

**2018 ANNUAL GROUNDWATER
MONITORING AND CORRECTIVE
ACTION REPORT
FEDERAL CCR RULE**

**WESTLAND ASH MANAGEMENT FACILITY
CELL B, DICKERSON, MARYLAND**

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1. INTRODUCTION

The Federal Coal Combustion Residuals (CCR) Rule (40 Code of Federal Regulations [CFR] Part 257.90(e)) (USEPA, 2015) requires owners and or operators of existing CCR landfills to prepare a Groundwater Monitoring and Corrective Action Report (Report) no later than 31 January 2019. Geosyntec Consultants (Geosyntec) has prepared this Report for Cell B at the Westland Ash Management Facility in Dickerson, Maryland (Site). This Report summarizes the groundwater monitoring activities conducted pursuant to the CCR Rule through December 31, 2018.

2. SITE DESCRIPTION

2.1 Site Description

The Site is located in Dickerson, Montgomery County, Maryland (**Figure 1**) and is operated by GenOn MD Ash Management LLC (MD Ash). The Site is a dry ash management operation and does not have CCR surface impoundments (SI) as defined in the CCR Rule. The Site encompasses 180 acres of which approximately 64.4 acres have been used to manage CCR at landfill Cell B. Cell C is located downgradient of Cell B and is inactive and therefore not regulated by the Federal CCR Rule. The active area of Cell B was constructed with a geosynthetic bottom liner and associated leachate collection system that directs leachate to Pond 003 located to the west of Cell C. The remaining portion of Cell B is not lined but does include a leachate collection layer constructed using bottom ash. Leachate collected from the unlined areas of Cell B is also directed to Pond 003. Non-contact storm water runoff is directed to Pond 002. Ponds 002 and 003, which are used to manage storm water and leachate (not wet ash), respectively, are also exempt from the Federal CCR Rule. Features of the Site and their locations are presented on **Figure 2**.

2.2 Regional Physiographic Setting

The Site is located in the Culpepper Basin portion of the Piedmont province of Maryland and was previously used for agricultural purposes. Fractured sandstones and siltstones of the Poolesville Member of the Manassas Sandstone (referred to as the New Oxford Formation by others), with interbedded shale layers, form the upper aquifer at the Site. The overlying saprolite soils are unsaturated. Bedrock bedding planes strike north-south and dip 10-20 degrees to the west.

The groundwater table in the upper aquifer generally follows topography and flows along bedding planes toward the west but is locally influenced by Big Stream to the south and flows along bedrock strike. The hydraulic conductivity of the more fractured interbedded thin shale layers is greater than that of the massive sandstones that comprise most of the bedrock stratigraphic sequence. Therefore, CCR constituent migration in groundwater is along the shale horizons. Groundwater monitoring wells are screened in the shale layers.

3. GROUNDWATER MONITORING SYSTEM

This section describes the groundwater monitoring well network for the CCR Rule at Cell B. This network utilizes monitoring wells initially installed as part of a separate site-wide hydrogeologic investigation. As described in the *Basis for Groundwater Monitoring Network* (Geosyntec, 2017a), the groundwater monitoring network around Cell B was designed to comply with 40 CFR 257.91.

Groundwater quality is monitored around Cell B through a network of ten monitoring wells. As shown on **Figure 2**, there are three upgradient monitoring wells (D-2, D-3 and D-4) that are used to measure background conditions and seven downgradient monitoring wells (MW-03, MW-09, MW-10S, MW-12, MW-13, D-6R, and Core-2S) that are used as compliance wells.

Federal CCR Rule compliance and background monitoring wells at the Site are designed to monitor the upper aquifer conditions. Monitoring well construction and soil boring logs were provided in Geosyntec (2017a). Compliance and background monitoring well construction details are summarized in **Table 1**.

4. CCR RULE GROUNDWATER KEY ACTIVITIES COMPLETED – 2018

4.1 Groundwater Monitoring

The Baseline Monitoring Program was completed in September 2017 and the Site transitioned to detection monitoring in October 2017. Assessment monitoring began in February 2018. Groundwater monitoring was conducted in accordance with the *Sampling and Analysis Plan* (SAP) provided in Geosyntec (2015). **Table 2** summarizes the history of baseline, detection, and assessment monitoring events through 2018.

4.1.1 *Detection Monitoring Program*

In October 2017, the first detection monitoring program samples were collected. In accordance with 40 CFR 257.94(a) of the CCR Rule, samples were analyzed for Appendix III list parameters only. Prior to sampling, a synoptic round of groundwater measurements was collected from the compliance and background monitoring wells. Groundwater elevation data are presented in **Table 3**. Groundwater elevation data and analytical results are presented in the *2017 Annual Groundwater Monitoring and Corrective Action Report* (Geosyntec, 2018a).

4.1.2 *Assessment Monitoring Program*

An Assessment Monitoring Program was triggered at the Site in January 2018 when statistically significant increases (SSIs) were detected in the detection monitoring results from the October 2017 groundwater monitoring samples. In February 2018, samples were collected for the full Appendix IV list of constituents for the first semi-annual assessment monitoring program. In accordance with 40 CFR 257.95(a) of the CCR Rule, samples were analyzed for all Appendix III

and IV list parameters. Resampling for the Appendix IV constituents detected in the February 2018 assessment monitoring samples was conducted in May 2018. The second semi-annual assessment monitoring event was completed in August 2018. Prior to sampling, a synoptic round of groundwater measurements was collected from the compliance and background monitoring wells. Groundwater elevation data are presented in Table 3. Analytical data for Appendix III constituents in background and compliance wells are summarized in **Table 4** and **Table 5**, respectively. Analytical data for Appendix IV constituents in background and compliance monitoring wells are summarized in **Table 6** and **Table 7**, respectively. The Site remains in assessment monitoring.

4.1.3 Groundwater Elevation and Flow Velocities

Groundwater elevation monitoring was conducted in February, May, and August 2018. A synoptic round of water level measurements was made at the start of each monitoring event. Groundwater elevation measurements were collected in accordance with the SAP. Potentiometric surface maps based on the elevations measured during the February, May, and August 2018 monitoring events are presented on **Figure 3**, **Figure 4**, and **Figure 5**. Only CCR Rule monitoring wells were gauged during the May 2018 event and therefore **Figure 4** presents the potentiometric surface surrounding Cell B and background locations only. Groundwater elevation data are summarized in **Table 3**. As shown on **Figures 3, 4, and 5** groundwater around Cell B flows from northeast to southwest. The groundwater elevations and flow directions are very stable across the multiple monitoring events.

As shown in **Appendix A** and on **Table A-1** and **Table A-2**, the average hydraulic gradient around Cell B ranged from 0.0451 ft/ft between monitoring wells D-2 and MW-09 to 0.0312 ft/ft between monitoring wells D-2 and MW-3. **Table A-2** shows groundwater flow velocities at the Site ranged from 2.15×10^{-5} centimeters per second (cm/sec) (22.2 inches/month; 22.2 feet/year) between monitoring wells D-2 and MW-3 to 4.45×10^{-6} cm/sec (4.6 inches/month; 4.6 feet/year) between monitoring wells D-2 and MW-13.

4.2 Data Usability

Upon receipt of laboratory analytical reports, the data were evaluated for usability. Analytical data were checked for the following:

- Samples were analyzed within the method specified hold times;
- Samples were received within holding temperature;
- The chain of custody was complete;
- Precision was within SAP control limits using relative percent differences of blind duplicate samples;
- Matrix spike and matrix spike duplicate recoveries and laboratory control samples were within the SAP control limits; and
- Potential for positive bias was evaluated using method blanks concentrations.

Upon completion of the data usability assessment the data were qualified as needed and added to the data tables. All data received were considered complete and usable.

4.3 Statistically Significant Increases Comparison Test

The baseline monitoring data collected from the three background wells (D-2, D-3, and D-4) between 2015 and 2017 were previously used to select statistical methods for calculating the range of background concentrations for Appendix III constituents. These data are discussed and presented in (Geosyntec, 2018a). The resulting background concentrations are summarized in **Table 5** based upon upper prediction limit (UPL) methods.

In January 2018, the calculated background concentrations were compared to the results of the detection monitoring event in October 2017. The comparison of those data to the calculated background concentrations resulted in SSIs over background and triggered the initiation of an Assessment Monitoring Program. Comparison of Appendix III parameters in Cell B compliance wells continued for the May and August 2018 assessment monitoring events and is shown in **Table 5**.

4.4 Statistically Significant Levels Test

The baseline and assessment monitoring data collected from the background wells were used to calculate background concentration limits for detected Appendix IV constituents. Groundwater protection standards (GWPS) were established for each detected Appendix IV constituent as the greater of background or the maximum contaminant level (MCL) (or the EPA Regional Screening Level for cobalt, lead, lithium, and molybdenum that do not have MCLs). The baseline and assessment monitoring data collected from the compliance wells between 2015 and 2018 were used to calculate the 95% lower confidence limit (LCL) of the mean concentration for each well for each Appendix IV constituent that exceeded the GWPS in one or more samples. These data are discussed and presented in Geosyntec (2018a). Those LCL concentrations were then compared to the GWPS for each Appendix IV constituent. The comparison of those LCLs and the GWPS resulted in statistically significant levels (SSLs) on September 4, 2018 and triggered an Assessment of Corrective Measures (ACM).

