June 11, 2024

GEOTECHNICAL MEMORANDUM

RE: Tecumseh Dam Spillway Improvements
Lenawee County, Michigan
Project No: 129021SG2020

This memorandum summarizes Spicer Group's geotechnical investigation for the proposed spillway improvement project.

Project Overview:
This project will involve removal and reconstruction of the current auxiliary spillway. The existing auxiliary spillway is located at the northeast end of the dam. It is approximately 40 feet wide at the upstream end and 25 feet wide at the downstream end. It is comprised of a concrete slab with 3- to 10-foot-high sidewall. Sidewalls are constructed of concrete and steel sheet piling. The top of the spillway slab is at about elevation 767 or 768. The dam impounds the Red Mill Pond.

The new spillway is conceived to be about 140 feet long by about 40 feet wide with an 18-inch thick concrete slab and concrete sidewalls up to about 11 feet tall.

Subsurface Investigation:
Subsurface conditions at the site were explored on April 4 and 6 and May 1, 2023 by drilling two rig-drilled borings and two hand auger borings near the spillway. Borings B1 through B3 were drilled by McDowell & Associates under subcontract to Spicer Group. B4 was drilled by Spicer Group.

Rig-drilled borings were dilled using hollow stem auger methods, with samples obtained at 2.5- to 5-foot intervals in accordance with the standard penetration test, in which a 2-inch O.D. split barrel sampler is driven three 6-inch increments by a 140-lb hammer falling 30 inches.

Hand auger borings were drilled by 2.75-inch diameter hand auger equipment in locations not accessible to a drill rig. In select locations, relative density and consistency were determined using a Sowers-type dynamic cone penetrometer, in which a 1.5-inch diameter cone is driven three successive 1.75-inch increments using a 15-lb hammer freely falling 20 inches.

During drilling, soils were visually/manually classified in accordance with the Unified Soil Classification System per ASTM D2487 and D248. Boring logs, are attached, along with boring location maps.

Laboratory testing, including moisture content, calibrated penetrometer, and grain-size analyses, were performed on selected soil samples. The results are attached and used to correlate with engineering properties and filtration requirements.

The ground surface elevation at the boring locations was estimated by plotting their locations on the topographic survey. The approximate elevations are shown below:

Boring	B-1	B-2	B-3	B-4
Elevation	773	776	779	771

Conclusions & Recommendations:
In general, the observed subsurface conditions should not impose any significant impediment to the proposed project. The soils at the site will tend to have moderate strength and moderate compressibility. Permeability, moisture sensitivity, and frost susceptibility will be variable, depending on fines content. Grain-size analysis results indicate that the some of the materials immediately below the bottom of the slab (the sand and gravel layer) are broadly graded, and may tend to be more susceptible to internal erosion.

The soils observed in the borings can be categorized into four general units. The units and their appropriate geotechnical design properties are listed below:

Soil	**Unit Weight** lb/ft^3	**Friction Angle** degrees	**Cohesion** lb/ft^2	**Undrained Shear Strength** lb/ft^2
Existing Fill	120	32	0	0
Sand & Gravel	120	33	0	0
Fine Sand	120	34	0	0
Silty Clay	125	32	400	4000

Retaining Walls & Foundations
Spillway walls will support lateral pressures from the soil and groundwater retained behind them. Earth pressure coefficients can be calculated from the parameters provided above. An underdrain system should be considered to prevent excess unbalanced hydrostatic forces.

We expect foundations for cast-in-place concrete spillway walls will bear in the fine sand unit. This material should provide suitable support with a recommended allowable bearing pressure of 2,000 lb/ft^2 (factor of safety of about 3). Under this loading, total settlement can be expected to be less than about 1/4 inch and differential settlements will be about half of the total.

If sheet piling is used to construct spillway walls, or used as temporary cofferdams during construction, the soil properties given in the table above can be used in their design. The cobbley soil units observed in the borings might make driving sheet piles more difficult; however, we do not expect to be an excessive hindrance (there is existing sheet piling at the site and the borings were able to be advanced and sampled through these soils).

