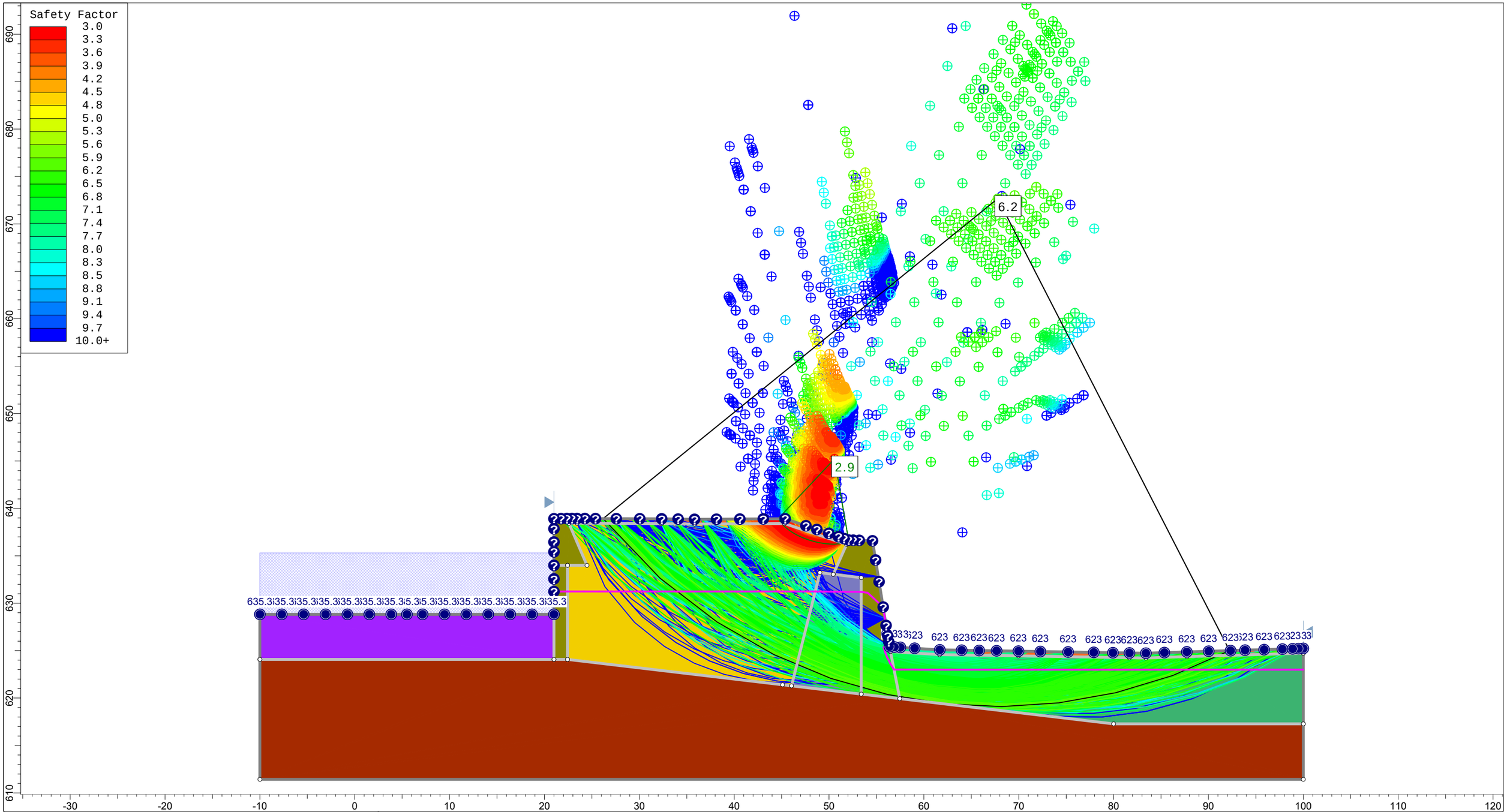


Tighe&Bond

Engineers | Environmental Specialists

SLIDEINTERPRET 8.018

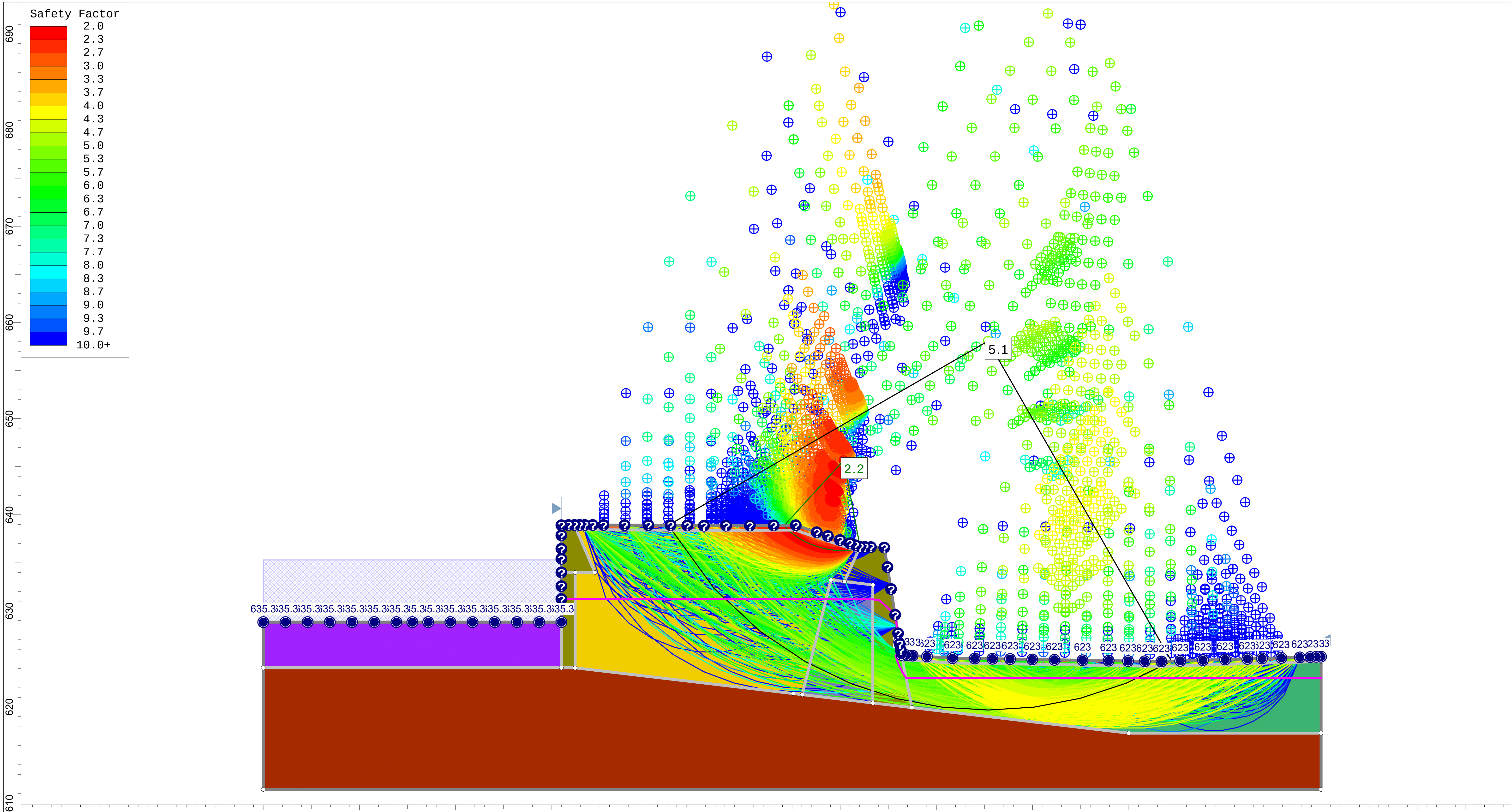
Project	McTaggarts Pond Dam			
Analysis Description	Upstream - Maximum Pool (Rapid Drawdown)			
Drawn By	D. Gnatek	*Scale*	1:115	*Company* Tighe & Bond, Inc.
Date	2/18/2019, 2:11:28 PM			*File Name* F-0079-047 - Copy.slmd