4.5 Assessment of Corrective Measures

In accordance with 40 CFR 257.96(a), an ACM was initiated at the Site on December 3, 2018, as required by the Federal CCR Rule when SSLs of Appendix IV constituents are detected above their respective GWPS. The Assessment Monitoring Program will continue during the ACM.

5. DETECTION MONITORING STATISTICS

In accordance with 40 CFR 257.94(e), detection monitoring statistics were used to evaluate groundwater concentrations of Appendix III parameters collected during the October 2017,

February 2018, and August 2018 detection monitoring events. SSIs above background groundwater concentrations were detected at six of seven compliance monitoring wells for concentrations of all Appendix III constituents except fluoride.

Table 5 provides a comparison of the Appendix III detection monitoring results to the calculated background concentrations. The calculations are documented and certified by a P.E. as being appropriate for the background data set in Geosyntec (2017b).

6. ASSESSMENT MONITORING STATISTICS

In accordance with 40 CFR 257.95(g) assessment monitoring statistics were used to evaluate if concentrations of Appendix IV constituents in Cell B compliance wells were SSLs above their respective GWPS. Statistical analysis was completed for Appendix IV parameters detected during the February and May assessment monitoring events. **Table 8** summarizes the SSLs of Appendix IV parameters. The data indicate SSLs for lithium, molybdenum, and selenium at five of seven Cell B compliance wells. SSLs for the August 2018 assessment monitoring samples will be calculated in January 2019 and will be discussed and presented in the *2019 Annual Groundwater Monitoring and Corrective Action Report*.

7. PROBLEMS ENCOUNTERED AND RESOLUTIONS

The following section discusses problems encountered and their resolution.

Problem 1: SSIs of Appendix III constituents were detected in samples from Cell B compliance wells.

Resolution 1: An Assessment Monitoring program was established at the Site to monitor concentrations of Appendix III and Appendix IV constituents.

Problem 2: SSLs of Appendix IV constituents were detected in Cell B compliance wells.

Resolution 2: An Assessment of Corrective Measures was initiated.

8. STATUS OF MONITORING PROGRAM

As of 31 December 2018, the Site is undergoing assessment monitoring and an Assessment of Corrective Measures has been initiated to address SSLs of Appendix IV constituents detected in groundwater.

9. PLANNED KEY ACTIVITIES FOR 2019

The following section outlines the activities planned for 2019.

January 2019: Statistical analysis of August 2018 samples for SSIs and SSLs.

February 2019: The 2018 Annual Groundwater Monitoring and Corrective Action Report will be entered into the facility's operating record and notification will be sent to the Maryland Department of Environment (MDE).

February 2019: Collection of semi-annual assessment groundwater monitoring samples.

March 2019: Assessment of Corrective Measures will be completed.

March 2019: The 2018 Annual Groundwater Monitoring and Corrective Action Report will be posted to the public internet site.

May/June 2019: SSI and SSL testing of the February 2019 assessment monitoring samples.

August 2019: Collection of semi-annual assessment groundwater monitoring samples.

December 2019: SSI and SSL testing of the August 2019 assessment monitoring samples.

December 2019: Preparation of the 2019 Annual Groundwater Monitoring and Corrective Action Report will begin.

10. REFERENCES

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Geosyntec Consultants, Inc. 2017b. Statistical Analysis Calculations Package for Background Groundwater - Cell B, Westland Ash Storage Facility, Dickerson, MD.

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TABLES

**TABLE 1
WELL CONSTRUCTION DETAILS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD**

Well ID	Compliance / Background	Permit Number	Installation Date	Northing (feet) Maryland State Plane 1900 NAD 1983	Easting (feet) Maryland State Plane 1900 NAD 1983	Ground Surface Elevation (ft msl)	Top of Casing Elevation (ft msl)	Inner Casing Diameter (inches)	Top of Sand Pack (ft bgs)	Screen Interval (ft bgs)	Screen Length (feet)	Screen Slot Size (inch)
CORE-2S	Compliance	MO-15-0119	6/30/2015	555694.88	1181659.23	298.07	300.82	2	33.0	35-45	10	0.010
D-2	Background	Unknown	6/1981	556397.52	1183798.46	358.37	366.03	4	32.0	110-120	10	0.010
D-3	Background	Unknown	6/1981	555135.30	1183455.78	359.32 [1]	361.82	4	40.0	86-96	10	0.010
D-4	Background	Unknown	6/1981	554151.88	1183976.22	335.41 [1]	337.91	4	Unknown	125-135	10	0.010
D-6R	Compliance	Unknown	6/2002	555014.92	1181455.87	277.90	281.075	4	51.0	55-70	15	Unknown
MW-03	Compliance	MO-15-0078	7/2/2015	556361.94	1182081.25	309.96	312.48	2	48.0	50-60	10	0.010
MW-09	Compliance	MO-15-0084	8/4/2015	555744.29	1181107.48	271.00	273.9	2	58.0	60-70	10	0.010
MW-10S	Compliance	MO-15-0100	6/29/2015	555127.15	1181077.31	268.29	271.03	2	36	38-48	10	0.010
MW-12	Compliance	MO-15-0106	8/6/2015	554978.07	1182086.13	293.26	296.11	2	32.0	34-44	10	0.010
MW-13	Compliance	MO-15-0107	8/7/2015	554733.88	1182475.50	308.02	310.77	2	48.0	50-60	10	0.010

Notes:

ft msl feet above mean sea level

ft bgs feet below ground surface

[1] Elevation is an estimated value

**TABLE 2
SUMMARY OF 2015-2018 MONITORING EVENTS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD**

Monitoring Program: Monitoring Event: Sample Date: Well ID	Baseline Monitoring																				
	3Q 2015			4Q 2015			1Q 2016			2Q 2016			3Q 2016			4Q 2016			1Q 2017		
	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17
Background Wells																					
D-2			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV			III,IV		
D-3			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV			III,IV		
D-4			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV			III,IV		
Compliance Wells																					
CORE-2S			III,IV [1,2]			III,IV [1,2]		III,IV [1,2]		III,IV				III,IV		III,IV			III,IV		
D-6R			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV			III,IV		
MW-03			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV			III,IV		
MW-09			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV			III,IV		
MW-10S			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV			III,IV		
MW-12			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV			III,IV		
MW-13			III,IV			III,IV		III,IV		III,IV				III,IV		III,IV		III,IV	III,IV	III,IV	

Monitoring Program: Monitoring Event: Sample Date: Well ID	Baseline Monitoring						Total Baseline Sampling Events [4]	Detection Monitoring				Total Detection Sampling Events	Assessment Monitoring									Total Assessment Sampling Events
	2Q 2017		3Q 2017			Total Baseline Sampling Events [4]		4Q 2017			Total Detection Sampling Events		1Q 2018		2Q 2018			3Q 2018				
	Apr-17	May-17	Jun-17	Jul-17	Aug-17			Sep-17	Oct-17	Nov-17			Dec-17	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	
Background Wells																						
D-2	III,IV						8	III			1		III,IV			III,IV			III,IV	3		
D-3	III,IV						8	III			1		III,IV			III,IV			III,IV	3		
D-4	III,IV						8	III			1		III,IV			III,IV			III,IV	3		
Compliance Wells																						
CORE-2S	III,IV	III,IV [3]			III,IV [3]	III,IV [3]	11	III			1		III,IV			III,IV			III,IV	3		
D-6R	III,IV						8	III			1		III,IV			III,IV			III,IV	3		
MW-03	III,IV						8	III			1		III,IV			III,IV			III,IV	3		
MW-09	III,IV						8	III			1		III,IV			III,IV			III,IV	3		
MW-10S	III,IV						8	III			1		III,IV			III,IV			III,IV	3		
MW-12	III,IV						8	III			1		III,IV			III,IV			III,IV	3		
MW-13	III,IV						8	III			1		III,IV			III,IV			III,IV	3		

Notes:

- III Groundwater samples collected for laboratory analysis of 40 CFR 257 Appendix III parameters.
- IV Groundwater samples collected for laboratory analysis of 40 CFR 257 Appendix IV parameters.
- [1] Fluoride inadvertently omitted.
- [2] Radium inadvertently omitted.
- [3] Location was sampled for fluoride and radium, only.
- [4] All background and compliance monitoring wells met the minimum number of samples collected. Monitoring well Core-2S was sampled on 11 different sampling events, which resulted in 8 complete sample sets.