Spillway Slab
We expect a new concrete slab will form the spillway bottom. We expect the subgrade to consist predominantly of medium dense fine sand; however, portions of the subgrade might include the existing fill unit or the sand and gravel material. Care should be taken if the subgrade material is existing fill, as undocumented fill can be highly variable and with unknown placement. The fill and sand and gravel soils observed in the borings at that elevation, however, appear to be capable of providing good support. We suggest placing the slab on a base of open-graded coarse crushed aggregate, such as MDOT 29A to provide uniform support and dissipation of excess hydrostatic pressure. A filter-compatible subbase

should be used under the aggregate, such as MDOT 2NS. A perforated underdrain (without geotextile sock) should be placed within the aggregate course and be extended to a positive outlet.

Earthwork

The on-site soils should be able to be readily excavated using conventional equipment. The on-site soils are variable and have a significant amount of clay and silt, so may prove challenging to adequately compact. Therefore, imported fill should be considered, especially for areas supporting structures or slabs. Imported fill should generally meet the requirements of MDOT Class III granular material.

Prior to placing new fill or concrete, the subgrade should be inspected for topsoil, highly organic soils, debris/rubbish, or excessively soft or loose soils. Where encountered, the unsuitable material should be excavated and replaced with compacted granular soil (such are MDOT Class II or III, or 2NS).

All fill should be conditioned to near its optimum moisture content, placed in thin lifts (generally less than about 8 inches thick, depending on the compaction equipment) and compacted to at least 95% of its maximum dry density, as determined by ASTM D1557 or the MDOT one-point cone method.

Temporary excavations should be appropriately sloped or shored, as determined by the contractor's competent person. Site soils can generally be classified as Type C soils, with maximum temporary slopes of 1.5H:1V.

To prevent internal erosion/piping of soils adjacent to the new spillway walls and/or slab, filtration characteristics of the fill should be considered. The procedure discussed in the NRCS *National Engineering Handbook* Part 633, Chapter 26 is appropriate. Based on the laboratory grain-size analyses performed, the coarser material observed in sample B1D would be adequately filtered by MDOT 6A aggregate. The other samples that were tested would be filtered by MDOT 2NS or ASTM C33 sand. MDOT 29A generally meets filter criteria for 2NS sand. For less critical applications, filtration can be accomplished with a needle-punched nonwoven geotextile meeting MDOT's specification for Geotextile Blanket, with an AOS less than 0.35 mm.

SOILS INVESTIGATION
TECUMSEH SPILLWAY
TECUMSEH, MICHIGAN

SPICER GROUP, INC.
331 BAY STREET
PETOSKEY, MICHIGAN 49770

APRIL 10, 2023
BY
McDOWELL & ASSOCIATES

McDowell & Associates
Geotechnical, Environmental & Hydrogeological Services • Materials Testing & Inspection
21355 Hatcher Avenue • Ferndale, MI 48220
Phone: (248) 399-2066 • Fax: (248) 399-2157
www.mcdowasc.com

April 10, 2023

Spicer Group, Inc.
331 Bay Street
Petoskey, Michigan 49770

Job No. 23-111

Attention: Mr. Nils W. Lindwall

Subject: Soils Investigation
Tecumseh Spillway
Tecumseh, Michigan

Dear Mr. Lindwall:

We welcome this opportunity to offer our services for your project.

In accordance with your request, we performed three (3) borings at the subject project. The borings were drilled at the locations you required and are shown approximately on the attached Soil Boring Location Plan.

Detailed soil descriptions and stratifications for each completed boring are shown on the attached boring logs.

If you have any questions or if we can be further service, please do not hesitate to call.

Very truly yours,

McDOWELL & ASSOCIATES

Tony (Antoine) Merheb, M.S., P.E.
Senior Geotechnical Engineer

TM/

McDOWELL & ASSOCIATES
Geotechnical, Environmental, & Hydrogeologic Services
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LOG OF SOIL BORING NO. 1