Tighe&Bond
Engineers | Environmental Specialists

SLIDEINTERPRET 8.018

Project	McTaggarts Pond Dam				
Analysis Description	Downstream - Normal Pool				
Drawn By	D. Gnatek	*Scale*	1:115	*Company*	Tighe & Bond, Inc.
Date	2/18/2019, 2:11:28 PM			*File Name*	F-0079-047 - Copy.slmd



Tighe&Bond
Engineers | Environmental Specialists

Project	McTaggarts Pond Dam		
Analysis Description	Downstream - Normal Pool (Seismic)		
Drawn By	D. Gnatek	Scale	1:115
Company	Tighe & Bond, Inc.		
Date	2/18/2019, 2:11:28 PM	File Name	F-0079-047 - Copy.slmd

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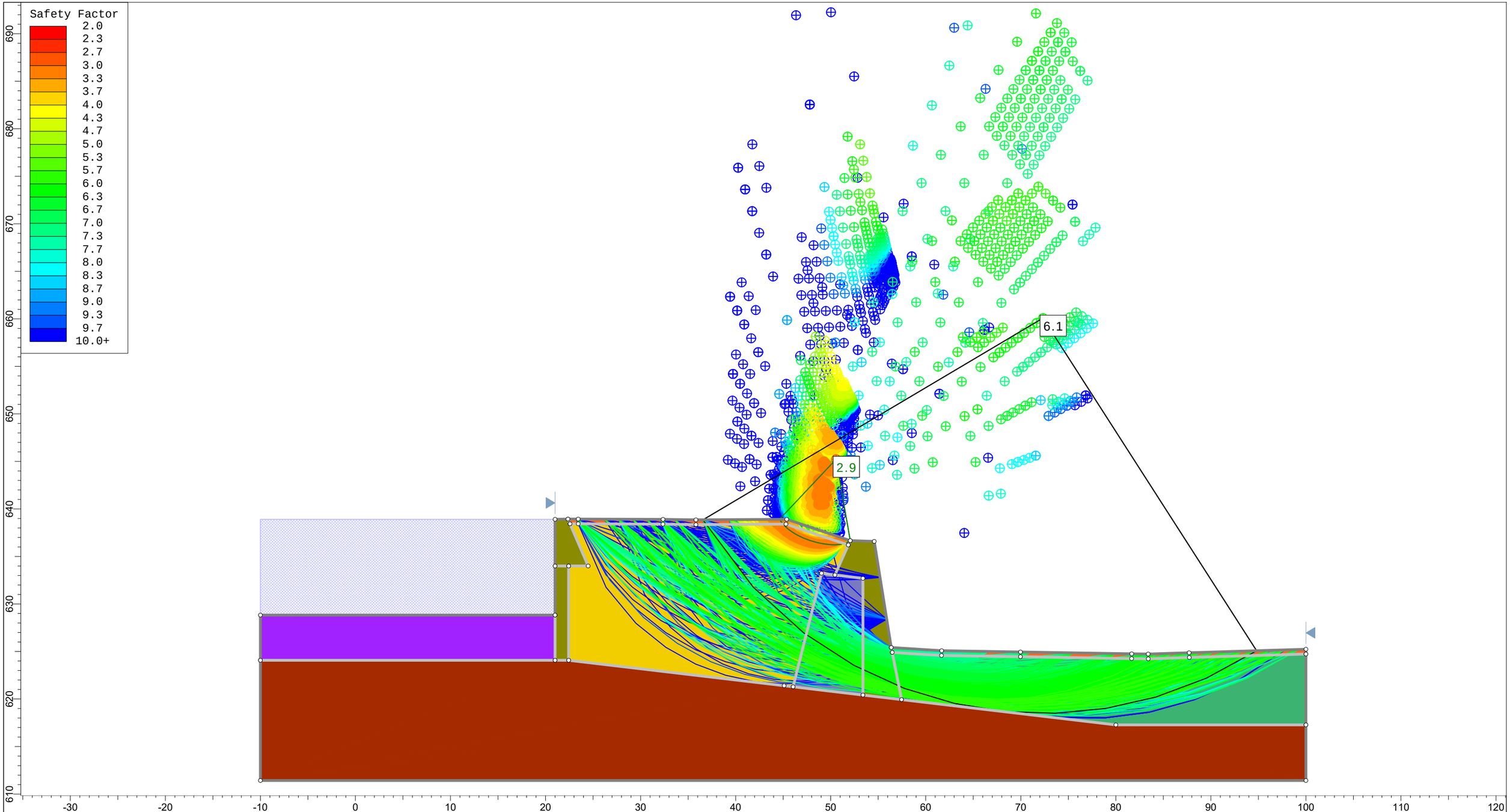