**TABLE 3
GROUNDWATER ELEVATION MEASUREMENTS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD**

Well ID	Top of Casing Elevation [1] (ft msl)	Depth to Water Measurement Date	Depth to Water (ft btoic)	Groundwater Elevation (ft msl)
CORE-2S	300.82	2/5/2018	15.89	284.93
		5/4/2018	13.73	287.09
		8/7/2018	12.78	288.04
D-2	366.03	2/5/2018	18.42	347.61
		5/3/2018	14.35	351.68
		8/7/2018	6.72	359.31
D-3	361.82	2/5/2018	49.35	312.47
		5/3/2018	46.13	315.69
		8/7/2018	43.95	317.87
D-4	337.91	2/5/2018	26.03	311.88
		5/3/2018	23.93	313.98
		8/7/2018	22.22	315.69
D-6R	281.08	2/5/2018	29.27	251.81
		5/3/2018	29.21	251.87
		8/7/2018	24.73	256.35
MW-03	312.48	2/5/2018	8.33	304.15
		5/3/2018	7.09	305.39
		8/7/2018	6.60	305.88
MW-09	273.90	2/5/2018	40.33	233.57
		5/3/2018	40.11	233.79
		8/7/2018	39.66	234.24
MW-10S	271.03	2/5/2018	30.54	240.49
		5/3/2018	29.00	242.03
		8/7/2018	27.94	243.09
MW-12	296.11	2/5/2018	24.46	271.65
		5/3/2018	23.43	272.68
		8/7/2018	22.42	273.69
MW-13	310.77	2/5/2018	30.84	279.93
		5/3/2018	30.92	279.85
		8/7/2018	30.49	280.28

Notes:

ft msl feet above mean sea level
ft btoic feet below top of inner case

MONITORING PROGRAM APPENDIX III ANALYTICAL DATA - BACKGROUND WELLS

FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD

Analyte:		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Well ID	Sample Date	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
D-2	2/6/2018	<10.1 U	36.6	12.1	<0.25 U	7.7	16.7	189
	5/3/2018	<10.1 U	39.4	11.3	<0.25 U	7.8	16.9	207
	8/8/2018	<12 U	39.5	14.1	<0.25 U	8.0	15.3	174
D-3	2/6/2018	<10.1 U	47.4	15.0	<0.25 U	7.9	23.6	241
	5/4/2018	<10.1 U	54.4	17.5	<0.25 U	8.1	24.9	241
	8/8/2018	<12 U	51.7	14.0	<0.25 U	8.1	22.9	262
D-4	2/6/2018	27.7 J	NS	9.7	<0.25 U	7.4	15.3	221
	5/4/2018	27.1 J	52.9	12.0	<0.25 U	8.2	15.9	239
	8/9/2018	<12 U	51.0	10.5	<0.25 U	8.3	16.1	192

Notes:

µg/L micrograms per Liter

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

NS Not Sampled

N.D. The sample result is non-detect.

TABLE 5
MONITORING PROGRAM APPENDIX III ANALYTICAL DATA - COMPLIANCE WELLS

FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD

Analyte:		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
UPL [1]		25	53.4	17.5	[2]	7.02 - 8.45	25.4	325
Well ID	Sample Date	µg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L
Core-2S	10/26/2017	317	199	181	<0.25 U	7.6	228	1,030
	2/14/2018	421	228	206	<0.25 U	7.6	232	1,040
	5/4/2018	371	234	195	<0.25 U	8.0	227	1,140
	8/8/2018	242	198	182	<0.25 U	7.9	202	728
D-6R	10/27/2017	5,180	676	338	<0.25	7.3	1,330	2,860
	2/6/2018	5,410	657	309	<0.25 U	7.4	1,330	2,280
	5/3/2018	5,650	648	288	<0.25 U	7.3	1,170	2,730
	8/10/2018	5,490	733	280	<0.25 U	7.6	1,250	2,230
MW-03	10/26/2017	10,700	494	362	<0.25 U	6.7	1,330	2,640
	2/13/2018	9,750	463	264	<0.25 U	7.1	1,301	2,700
	5/4/2018	9,980	460	209	<0.25 U	7.0	1,130	2,380
	8/13/2018	8,510	341	165	<0.25 U	7.6	980	1,460
MW-09	10/26/2017	2,580	276	95	<0.25 U	7.4	505	1,410
	2/14/2018	2,660	289	92.9	<0.25 U	7.5	244	1,220
	5/3/2018	2,760	292	85.5	<0.25 U	7.8	475	1,280
	8/9/2018	2,680	287	91.4	<0.25 U	7.6	498	1,050
MW-10S	10/26/2017	311	353	86.5	<0.25 U	7.3	608	1,290
	2/14/2018	331	351	81.4	<0.25 U	7.4	587	1,260
	5/3/2018 [3]	310	334	54.9	<0.25 U	7.7	409	1,190
	8/10/2018	305	327	66.9	<0.25 U	7.7	516	1,240
MW-12	10/26/2017	1,990	371	101	<0.25 U	6.7	991	1,990
	2/14/2018	8,050	378	107	<0.25 U	6.8	912	1,810
	5/4/2018	6,280	386	90.2	<0.25 U	7.0	885	1,850
	8/13/2018	5,450	323	67.3	<0.25 U	7.6	716	1,410
MW-13	10/30/2017	<10.1 U	44.5	11.0	<0.25 U	7.4	24.9	256
	2/13/2018	<10.1 U	49.6	12.6	<0.25 U	8.0	31.4	371
	5/4/2018	21.3 J	50.7	11.3	<0.25 U	8.1	30.8	225
	8/13/2018	<12 U	48.4	11.5	<0.25 U	8.2	27.9	221

Notes:

Concentration is a statistically significant increase (SSI) over the background concentration

UPL Upper prediction limit

µg/L micrograms per Liter

mg/L milligrams per Liter

S.U. Standard Units

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

[1] Subject to change as additional data are generated. Calculations provided in Statistical Analysis Calculations Package for Background Groundwater – Cell B, Westland Ash Storage Facility, Dickerson, MD (Geosyntec, 2017).

[2] The Double Quantification Rule (DQR) is used for background data sets with no detections.

[3] Duplicate sample collected.

**TABLE 6
MONITORING PROGRAM APPENDIX IV ANALYTICAL DATA - BACKGROUND WELLS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD**

Analyte:		Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt [1]	Fluoride	Lead
Well ID	Sample Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L
D-2	2/14/2018	<0.45 U	0.84 J	329	<0.071 U	<0.15 U	<0.87 U	<1.7 U	<0.25 U	0.34 J
	5/3/2018	<0.45 U	<0.72 U	356	<0.071 U	<0.15 U	0.88 J	NS	<0.25 U	1.1
	8/8/2018	<0.41 U	<0.68 U	360	<0.091 U	<0.15 U	<0.70 U	<1.5 U	<0.25 U	<1.1 U
D-3	2/6/2018	<0.45 U	0.74 J	86.1	<0.071 U	<0.15 U	<0.87 U	<1.7 U	<0.25 U	1.1
	5/4/2018	0.46 J	<0.72 U	93	<0.071 U	<0.15 U	<0.87 U	NS	<0.25 U	0.95 J
	8/8/2018	<0.41 U	<0.68 U	95	<0.091 U	<0.15 U	0.78 J	<1.5 U	<0.25 U	<1.1 U
D-4	2/6/2018	<0.45 U	<0.72 U	401	<0.071 U	<0.15 U	<0.87 U	<1.7 U	<0.25 U	0.13 J
	5/4/2018 [4]	<0.45 U	<0.72 U	428	<0.071 U	<0.15 U	1.3 J	NS	<0.25 U	1.8
	8/9/2018	<0.41 U	<0.68 U	468	<0.091 U	<0.15 U	0.92 J	<1.5 U	<0.25 U	<1.1 U

Notes:

µg/L micrograms per Liter

mg/L milligrams per Liter

pCi/L picocurie per Liter

NS Not Sampled

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

[1] Appendix IV constituents not detected in the initial Assessment Monitoring conducted in February 2018 were not analyzed in the May 2018 resampling event.

[2] Radium values shown are the 'result' reported by lab, including non-detects shown with '<'.

[3] The sum of Radium-226 + Radium-228 uses one-half the reporting limit (data not shown) for non-detect (<) values.