PROJECT Soils Investigation
Tecumseh Dam Spillway

LOCATION Evans and Maumee Streets
Tecumseh, Michigan

JOB NO. 23-111

SURFACE ELEV. _____ **DATE** 4/6/2023

Sample & Type	Depth	SOIL DESCRIPTION	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	1	Moist dark brown sandy TOPSOIL with trace of gravel, fill						
		1'0"						
A	2	Very compact moist brown clayey SAND with gravel and trace of brick, fill	7					
SS			12	8.6				
	3		7					
		3'6"						
	4	Compact moist dark brown to black SAND & GRAVEL with brick, stones and asphalt, fill						
		4'6"						
B	5	Very stiff moist brown silty CLAY with sand and trace of pebbles, fill	4					
SS			7	14.4				
	6	5'8"	11			*	(3000)	
	7	COBBLES and stones, possible fill						
C								
SS	8	7'7"						
	9							
D	10		3					
SS		Medium compact wet brown fine to coarse SAND & GRAVEL with trace of silt	3	10.1				
	11		4					
	12							
	13							
	14							
E	15	14'6" Very stiff moist blue silty CLAY with sand and						
SS		15'0" pebbles and occasional stones	2					
	16	Very compact wet brown to gray fine SAND with occasional stone and pebbles and discolored streaks	7	11.7				
	17		10					
		17'6"						
	18							
	19							
F	20		7					
SS		Extremely compact wet brown fine SAND with trace of silt	14	22.6				
	21		21					
	22							
	23							
	24	23'8"						
G		Compact wet gray fine SAND with trace of gravel	4					
SS	25	24'6" Very stiff moist blue silty CLAY with traces of sand and pebbles	9					
			12					

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
R.C. - ROCK CORE
( ) - PENETROMETER

REMARKS: *Calibrated penetrometer

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30": Count Made at 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	7	FT.	7	INS.
G.W. ENCOUNTERED AT	15	FT.	2	INS.
G.W. AFTER COMPLETION	5	FT.	6	INS.
G.W. AFTER HRS.		FT.		INS.
G.W. VOLUMES	Heavy			

McDOWELL & ASSOCIATES
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LOG OF SOIL BORING NO. 1 (continued)

PROJECT Soils Investigation
Tecumseh Dam Spillway

LOCATION Evans and Maumee Streets
Tecumseh, Michigan

JOB NO. 23-111

SURFACE ELEV. _____ **DATE** 4/6/2023

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	26								
			Very stiff moist blue silty CLAY with traces of sand and pebbles						
	27								
	28								
			28'2" COBBLE						
	29		28'11"						
H				34					
SS	30			60					

	31		Extremely stiff moist blue silty CLAY HARDPAN with sand and pebbles						
	32								
	33								
	34								
I				25					
SS	35		35'0"	40					

	36								
	37								
			Note: Used track rig.						
	38								
	39								
	40								
	41								
	42								
	43								
	44								
	45								
	46								
	47								
	48								
	49								
	50								

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
R.C. - ROCK CORE
( ) - PENETROMETER

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30": Count Made at 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	7 FT.	7 INS.
G.W. ENCOUNTERED AT	15 FT.	2 INS.
G.W. AFTER COMPLETION	5 FT.	6 INS.
G.W. AFTER HRS.	FT.	INS.
G.W. VOLUMES	Heavy	

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LOG OF SOIL BORING NO. 2

PROJECT Soils Investigation
Tecumseh Dam Spillway

LOCATION Evans and Maumee Streets
Tecumseh, Michigan

JOB NO. 23-111

SURFACE ELEV. _____ **DATE** 4/4/2023

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
	1		Moist dark brown clayey TOPSOIL, fill						
			1'1"						
			Stiff moist brown sandy CLAY with pebbles,						
A	2		stones and concrete, fill	4					
SS			2'0"	4	10.6				
	3		Medium compact moist brown fine to medium	3					
			SAND with traces of clay, gravel and concrete						
	4		and topsoil seams, fill						
B				4					
SS	5		4'6"	4	14.1				
			Stiff moist brown gravelly CLAY with trace of	5					
	6		concrete, fill						
			6'2"						
C	7		COBBLES and stones, possible fill	8					
SS				8					
	8		7'6"	9					
			Compact moist brown SAND & GRAVEL with						
	9		stones, possible fill						
D				6					
SS	10		9'6" Stiff moist blue sandy CLAY with sand and	6	16.9				
			10'0" pebbles, possible fill	3					
	11								
			Compact wet gray clayey gravelly SAND						
	12								
	13								
			13'0"						
	14								
E				2					
SS	15			5	23.1				
				7					
	16								
			Compact wet brown fine SAND with trace of silt						
	17								
	18								
	19								
			19'6"	2					
F	20		Compact wet gray fine SAND	3					
SS				6					
	21		20'6"						
	22								
			Note: Used track rig.						
	23								
	24								
	25								