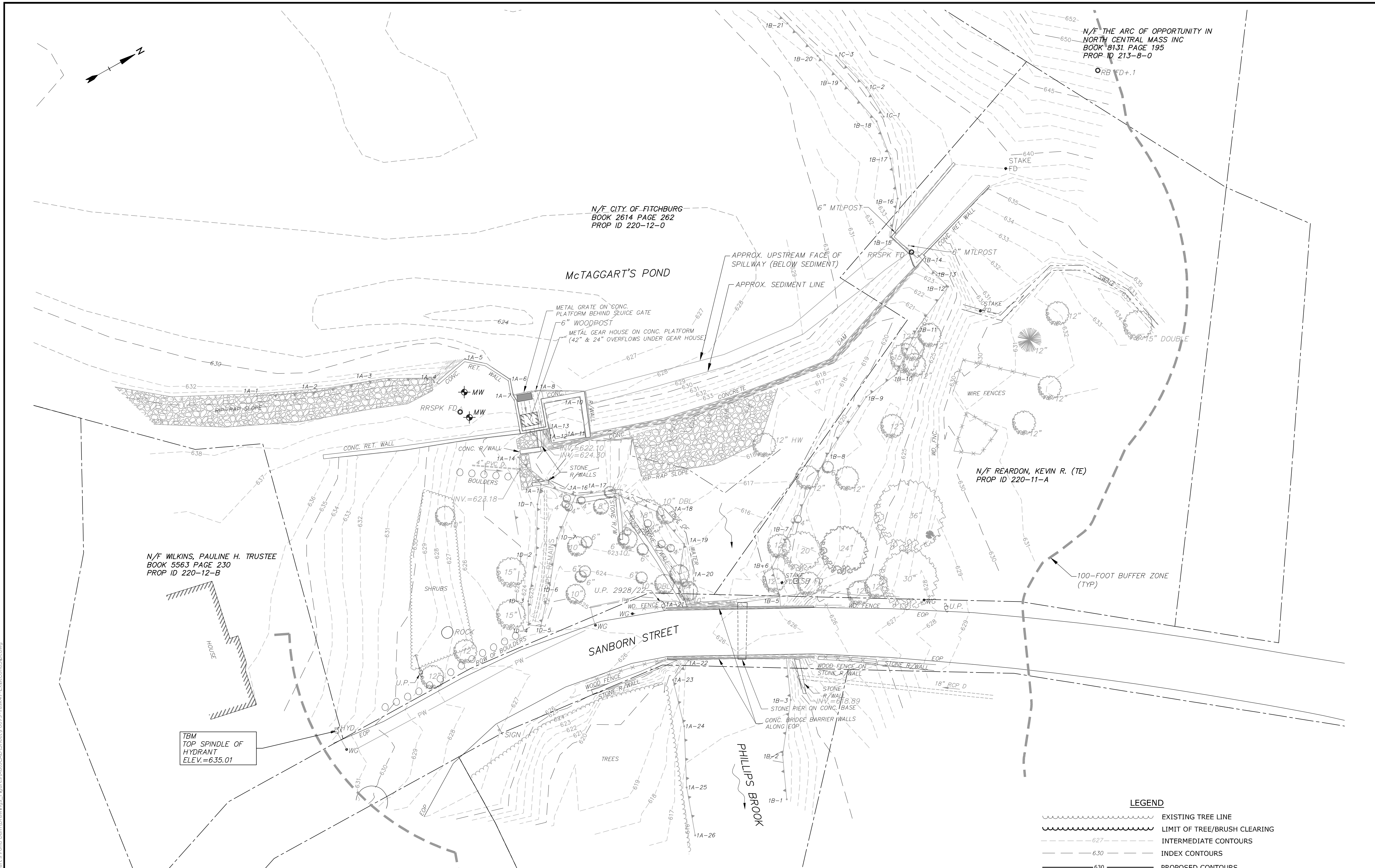
Tighe&Bond

Engineers | Environmental Specialists

SLIDEINTERPRET 8.018

Project	McTaggarts Pond Dam				
Analysis Description	Downstream - Maximum Pool				
Drawn By	D. Gnatek	*Scale*	1:115	*Company*	Tighe & Bond, Inc.
Date	2/18/2019, 2:11:28 PM			*File Name*	F-0079-047 - Copy.slmd

APPENDIX G
Drawings



NOTES:

1. THE EXISTING TOPOGRAPHY WAS TAKEN FROM AN ON THE GROUND SURVEY PLAN TITLED "PLAN OF LAND IN FITCHBURG, MA, PREPARED FOR TIGHE & BOND, INC.", DATED 08/07/19 BY SHERMAN & FRYDRYK, LLC. LAND SURVEYING AND ENGINEERING, 3 CONVERSE STREET, SUITE 203, PALMER, MA.
2. WETLAND RESOURCE AREAS WERE DELINEATED BY TIGHE & BOND, INC. ON 11/08/18.
3. HORIZONTAL DATUM IS NAD83 AND VERTICAL DATUM IS NAVD88. BOTH DATUMS WERE ESTABLISHED AT THE SITE BY GPS METHODS.
4. PROPERTY LINES SHOWN ARE BASED ON MASS GIS/ASSESSORS' DATA AND NOT A RESULT OF THIS SURVEY.
5. ALL PROPOSED WORK IS WITHIN THE 100-FOOT BUFFER ZONE.

LEGEND

- EXISTING TREE LINE
- LIMIT OF TREE/BRUSH CLEARING
- 627 INTERMEDIATE CONTOURS
- 630 INDEX CONTOURS
- 630 PROPOSED CONTOURS
- EXISTING DRAINAGE PIPE
- EXISTING PROPERTY LINE
- 100-FOOT BUFFER ZONE
- IB-4 VEGETATED WETLAND BOUNDARY (BVW) WITH WETLAND FLAG
- TOP OF BANK (OHW)
- EDGE OF WATER
- UTILITY POLE
- SOIL BORING