[4] Duplicate sample collected

**TABLE 6
MONITORING PROGRAM APPENDIX IV ANALYTICAL DATA - BACKGROUND WELLS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD**

Analyte:		Lithium	Mercury	Molybdenum	Selenium	Thallium [1]	Radium-226 [2]	Radium-228 [2]	Radium (226+228) [3]
Well ID	Sample Date	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	pCi/L	pCi/L
D-2	2/14/2018	<9.0 U	<0.05 U	<3.4 U	<0.50 U	<0.12 U	<0.184 U	<0.0905 U	<2.0 U
	5/3/2018	<9.0 U	<0.05 U	<3.4 U	<0.50 U	<0.12 U	1.23	<0.908 U	2.73 J
	8/8/2018	<11.0 U	<0.05 U	<2.0 U	<0.65 U	<0.12 U	3.08	<0.537 U	4.58 J
D-3	2/6/2018	11 J	<0.05 U	<3.4 U	<0.50 U	<0.12 U	<0.137 U	<0.96 U	<2.0 U
	5/4/2018	<9.0 U	<0.05 U	<3.4 U	<0.50 U	NS U	0.217	<-0.0388 U	1.72 J
	8/8/2018	<11.0 U	<0.05 U	<2.0 U	<0.65 U	<0.12 U	<0.284 U	<0.541 U	<2.0 U
D-4	2/6/2018	<9.0 U	<0.05 U	<3.4 U	<0.50 U	<0.12 U	<0.271 U	<-0.143 U	<2.0 U
	5/4/2018 [4]	<9.0 U	<0.05 U	<3.4 U	<0.50 U	NS U	1.11	<0.844 U	2.61 J
	8/9/2018	<11.0 U	<0.05 U	<2.0 U	<0.65 U	<0.11 U	2.7	<1.75 U	4.2 J

Notes:

µg/L micrograms per Liter

mg/L milligrams per Liter

pCi/L picocurie per Liter

NS Not Sampled

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

[1] Appendix IV constituents not detected in the initial Assessment Monitoring conducted in February 2018 were not analyzed in the May 2018 resampling event.

[2] Radium values shown are the 'result' reported by lab, including non-detects shown with '<'.

[3] The sum of Radium-226 + Radium-228 uses one-half the reporting limit (data not shown) for non-detect (<) values.

[4] Duplicate sample collected

**TABLE 7
MONITORING PROGRAM APPENDIX IV ANALYTICAL DATA - COMPLIANCE WELLS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD**

Analyte:		Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Fluoride	Lead
Well ID	Sample Date	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L
Core-2S	2/14/2018	<0.45 U	<0.72 U	61.4	0.074 J	<0.15 U	1.2 J	<1.70 U	<0.25 U	0.19 J
	5/4/2018	<0.45 U	0.9 J	88.7	<0.091 U	<0.15 U	1.6 J	NS	<0.25 U	0.63 J
	8/8/2018	<0.41 U	<0.68 U	76.8	<0.071 U	<0.15 U	<0.70 U	<1.50 U	<0.25 U	<1.10 U
D-6R	2/6/2018	<0.45 U	1.3 J	26.5	<0.071 U	<0.15 U	<0.87 U	<1.7 U	<0.25 U	<0.11 U
	5/3/2018	0.86 J	<0.72 U	28.6	<0.071 U	<0.15 U	<0.87 U	NS	<0.25 U	<0.11 U
	8/10/2018	1.1 J	<0.68 U	26.6	<0.091 U	<0.15 U	<0.70 U	<1.50 U	<0.25 U	<1.10 U
MW-03	2/13/2018	0.94 J	2.0 J	68.6	0.25 J	0.28 J	10.1	<1.7 U	<0.25 U	1.8
	5/3/2018 [1]	0.62 J	0.88 J	42.3	<0.071 U	0.33 J	4.2	NS	<0.25 U	0.28 J
	8/13/2018	<0.41 U	0.98 J	38.2	<0.091 U	<0.15 U	3.2 J	<1.5 U	<0.25 U	<1.1 U
MW-09	2/14/2018	1.9	<0.72 U	48	<0.071 U	<0.15 U	1.4 J	<1.7 U	<0.25 U	0.27 J
	5/3/2018	2.0	<0.72 U	42.4	<0.071 U	<0.15 U	1.1 J	NS	<0.25 U	0.16 J
	8/9/2018	1.1 J	<0.68 U	64	<0.091 U	<0.15 U	1.0 J	<1.5 U	<0.25 U	<1.1 U
MW-10S	2/14/2018	<0.45 U	0.81 J	67.4	<0.071 U	<0.15 U	2.2	<1.7 U	<0.25 U	<0.11 U
	5/3/2018 [1]	<0.45 U	<0.72 U	81.8	<0.071 U	<0.15 U	1.6 J	NS	<0.25 U	<0.11 U
	8/10/2018	<0.41 U	<0.68 U	87.9	<0.091 U	<0.15 U	1.5 J	<1.5 U	<0.25 U	<1.10 U
MW-12	2/14/2018	0.47 J	<0.72 U	45	0.11 J	0.16 J	8.6	<1.7 U	<0.25 U	0.17 J
	5/4/2018	0.48 J	<0.72 U	43.8	<0.071 U	0.21 J	8.4	NS	<0.25 U	<0.11 U
	8/13/2018	0.48 J	<0.68 U	51.8	<0.091 U	<0.15 U	8.1	<1.5 U	<0.25 U	<1.10 U
MW-13	2/13/2018	<0.45 U	<0.72 U	54.1	<0.071 U	<0.15 U	0.93 J	<1.7 U	<0.25 U	<0.11 U
	5/4/2018	<0.45 U	<0.72 U	50.3	<0.071 U	<0.15 U	<0.87 U	NS	<0.25 U	<0.11 U
	8/13/2018	<0.41 U	<0.68 U	56.9	<0.091 U	<0.15 U	<0.70 U	<1.5 U	<0.25 U	<1.10 U

Notes:

µg/L micrograms per Liter

mg/L milligrams per Liter

pCi/L picocurie per Liter

NS Not Sampled

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

[1] Duplicate sample collected

[2] Radium values shown are the 'result' reported by lab, including non-detects shown with '<'.

[3] The sum of Radium-226 + Radium-228 uses one-half the reporting limit (data not shown) for non-detect (<) values.

**TABLE 7
MONITORING PROGRAM APPENDIX IV ANALYTICAL DATA - COMPLIANCE WELLS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD**

Analyte:		Lithium	Mercury	Molybdenum	Selenium	Thallium	Radium-226 [2]	Radium-228 [2]	Radium (226+228) [3]
Well ID	Sample Date	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	pCi/L	pCi/L
Core-2S	2/14/2018	16.4 J	<0.05 U	<3.4 U	48.5	<0.12 U	<0.0263 U	<0.221 U	<2.0 U
	5/4/2018	30.7	NS	<3.4 U	52.8	NS	7.47	<0.218 U	9.47
	8/8/2018	<11.0 U	<0.05 U	2.7 J	47.9	<0.11 U	<1.20 U	<0.243 U	<2.0 U
D-6R	2/6/2018	863	0.13 J	38.5	81.3	<0.12 U	<0.204 U	<0.419 U	<2.0 U
	5/3/2018	841	0.09 J	43.7	103	<0.12 U	1.01	<1.31 U	2.51 J
	8/10/2018	927	0.39	43.8	96.5	<0.11 U	NS	NS	NS
MW-03	2/13/2018	145	1.3	1,030	36.7	<0.12 U	2.98	<0.372 U	4.48 J
	5/3/2018 [1]	198	NS	1,290	41.3	NS	7.65	<0.487 U	9.15
	8/13/2018	134	0.46	1,550	32.8	<0.11 U	5.96	<0.281 U	7.46
MW-09	2/14/2018	18.8 J	<0.05 U	4.1 J	82.7	<0.12 U	<0.0758 U	<0.80 U	<2.0 U
	5/3/2018	<9.0 U	NS	<3.4 U	90.6	NS	1.07	<0.0144 U	2.57 J
	8/9/2018	<11.0 U	<0.05 U	5.2 J	81.2	<0.11 U	<0.296 U	<0.147 U	<2.0 U
MW-10S	2/14/2018	21.7	<0.05 U	<3.4 U	207	<0.12 U	0.455	<0.613 U	1.95 J
	5/3/2018 [1]	<9.0 U	NS	<3.4 U	241	NS	8.12	<-0.352 U	9.62
	8/10/2018	15.9 J	0.08 J	<2.0 U	223	<0.11 U	3.65	<-0.0279 U	5.15
MW-12	2/14/2018	206	0.47	748	267	<0.12 U	<0.299 U	<-0.154 U	<2.0 U
	5/4/2018	256	NS	814	303	NS	7.56	<0.234 U	9.06
	8/13/2018	238	0.2	824	297	<0.11 U	6.62	<0.415 U	8.12
MW-13	2/13/2018	<9.0 U	<0.05 U	<3.4 U	1.1 J	<0.12 U	3.52	<0.183 U	5.02
	5/4/2018	<9.0 U	NS	<3.4 U	1.8 J	NS	9.2	<-0.0897 U	10.7
	8/13/2018	<11.0 U	<0.05 U	<2.0 U	1.3 J	<0.11 U	5.53	<1.38 U	7.03

Notes:

µg/L micrograms per Liter

mg/L milligrams per Liter

pCi/L picocurie per Liter

NS Not Sampled

J Constituent detected below reportable quantitation limit; result is an estimated value.

U Constituent not detected above method detection limit.

[1] Duplicate sample collected

[2] Radium values shown are the 'result' reported by lab, including non-detects shown with '<'.



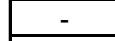
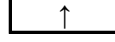



[3] The sum of Radium-226 + Radium-228 uses one-half the reporting limit (data not shown) for non-detect (<) values.