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
R.C. - ROCK CORE
( ) - PENETROMETER

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30": Count Made at 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT	9	FT.	0	INS.
G.W. ENCOUNTERED AT		FT.		INS.
G.W. AFTER COMPLETION	8	FT.	0	INS.
G.W. AFTER HRS.		FT.		INS.
G.W. VOLUMES	Heavy			

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LOG OF SOIL BORING NO. 3

PROJECT Soils Investigation
Tecumseh Dam Spillway

LOCATION Evans and Maumee Streets
Tecumseh, Michigan

JOB NO. 23-111

SURFACE ELEV. _____ **DATE** 4/4/2023

Sample & Type	Depth	Legend	SOIL DESCRIPTION	Penetration Blows for 6"	Moisture %	Natural Wt. P.C.F.	Dry Den Wt. P.C.F.	Unc. Comp. Strength PSF.	Str. %
			0'11" Moist dark brown sandy TOPSOIL with gravel, trace of vegetation and occasional stones, fill						
	1								
			Moist brown clayey fine SAND with gravel and stones, fill						
	2		2'2"						
			Moist brown clayey fine SAND with silt, gravel, cobbles and topsoil streaks, fill						
	3		3'0"						
	4								
	5								
	6								
	7								
	8								
	9								
	10								
	11								
	12								
	13								
	14								
	15								
	16								
	17								
	18								
	19								
	20								
	21								
	22								
	23								
	24								
	25								

Notes:

(1) Boring advanced by hand drilling methods.

(2) Four attempts to drill deeper than 3' but too much stones to advance boring. First attempt refusal at 2'4". Second attempt refusal at 2'8". Third attempt refusal at 3'. Fourth attempt refusal at 2'6".

Note: Used track rig.

TYPE OF SAMPLE
D. - DISTURBED
U.L. - UNDIST. LINER
S.T. - SHELBY TUBE
S.S. - SPLIT SPOON
R.C. - ROCK CORE
( ) - PENETROMETER

REMARKS:

Standard Penetration Test - Driving 2" OD Sampler 1' With 140# Hammer Falling 30": Count Made at 6" Intervals

GROUND WATER OBSERVATIONS

G.W. ENCOUNTERED AT FT. None INS.
G.W. ENCOUNTERED AT FT. INS.
G.W. AFTER COMPLETION FT. INS.
G.W. AFTER HRS. FT. INS.
G.W. VOLUMES

Job No. 23-111

SIEVE ANALYSIS SUMMARY

Boring	Sample	% Passing #4 Sieve	% Passing #10 Sieve	% Passing #40 Sieve	% Passing #100 Sieve	% Passing #200 Sieve
1	D	45.0	24.7	8.6	4.7	3.8
	F	100.0	100.0	98.5	9.0	6.3
2	D	75.7	66.4	46.1	33.6	28.9
	E	100.0	100.0	96.2	4.3	3.4

LEGEND

Soil Boring Locations, 1 through 3:
Drilled by McDowell & Associates

McDowell & Associates
21355 Hatcher Avenue
Ferndale, Michigan 48220
Phone: (248) 399-2066
Fax: (248) 399-2157

Soil Boring Location Plan

Job No. 23-111

LOGS OF HAND AUGER BORINGS

Client: Lenawee County Drain Commissioner
Project No: 129021SG2020

Project Name: Tecumseh Dam Spillway
Project Location: Lenawee County, Michigan

4

Location: 6 feet south and 8 feet west of d/s end of concrete traiing wall in area between spillway and river.
Lat: Long: By: NWL
Surface: grass/weeds GW: 4.5 feet during drilling Date: 5/1/2023