SCALE IN FEET 0 20' 40'
GRAPHIC SCALE

Tighe&Bond
www.tighebond.com

Conceptual Not For Construction

Department of Public Works

McTaggart's Pond Dam Rehabilitation

Fitchburg, Massachusetts

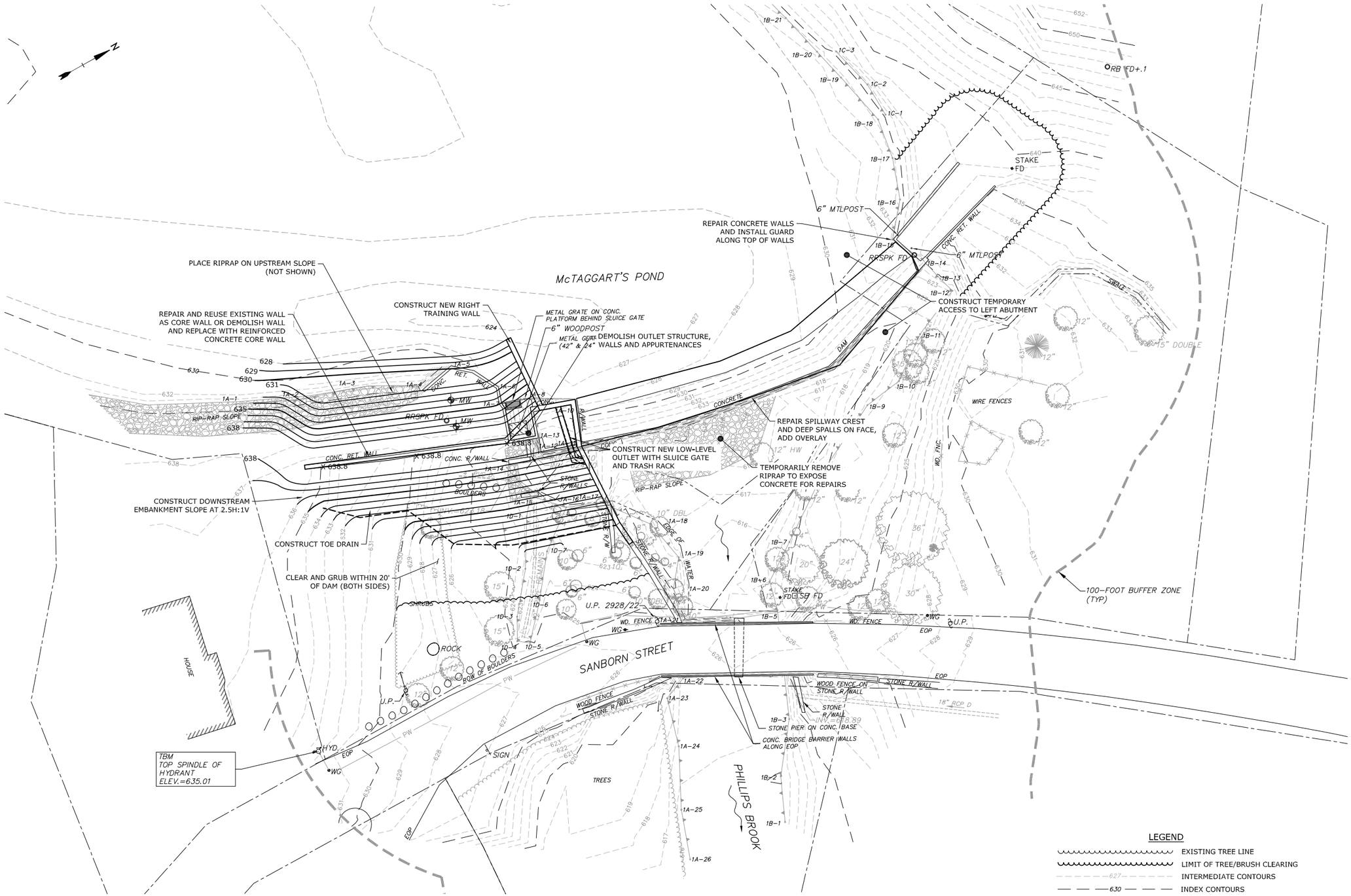
MARK	DATE	DESCRIPTION
0	10/19	Conceptual Review

PROJECT NO:	F0079/047
FILE: F0079-Task47-ExistCondSipl.dwg	
DRAWN BY:	LPT
CHECKED:	DRB
APPROVED:	PMV

EXISTING CONDITIONS SITE PLAN

SCALE: 1"=20'

Appendix G Figure 1



NOTES:

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2. WETLAND RESOURCE AREAS WERE DELINEATED BY TIGHE & BOND, INC. ON 11/08/18.
3. HORIZONTAL DATUM IS NAD83 AND VERTICAL DATUM IS NAVD88. BOTH DATUMS WERE ESTABLISHED AT THE SITE BY GPS METHODS.
4. PROPERTY LINES SHOWN ARE BASED ON MASS GIS/ASSESSORS' DATA AND NOT A RESULT OF THIS SURVEY.
5. ALL PROPOSED WORK IS WITHIN THE 100-FOOT BUFFER ZONE.