**TABLE 8
STATISTICALLY SIGNIFICANT LEVELS - APPENDIX IV CONSTITUENTS**

**FEDERAL CCR RULE - 2018 ANNUAL GROUNDWATER AND CORRECTIVE ACTION REPORT
Westland Facility Cell B - MD**

WELL ID	Antimony		Arsenic		Chromium		Lead		Lithium		Molybdenum		Radium 226, 228 Combined		Selenium	
	GWPS = 6 µg/L		GWPS = 10 µg/L		GWPS = 100 µg/L		GWPS = 15 µg/L		GWPS = 40 µg/L		GWPS = 100 µg/L		GWPS = 5 pCi/L		GWPS = 50 µg/L	
	LCL	Trend	LCL	Trend	LCL	Trend	LCL	Trend	LCL	Trend	LCL	Trend	LCL	Trend	LCL	Trend
CORE-2S																
D-6R									●	↑					●	-
MW-03									●	-	●	↑				
MW-09															●	↑
MW-10S															●	↑
MW-12									●	-	●	-			●	-
MW-13																

Notes:

-  Not evaluated because no SSI for the constituent in this well.
-  LCL does not exceed GWPS.
-  - Constituent does not have a significant trend in this monitoring well (based on Mann Kendall Trend Analysis).
-  ↑ Increasing trend for the constituent in this monitoring well (based on Mann Kendall Trend Analysis).
- SSL: LCL increase over GWPS
-  ● LCL is greater than GWPS by 1 to 2 times
-  ● LCL is greater than GWPS by >2 to 10 times
-  ● LCL is greater than GWPS by >10 times

µg/L micrograms per Liter

pCi/L picoCurie per Liter

SSL Statistically Significant Level

SSI Statistically Significant Increase

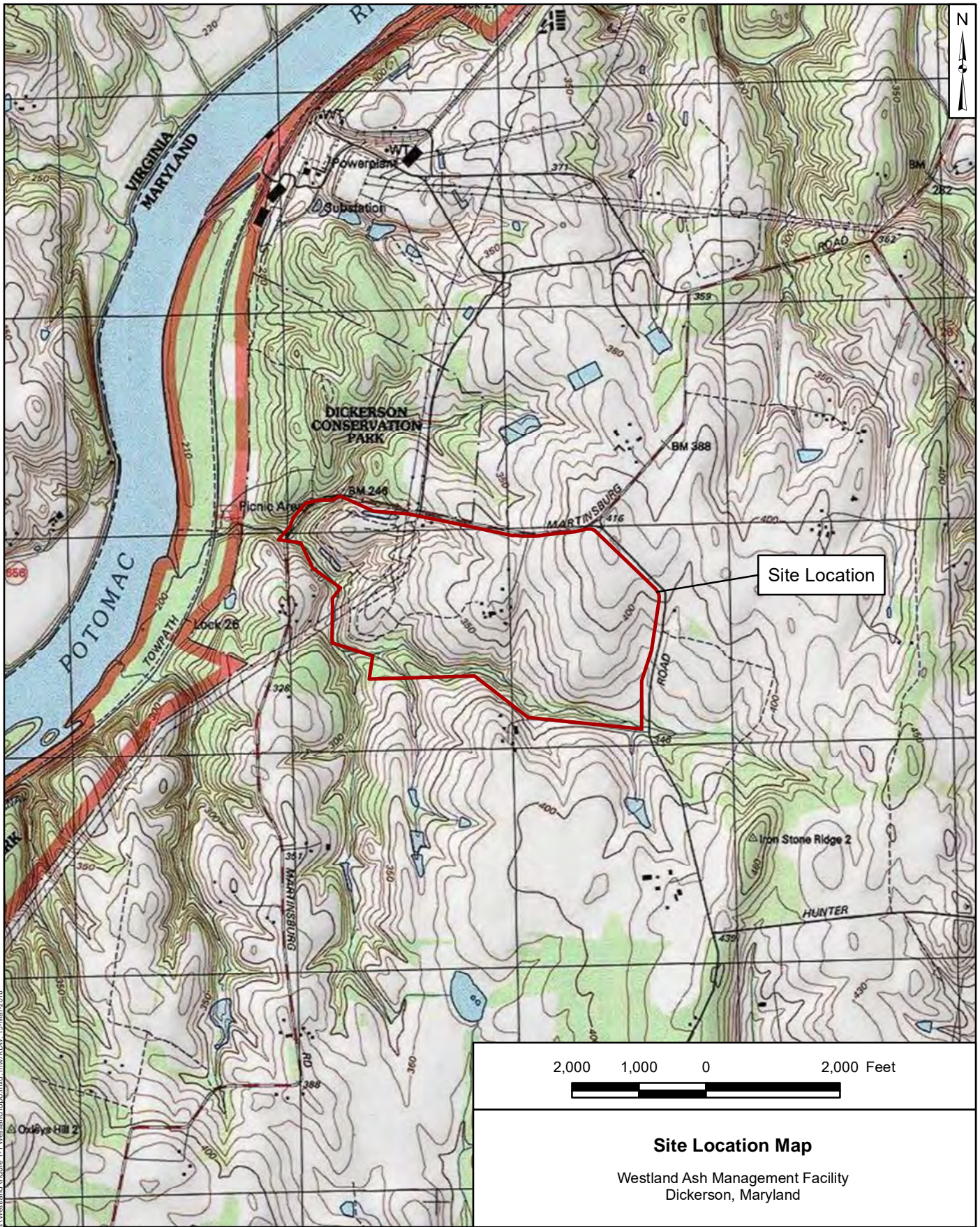
LCL Lower Confidence Limit

GWPS Groundwater Protection Standard

[1] Barium, beryllium, cadmium, fluoride, and mercury did not exceed their GWPS in any compliance well in any monitoring event; thus, the LCL was not calculated for these constituents.

[2] SSL test was not due to be conducted on data collected in August 2018 until January 2019. Those SSL tests will be included in the 2019 Annual Report.

FIGURES



Path: P:\GIS\NRG\GenCon\Map\Westland\Figure 1-1 Westland Topo.mxd, mwf/BDW, 15. Mar 2016

Source:
 USGS Topographic Quadrangle - Dickerson, Maryland, provided by
 the National Geographic Society, i-cubed. © 2011 National
 Geographic Society, i-cubed



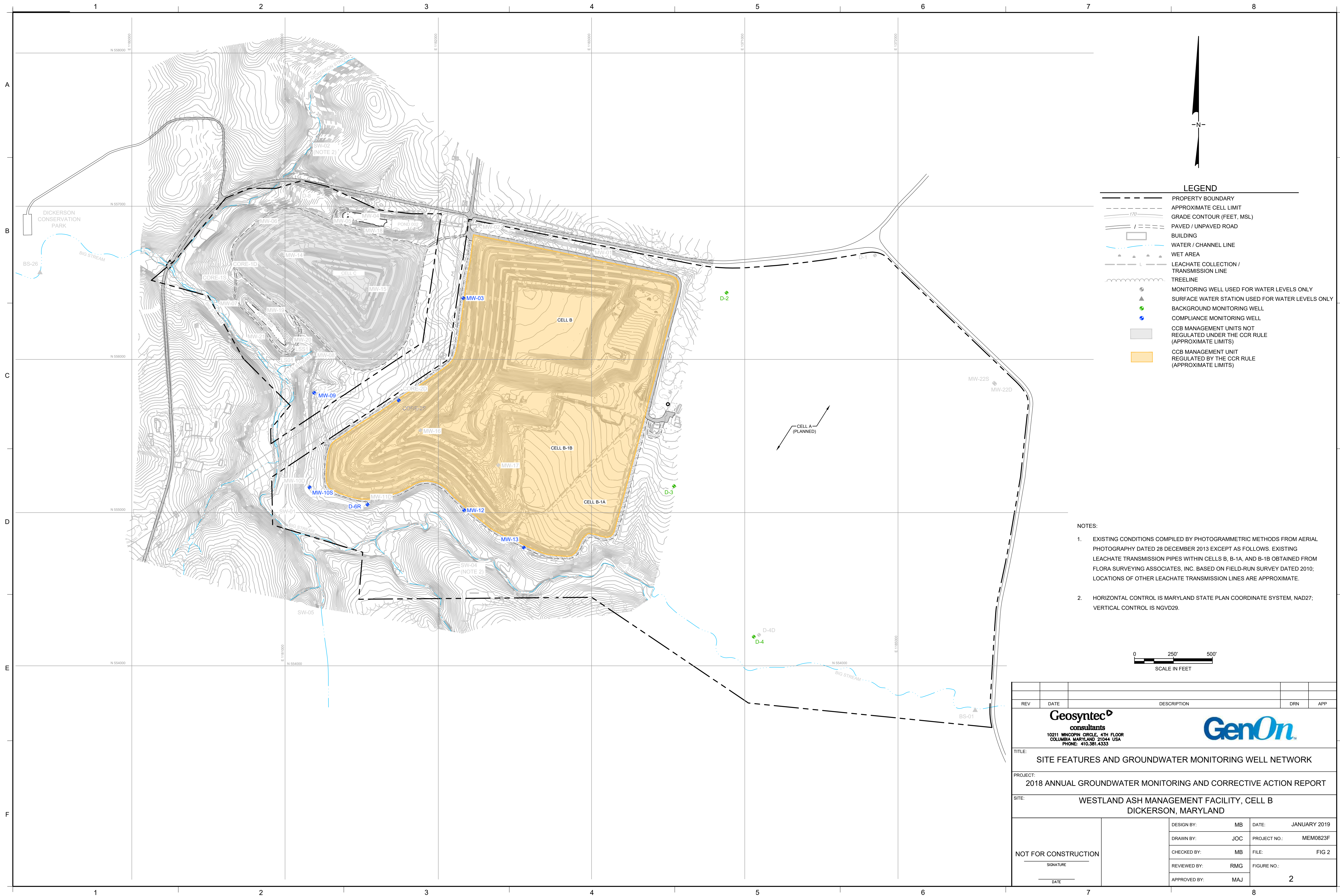
Site Location Map
 Westland Ash Management Facility
 Dickerson, Maryland