Depth	Material Description	Sample	DCPT	Other
0	2 inches Topsoil			
	Orange-brown, fine to coarse, CLAYEY SAND (SC) with gravel - moist - loose			
1				
2			6 6 6	
	Light brown, fine, CLAYEY SAND (SC) - moist - loose			
3	Orange-brown, SANDY CLAY (CL) - moist - loose		3 4 7	PP:0.25-0.75tsf
4				
	becomes wet			
5	Brown, fine, SAND WITH SILT (SP-SM) - saturated - loose		3 3 5	
6	becomes gray			
7	Boring termnated at 7 feet below ground surface. Two other attempts encountered refusal on coarse gravel at 1 to 2 feet.			
8				

August 5, 2024

GEOTECHNICAL MEMORANDUM

RE: Tecumseh Dam Spillway Improvements
Lenawee County, Michigan
Project No: 129021SG2020

This memorandum provides revised recommendations for filter sand and drainstone gradations for the spillway underdrain system.

Filter sand and drainstone gradation requirements were determined using the filter methodology presented in NRCS's National Engineering Handbook, Part 633, Chapter 26: *Gradation Design of Sand and Gravel Filters*. A summary of the calculations is attached. The resulting gradations do not exactly fit common AASHTO or MDOT material specifications, so the materials must be produced by blending multiple materials.

Drainstone

Sieve	Opening	Percent Passing
2-in	50 mm	100
1 ½-in	37.5 mm	90 – 100
¾-in	19 mm	40 – 85
½-in	12.5 mm	10 – 50
3/8-in	9.5 mm	5 – 40
No. 4	4.75 mm	0 – 25
No. 8	2.36 mm	0 – 10
No. 200	0.075 mm	0 – 3

This gradation is very similar to MDOT 6A or 46G.

Filter Sand

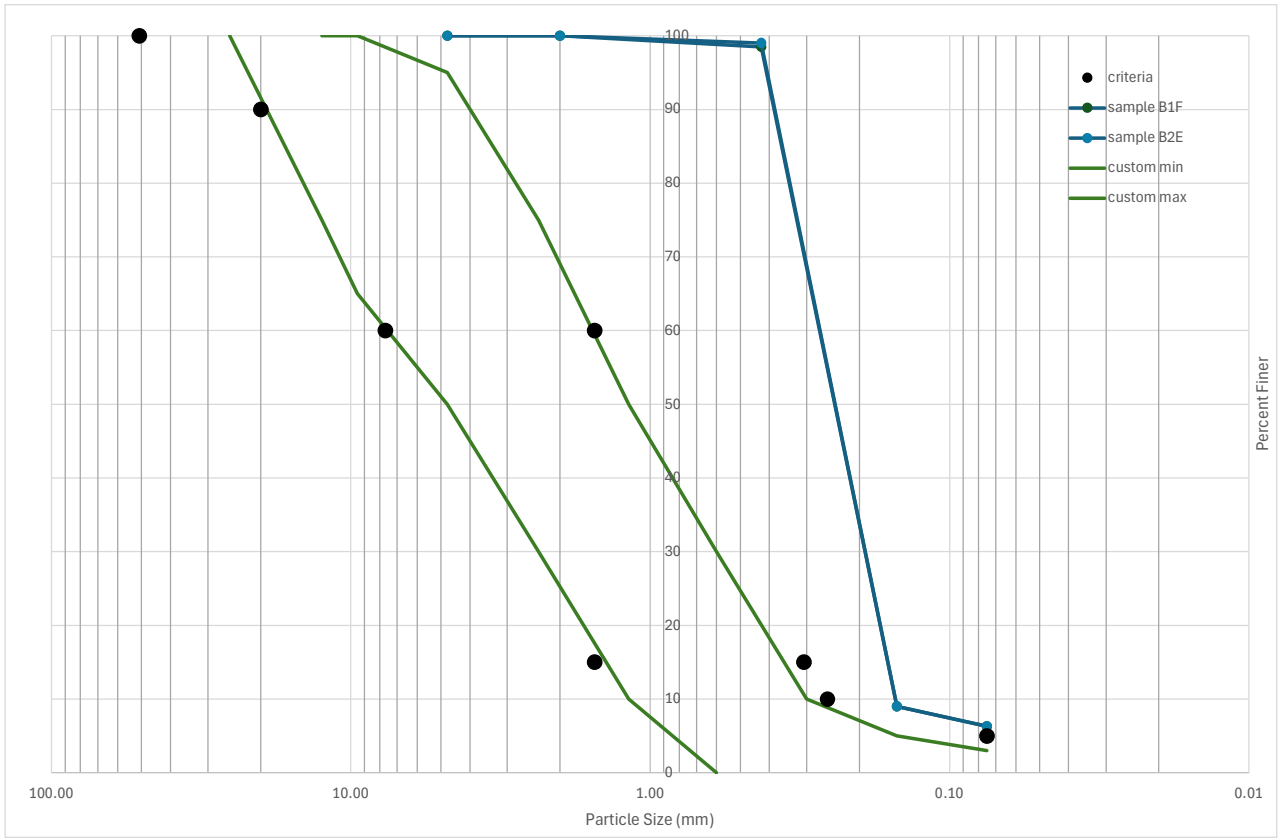
Sieve	Opening	Percent Passing
1-in	25 mm	100
½-in	12.5 mm	75 – 100
3/8-in	9.5 mm	65 – 100
No. 4	4.75 mm	50 – 95
No. 8	2.36 mm	30 – 75
No. 16	1.18 mm	10 – 50
No. 30	0.60 mmm	0 – 30
No. 50	0.30 mm	0 – 10
No. 100	0.15 mm	0 – 5
No. 200	0.075 mm	0 – 3