LEGEND

- EXISTING TREE LINE
- LIMIT OF TREE/BRUSH CLEARING
- INTERMEDIATE CONTOURS
- INDEX CONTOURS
- PROPOSED CONTOURS
- EXISTING DRAINAGE PIPE
- EXISTING PROPERTY LINE
- 100-FOOT BUFFER ZONE
- VEGETATED WETLAND BOUNDARY (BVW) WITH WETLAND FLAG
- TOP OF BANK (OHW)
- EDGE OF WATER
- UTILITY POLE
- SOIL BORING

SCALE IN FEET
0 20' 40'
GRAPHIC SCALE

Tighe&Bond
www.tighebond.com

Conceptual
Not For
Construction

Department of Public Works

McTaggart's Pond Dam Rehabilitation

Fitchburg, Massachusetts

MARK	DATE	DESCRIPTION
0	10/19	Conceptual Review

PROJECT NO:	F0079/047
FILE:	F0079-Task47-AlternateNo1Sipl.dwg
DRAWN BY:	LPT
CHECKED:	DRB
APPROVED:	PMV

ALTERNATIVE NO. 1 REHABILITATION

SCALE: 1"=20'

Appendix G Figure 2

SEDIMENT PLACEMENT AND STABILIZATION AREA IF ACTIVE SEDIMENT MANAGEMENT IS NEEDED

OVERBANK AREA

LOW-FLOW CHANNEL ALONG ALIGNMENT OF HISTORICAL CHANNEL

STABILIZE IN ACCORDANCE WITH GENERALLY-ACCEPTED STREAM RESTORATION TECHNIQUES IF ACTIVE SEDIMENT MANAGEMENT IS NEEDED

McTAGGART POND

METAL GRATE ON CONC. PLATFORM BEHIND SLUICEGATE

6" WOODPOST

METAL GEAR HOUSE ON CONC. PLATFORM (42" & 24" OVERFLOWS UNDER GEAR HOUSE)

PERFORM MINOR REPAIRS AND PROVIDE FENCING FOR SAFETY

WIDTH OF BREACH = 70'±
BASE ELEV.=619
SIDES SLOPED AT 1:1

RETAIN OUTLET STRUCTURE FOR HISTORICAL PURPOSES. PERFORM MINOR REPAIRS AND PROVIDE FENCING FOR SAFETY

INV.=622.10
INV.=624.30

12" HW

10" DBL

U.P. 2928/25

SANBORN STREET

PHILLIPS BROOK

100-FOOT BUFFER ZONE (TYP)

TBM
TOP SPINDLE OF HYDRANT
ELEV.=635.01

CONC. BRIDGE BARRIER WALLS ALONG EOP

STONE PIER ON CONC. BASE

WIRE FENCES

TREES

SHRUBS

RRSPK FD

STAKE FD

RB FD+.1

NOTES:

1. THE EXISTING TOPOGRAPHY WAS TAKEN FROM AN ON THE GROUND SURVEY PLAN TITLED "PLAN OF LAND IN FITCHBURG, MA, PREPARED FOR TIGHE & BOND, INC.", DATED 08/07/19 BY SHERMAN & FRYDRYK, LLC. LAND SURVEYING AND ENGINEERING, 3 CONVERSE STREET, SUITE 203, PALMER, MA.
2. WETLAND RESOURCE AREAS WERE DELINEATED BY TIGHE & BOND, INC. ON 11/08/18.
3. HORIZONTAL DATUM IS NAD83 AND VERTICAL DATUM IS NAVD88. BOTH DATUMS WERE ESTABLISHED AT THE SITE BY GPS METHODS.
4. PROPERTY LINES SHOWN ARE BASED ON MASS GIS/ASSESSORS' DATA AND NOT A RESULT OF THIS SURVEY.
5. ALL PROPOSED WORK IS WITHIN THE 100-FOOT BUFFER ZONE.