Geosyntec
 consultants

Figure
1

Columbia, Maryland

January 2019

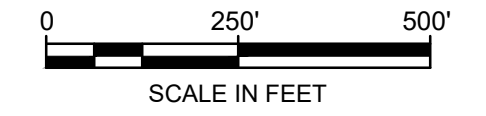


LEGEND

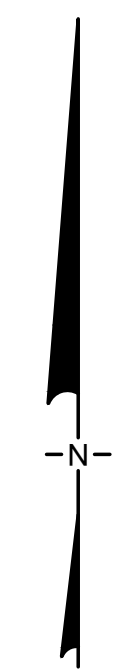
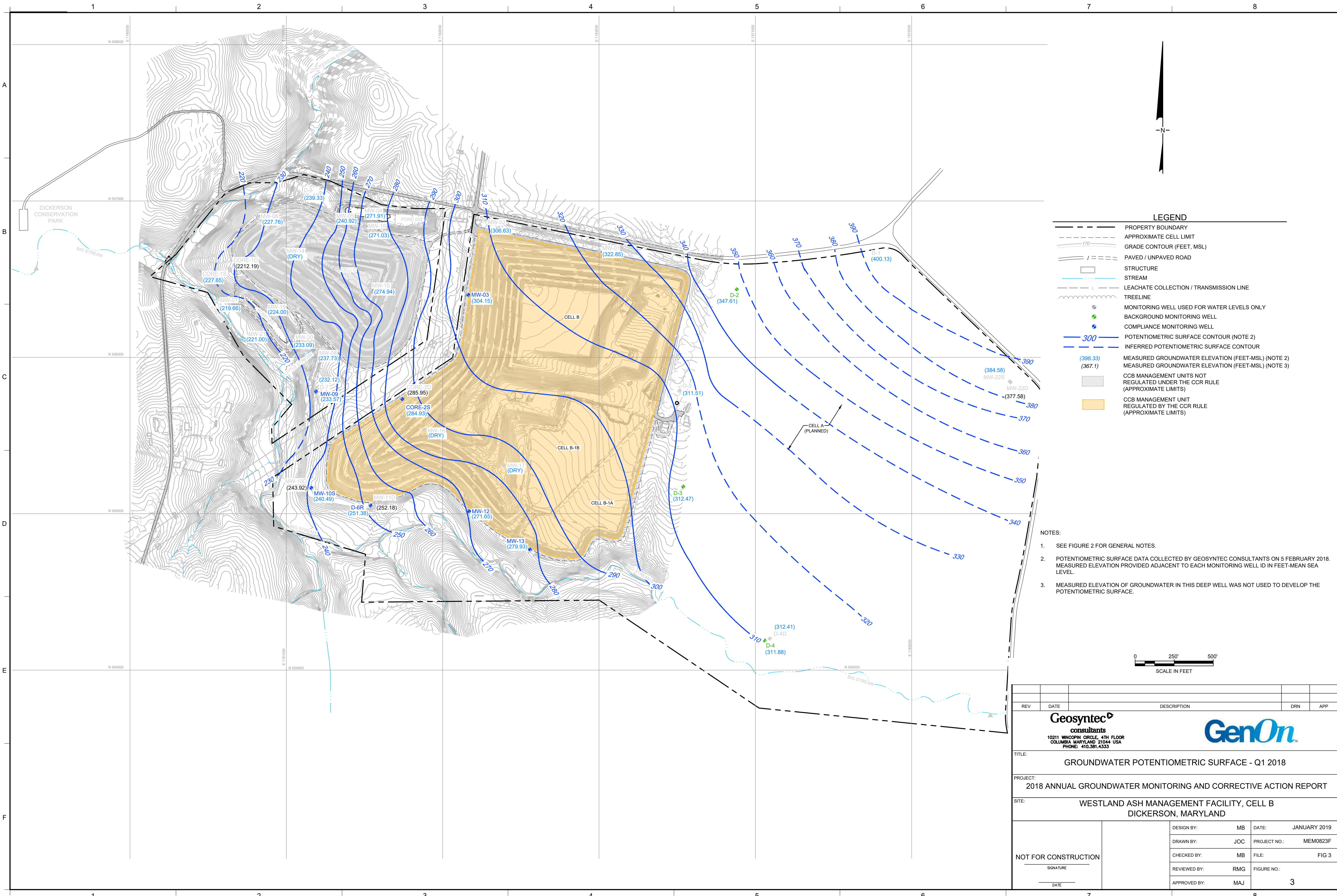
- PROPERTY BOUNDARY
- APPROXIMATE CELL LIMIT
- GRADE CONTOUR (FEET, MSL)
- PAVED / UNPAVED ROAD
- BUILDING
- WATER / CHANNEL LINE
- WET AREA
- LEACHATE COLLECTION / TRANSMISSION LINE
- TREELINE
- MONITORING WELL USED FOR WATER LEVELS ONLY
- SURFACE WATER STATION USED FOR WATER LEVELS ONLY
- BACKGROUND MONITORING WELL
- COMPLIANCE MONITORING WELL
- CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
- CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

NOTES:

1. EXISTING CONDITIONS COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED 28 DECEMBER 2013 EXCEPT AS FOLLOWS. EXISTING LEACHATE TRANSMISSION PIPES WITHIN CELLS B, B-1A, AND B-1B OBTAINED FROM FLORA SURVEYING ASSOCIATES, INC. BASED ON FIELD-RUN SURVEY DATED 2010; LOCATIONS OF OTHER LEACHATE TRANSMISSION LINES ARE APPROXIMATE.
2. HORIZONTAL CONTROL IS MARYLAND STATE PLAN COORDINATE SYSTEM, NAD27; VERTICAL CONTROL IS NGVD29.



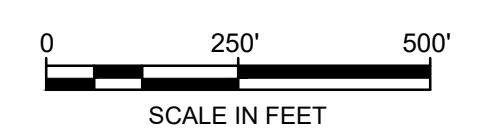
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TITLE: SITE FEATURES AND GROUNDWATER MONITORING WELL NETWORK				
PROJECT: 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT				
SITE: WESTLAND ASH MANAGEMENT FACILITY, CELL B DICKERSON, MARYLAND				
NOT FOR CONSTRUCTION _____ SIGNATURE _____ DATE		DESIGN BY: MB DRAWN BY: JOC CHECKED BY: MB REVIEWED BY: RMG APPROVED BY: MAJ	DATE: JANUARY 2019 PROJECT NO.: MEM0823F FILE: FIG 2 FIGURE NO.: 2	



LEGEND

	PROPERTY BOUNDARY
	APPROXIMATE CELL LIMIT
	GRADE CONTOUR (FEET, MSL)
	PAVED / UNPAVED ROAD
	STRUCTURE
	STREAM
	LEACHATE COLLECTION / TRANSMISSION LINE
	TREELINE
	MONITORING WELL USED FOR WATER LEVELS ONLY
	BACKGROUND MONITORING WELL
	COMPLIANCE MONITORING WELL
	POTENTIOMETRIC SURFACE CONTOUR (NOTE 2)
	INFERRED POTENTIOMETRIC SURFACE CONTOUR
	MEASURED GROUNDWATER ELEVATION (FEET-MSL) (NOTE 2)
	MEASURED GROUNDWATER ELEVATION (FEET-MSL) (NOTE 3)
	CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
	CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

- NOTES:**
- SEE FIGURE 2 FOR GENERAL NOTES.
 - POTENTIOMETRIC SURFACE DATA COLLECTED BY GEOSYNTEC CONSULTANTS ON 5 FEBRUARY 2018. MEASURED ELEVATION PROVIDED ADJACENT TO EACH MONITORING WELL ID IN FEET-MEAN SEA LEVEL.
 - MEASURED ELEVATION OF GROUNDWATER IN THIS DEEP WELL WAS NOT USED TO DEVELOP THE POTENTIOMETRIC SURFACE.