This gradation is similar to the coarse side of MDOT 2NS.

Aggregates used for sand filter and drainstone should be produced from natural aggregate or ledgestone. Aggregates must be clean, hard, durable, uncoated, and free of clay lumps, organic matter, soft or flakey material, and other foreign matter. Crushed Portland cement concrete or asphaltic concrete should not be used.

Filter Criteria
(in accordance with NRCS Part 633 Soils Engineering, National Engineering Handbook, Chapter 26 Gradation Design of Sand and Gravel Filters)
Tecumseh Dam - Spillway Slab

		Base Soil = B1F		**Base Soil = B2E**	
	Sieve Size (mm)	% Passing	Corrected % Passing	% Passing	Corrected % Passing
No. 4	4.75	100	100.0	100	100.0
No. 10	2	100	100.0	100	100.0
No. 40	0.425	98.5	98.5	99	96.2
No. 100	0.15	9	9.0	9	4.3
No. 200	0.075	6.3	6.3	6.3	3.4



CF =	1.00		1.00	
Category =	4		4	
Filter Gradation				
d85 =	0.38	mm	0.39	mm
Max D15 =	1.53	mm	1.57	mm
Min D15 =	0.31	mm	0.31	mm
Max D60 =	7.67	mm	7.83	mm
Min D60 =	1.53	mm	1.57	mm
Max D100 =	50.80	mm	50.80	mm
Max P200 =	5	percent	5	percent
Min D10 =	0.26	mm	0.26	mm
Min D5 =	0.075	mm	0.075	mm
Max D90 =	20	mm	20	mm

Filter Criteria
(in accordance with NRCS Part 633 Soils Engineering, National Engineering Handbook, Chapter 26 Gradation Design of Sand and Gravel Filters)

Base Soil =Custom Filter (fine side)

	Sieve Size (mm)	% Passing	Corrected % Passing
1"	25	100	100.0
1/2"	12.5	100	100.0
3/8"	9.5	100	100.0
No. 4	4.75	95	95.0
No. 8	2.36	75	75.0
No. 16	1.18	50	50.0
No. 30	0.6	30	30.0
No. 50	0.3	10	10.0
No. 100	0.15	5	5.0
No. 200	0.075	3	3.0

CF =	1.00	
Category =	4	
Filter Gradation		
d85 =	3.56	mm
Max D15 =	14.22	mm
Min D15 =	2.84	mm
Max D60 =	71.10	mm
Min D60 =	14.22	mm
Max D100 =	50.80	mm
Max P200 =	5	percent
Min D10 =	2.37	mm
Min D5 =	0.075	mm
Max D90 =	40	mm