LEGEND

- EXISTING TREE LINE
- LIMIT OF TREE/BRUSH CLEARING
- INTERMEDIATE CONTOURS
- 630 INDEX CONTOURS
- 630 PROPOSED CONTOURS
- EXISTING DRAINAGE PIPE
- EXISTING PROPERTY LINE
- 100-FOOT BUFFER ZONE
- 1B-4 VEGETATED WETLAND BOUNDARY (BVW) WITH WETLAND FLAG
- TOP OF BANK (OHW)
- EDGE OF WATER
- UTILITY POLE
- SOIL BORING

SCALE IN FEET 0 20' 40'
GRAPHIC SCALE

Tighe&Bond
www.tighebond.com

Conceptual
Not For
Construction

Department of Public Works

McTaggart's Pond Dam Rehabilitation

Fitchburg, Massachusetts

MARK	DATE	DESCRIPTION
0	10/19	Conceptual Review

PROJECT NO:	F0079/047
FILE:	F0079-Task47-AlternateNo3ASiPl.dwg
DRAWN BY:	LPT
CHECKED:	CW,DRB
APPROVED:	PMV

ALTERNATIVE NO. 3
PARTIAL REMOVAL

SCALE: 1"=20'

Appendix G Figure 3

LEGEND

- EXISTING TREE LINE
- LIMIT OF TREE/BRUSH CLEARING
- INTERMEDIATE CONTOURS
- INDEX CONTOURS
- PROPOSED CONTOURS
- EXISTING DRAINAGE PIPE
- EXISTING PROPERTY LINE
- 100-FOOT BUFFER ZONE
- VEGETATED WETLAND BOUNDARY (BVW) WITH WETLAND FLAG
- TOP OF BANK (OHW)
- EDGE OF WATER
- UTILITY POLE
- SOIL BORING

SCALE IN FEET 0 20' 40'
GRAPHIC SCALE

NOTES:

1. THE EXISTING TOPOGRAPHY WAS TAKEN FROM AN ON THE GROUND SURVEY PLAN TITLED "PLAN OF LAND IN FITCHBURG, MA, PREPARED FOR TIGHE & BOND, INC.", DATED 08/07/19 BY SHERMAN & FRYDRYK, LLC. LAND SURVEYING AND ENGINEERING, 3 CONVERSE STREET, SUITE 203, PALMER, MA.
2. WETLAND RESOURCE AREAS WERE DELINEATED BY TIGHE & BOND, INC. ON 11/08/18.
3. HORIZONTAL DATUM IS NAD83 AND VERTICAL DATUM IS NAVD88. BOTH DATUMS WERE ESTABLISHED AT THE SITE BY GPS METHODS.
4. PROPERTY LINES SHOWN ARE BASED ON MASS GIS/ASSESSORS' DATA AND NOT A RESULT OF THIS SURVEY.
5. ALL PROPOSED WORK IS WITHIN THE 100-FOOT BUFFER ZONE.

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Conceptual
Not For
Construction

Department of Public Works

McTaggart's Pond Dam Rehabilitation

Fitchburg, Massachusetts

MARK	DATE	DESCRIPTION
0	10/19	Conceptual Review

PROJECT NO:	F0079/047
FILE: F0079-Task47-AlternateNo3BSiPl.dwg	
DRAWN BY:	LPT
CHECKED:	CW,DRB
APPROVED:	PMV

ALTERNATIVE NO. 3
FULL REMOVAL

SCALE: 1"=20'

Appendix G Figure 4

Last Saved: 1/28/2020
Plotted On: Jan 28, 2020-1:25pm By: DRB
Tighe & Bond, Inc. J:\F\F0079 Fitchburg\047 McTaggart's Pond Dam\Drawings_Figures\AutoCAD\Sheet\F0079-Task47-AlternateNo3BSiPl.dwg

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