REV	DATE	DESCRIPTION	DRN	APP

Geosyntec
consultants
10211 WINDSPIN CIRCLE, 4TH FLOOR
COLUMBIA, MARYLAND 21044 USA
PHONE: 410.381.4333

TITLE: GROUNDWATER POTENTIOMETRIC SURFACE - Q1 2018

PROJECT: 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

SITE: WESTLAND ASH MANAGEMENT FACILITY, CELL B
DICKERSON, MARYLAND

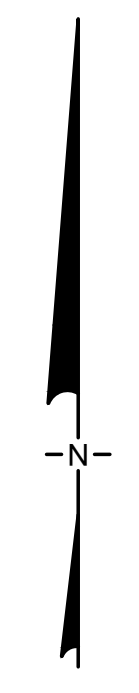
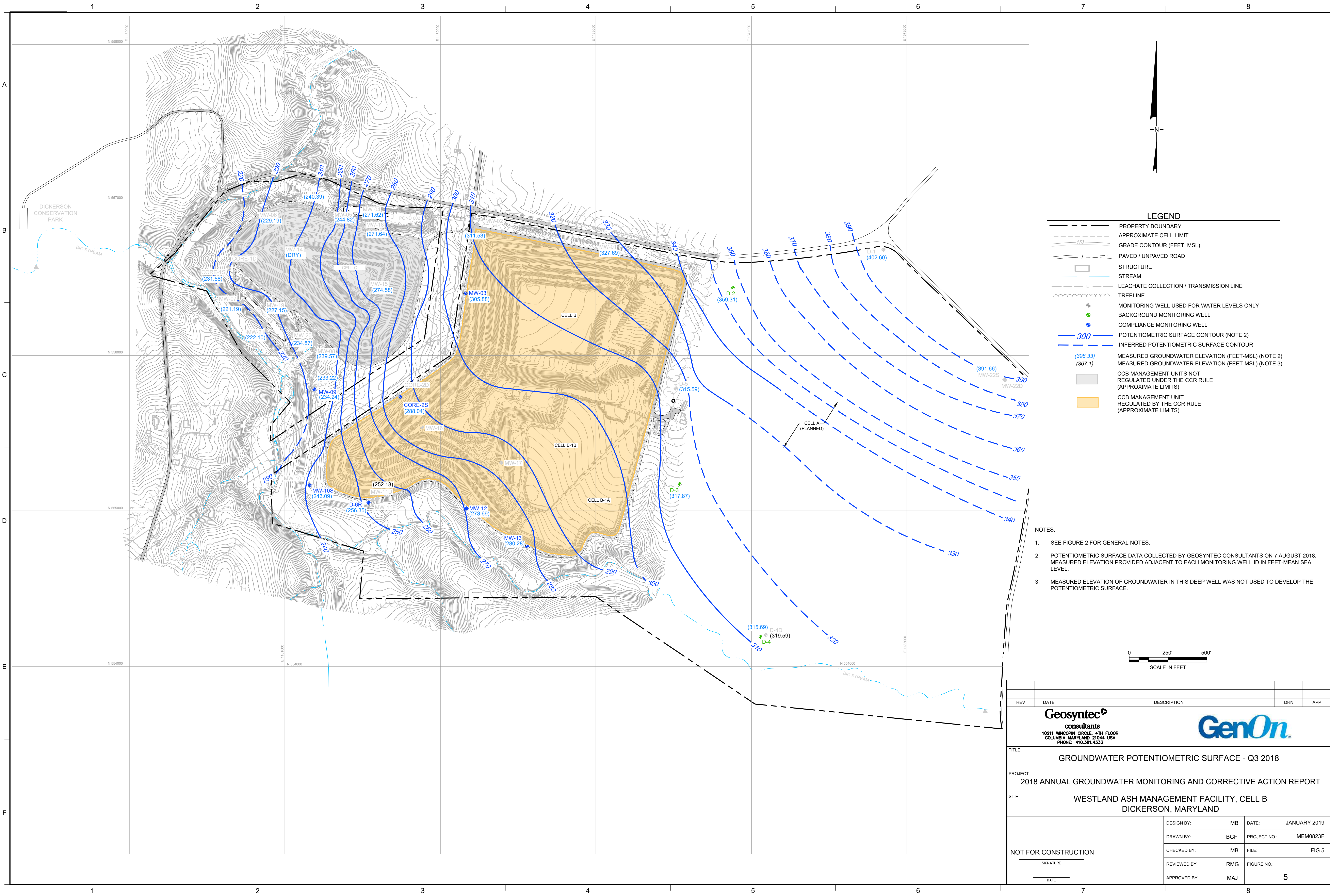
DESIGN BY: MB	DATE: JANUARY 2019
DRAWN BY: JOC	PROJECT NO.: MEM0823F
CHECKED BY: MB	FILE: FIG 3
REVIEWED BY: RMG	FIGURE NO.:
APPROVED BY: MAJ	3

NOT FOR CONSTRUCTION

SIGNATURE _____

DATE _____

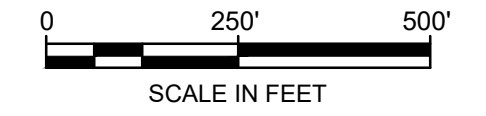
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LEGEND

	PROPERTY BOUNDARY
	APPROXIMATE CELL LIMIT
	GRADE CONTOUR (FEET, MSL)
	PAVED / UNPAVED ROAD
	STRUCTURE
	STREAM
	LEACHATE COLLECTION / TRANSMISSION LINE
	TREELINE
	MONITORING WELL USED FOR WATER LEVELS ONLY
	BACKGROUND MONITORING WELL
	COMPLIANCE MONITORING WELL
	POTENTIOMETRIC SURFACE CONTOUR (NOTE 2)
	INFERRED POTENTIOMETRIC SURFACE CONTOUR
	MEASURED GROUNDWATER ELEVATION (FEET-MSL) (NOTE 2)
	MEASURED GROUNDWATER ELEVATION (FEET-MSL) (NOTE 3)
	CCB MANAGEMENT UNITS NOT REGULATED UNDER THE CCR RULE (APPROXIMATE LIMITS)
	CCB MANAGEMENT UNIT REGULATED BY THE CCR RULE (APPROXIMATE LIMITS)

- NOTES:**
- SEE FIGURE 2 FOR GENERAL NOTES.
 - POTENTIOMETRIC SURFACE DATA COLLECTED BY GEOSYNTEC CONSULTANTS ON 7 AUGUST 2018. MEASURED ELEVATION PROVIDED ADJACENT TO EACH MONITORING WELL ID IN FEET-MEAN SEA LEVEL.
 - MEASURED ELEVATION OF GROUNDWATER IN THIS DEEP WELL WAS NOT USED TO DEVELOP THE POTENTIOMETRIC SURFACE.



REV	DATE	DESCRIPTION	DRN	APP

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TITLE: GROUNDWATER POTENTIOMETRIC SURFACE - Q3 2018

PROJECT: 2018 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

SITE: WESTLAND ASH MANAGEMENT FACILITY, CELL B
DICKERSON, MARYLAND

DESIGN BY: MB	DATE: JANUARY 2019
DRAWN BY: BGF	PROJECT NO.: MEM0823F
CHECKED BY: MB	FILE: FIG 5
REVIEWED BY: RMG	FIGURE NO.:
APPROVED BY: MAJ	5

NOT FOR CONSTRUCTION

SIGNATURE _____

DATE _____

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 M:\08\2018\2018 Annual Groundwater Monitoring and Corrective Action Report\Fig 5.dwg, REV 5, 11/08/2019 2:57:27 PM

APPENDIX A

Groundwater Flow Velocity Calculation

Appendix A

Groundwater Velocity Calculation

Westland Ash Management Facility Cell B

Dickerson, Maryland

1. Governing Equation

Groundwater flow velocity at the Site was calculated between several monitoring wells around Cell B of the Site. The calculations were performed using the following equation.

$$V_{\eta} = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

Where:

V_{η} = Groundwater velocity (cm per second)

K = Hydraulic conductivity estimated through aquifer pumping tests (cm per second)

η = Effective porosity % (unitless)

Δh = Change in groundwater elevation between two points (feet)

Δl = Distance between two points (feet)

This equation is for Darcy flow through porous media, but is a reasonable approximation at the site-wide scale for fractured bedrock at Westland.

2. Hydraulic Conductivity

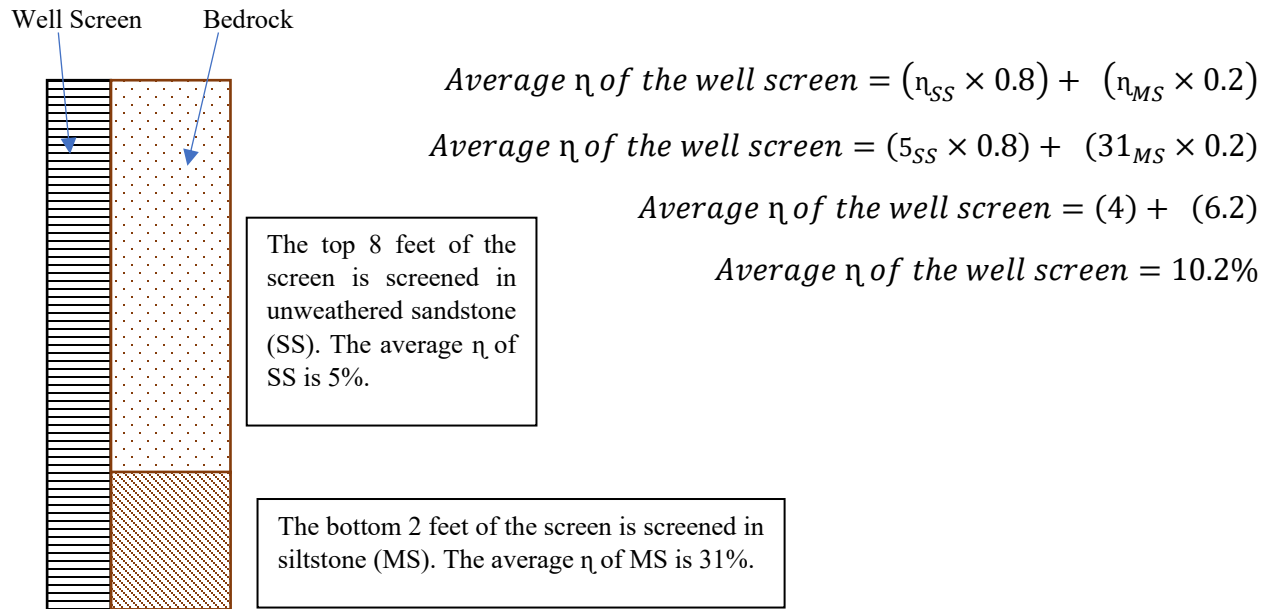
Hydraulic conductivity (K) was calculated at select monitoring wells around Phase II. The boreholes for monitoring wells Core 2S, MW-03, MW-09, MW-10S, MW-12, and MW-13 were packer tested prior to well installation. The location of the packer tested wells are shown on **Figure 2**. Straddle packer tests were used to calculate K of each monitoring well. The K value for each packer test interval within a given borehole was averaged, which generated an average K for each test interval. Average K values are presented in **Table A-1**. The average of the K value between two monitoring wells is presented on **Table A-2**.

3. Average Porosity

As shown on **Table A-1**, each monitoring well has an average porosity (η) calculated for each screen interval. The averaged η values were obtained from *Groundwater and Wells, Second Edition, Driscoll* [Driscoll, 1986]. A range for η is presented in [Driscoll, 1986] and the average for each η range was used in the calculation. The published η values and the calculated average η values are presented on **Table A-1**.

The averaged η value was then used to estimate an η value for each screen based on the geology observed during the well installation. See diagram below to see how η was estimated for each boring monitoring well screen.

EXAMPLE POROSITY ESTIMATION FOR WELL SCREEN



Boring logs were provided in *Basis for Groundwater Monitoring Network* [Geosyntec, 2017a].

After the average η value was calculated for each well screen, the average of the η values between the two monitoring wells along a groundwater flow path was calculated. See **Table A-1** for the calculated average η for each monitoring well screen. The average η value between the two monitoring wells was the η used to calculate the groundwater velocity. Average η value between monitoring wells is presented on **Table A-2**.

4. Monitoring Well Selection

To estimate groundwater velocity, monitoring wells upgradient and downgradient of Cell B were selected. Ideally, monitoring wells should be along a groundwater flow path. Based on that requirement, the groundwater velocity was calculated between D-2 and the downgradient monitoring wells. See **Figure 3** through **Figure 5** for the selected well locations relative to groundwater flow.

5. Groundwater Velocity

Groundwater velocity around Cell B ranged from 2.15×10^{-5} centimeters per second (cm/sec) (22.25 feet/year) between monitoring wells D-2 and MW-3 to 4.45×10^{-6} cm/sec (4.61 feet/year) between monitoring wells D-2 and MW-13. The average groundwater velocity around Cell B was calculated at 6.81×10^{-6} cm/sec (7.04 feet/year). **Table A-2** presents the calculated groundwater velocities. Therefore, to be considered independent samples, groundwater monitoring events should be at least 1.5 months apart for groundwater to completely travel through the 8-inch diameter borehole.

APPENDIX A
TABLE A-1
Groundwater Flow Velocity Variables

Westland CCR Management Facility Cell B
Dickerson, Maryland

Groundwater Velocity Equation

$$V_{\eta} = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

V_{η} = linear groundwater velocity (cm/sec)

K = hydraulic conductivity (cm/sec)

η = effective porosity (unitless)

Δh = change in head between wells (ft)

Δl = distance between wells (ft)

Well ID:	Average Hydraulic Conductivity (K) (cm/sec) [3]
D-2 [1]	5.73E-05
Core-2S	7.22E-06
D-6R [2]	1.89E-05
MW-3	3.32E-04
MW-09	5.08E-08
MW-10S	1.12E-05
MW-12	2.66E-05
MW-13	5.04E-06

Upgradient Well	Downgradient Well	Δl (ft)	Δh (ft) [6]
D-2	Core-2S	2,220	71.27
D-2	D-6R	2,737	102.97
D-2	MW-3	1,710	53.43
D-2	MW-09	2,772	125.07
D-2	MW-10S	2,997	116.22
D-2	MW-12	2,207	85.62
D-2	MW-13	2,115	79.03

Rock Type	Effective Porosity % (η) [4]	Average η
Sandstone (SS)	5	5
Sandstone (mod. Weathered)	15	15
Sandstone (highly weathered)	30	30
Siltstone (MS)	21 - 41	31

Well Location	Geology Observed in Screened Interval	Average η of Screen
D-2 [5]	Unknown	27.5
Core-2S	50/50 High-moderate weather SS	22.5
D-6R [5]	Unknown	27.5
MW-3	Highly Weathered SS	30.0
MW-09	Moderately Weathered SS and MS	27.8
MW-10S	Highly/Moderately Weathered SS and MS	24.2
MW-12	Highly Weathered SS	30.0
MW-13	Highly Weathered SS	30.2

Notes:

ft - feet

cm/sec - centimeters per second

[1] - Hydraulic conductivity is an average of the Cell B compliance monitoring wells.

[2] - Hydraulic conductivity is an average of MW-12 and MW-10s, which are located on either side of D-6R.

[3] - Average hydraulic conductivity is the average of the hydraulic conductivity calculated in the interval in which the well is screened.

[4] - Porosity is an average of the rock types observed at the Site.

[5] - Average porosity of the screen is an average of the Cell B compliance well screen porosity values.

[6] - Groundwater elevation used to calculate groundwater velocity from the August 2018 monitoring events.

APPENDIX A
Table A-2
Groundwater Flow Velocity Calculation

Westland CCR Management Facility Cell B
Dickerson, Maryland

Well ID:	Hydraulic Conductivity (K) (cm/sec)	Average Porosity of Screen Interval (%)	Average K (cm/sec) [1]	Average η	Δh (ft)	Δl (ft)	$\Delta h/\Delta l$	Linear Velocity (cm/sec)	Linear Velocity (inches/month)
Core-2S	7.22E-06	22.5	3.54E-05	0.24975	71.27	2,220	0.0321	4.56E-06	4.71
D-6R	1.89E-05	27.5	4.13E-05	0.27450	102.97	2,737	0.0376	5.66E-06	5.85
MW-3	3.32E-04	30.0	1.98E-04	0.28725	53.43	1,710	0.0312	2.15E-05	22.25
MW-09	5.08E-08	27.8	3.19E-05	0.27625	125.07	2,772	0.0451	5.20E-06	5.38
MW-10S	1.12E-05	24.2	3.74E-05	0.25825	116.22	2,997	0.0388	5.62E-06	5.82
MW-12	2.66E-05	30.0	4.51E-05	0.28725	85.62	2,207	0.0388	6.09E-06	6.31
MW-13	5.04E-06	30.2	3.43E-05	0.28825	79.03	2,115	0.0374	4.45E-06	4.61

Groundwater Velocity Equation

$$V_{\eta} = \frac{K}{\eta} \times \frac{\Delta h}{\Delta l}$$

V_{η} = linear groundwater velocity

K = hydraulic conductivity (cm/sec)

η = effective porosity (unitless)

Δh = change in head between wells (ft)

Δl = distance between wells (ft)

[1] Average hydraulic conductivity is the average hydraulic conductivities between D-2 and identified well.

Groundwater Velocity Mean	6.40E-06 cm/sec	6.62 inches/month
Groundwater Velocity Median	5.62E-06 cm/sec	5.82 inches/month