Methodology for Determining Whether Private Water Supply Wells May Be Impacted by Coal Ash Placement at Waugh Chapel and Turner Pit Sites

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Background:

This report addresses paragraph 42 of the Consent Decree issued October 1, 2007 by the Maryland Department of the Environment (MDE) to BBSS, Inc. and Constellation Power Source Generation, Inc (CPSG) for the BBSS site located in Crofton, Maryland. Paragraph 42 requires proposal of a methodology for determining whether private water supply wells may be impacted by coal ash placement at the Site.

Basis for the Methodology:

The following chemicals are proposed as primary indicator parameters for evaluating potential coal ash impacts from the Crofton site to a private water supply well: sulfate, chloride, boron, and lithium. The presence of all four primary parameters at the levels described in Table 3 would suggest that coal ash leachate is a source of the constituents, and this inference should then be verified by use of secondary parameters (calcium, sodium, total dissolved solids (TDS), potassium, and magnesium) and other available site characterization information and data. If one or more primary parameters are not present at the Table 3 levels, then coal ash leachate impact is not proven, but ongoing monitoring and evaluation may be recommended. No single indicator shall be considered determinative.

As a preliminary matter, this methodology also uses sulfate as the primary parameter to trigger whether the above in-depth evaluation should be conducted. Sulfate alone cannot be used to definitely determine that an impact is caused from the ash placement at the Crofton site, because at that location sulfate is also naturally occurring in the groundwater at variable concentrations both spatially and temporally. For example, the naturally occurring black soils in the area significantly contribute sulfate to the groundwater quality.

In contrast with sulfate, other proposed parameters for this site are less likely to be naturally present in groundwater in significant concentrations. For this reason, the methodology utilizes the presence of these additional parameters to verify a coal ash impact, or to define a coal ash "signature."

Tables 1 and 2 provide a summary of the eight individual chemicals and TDS in coal ash leachate and in ambient/background groundwater showing the range of measured concentrations from available data for the Site.

Table 1 Leachate composition data for major constituents(mg/L)

Location	Calcium	Boron	Lithium	Sodium	Chloride	Potassium	Magnesium	Sulfate	TDS
MW-14	40-236	5.3	5.7	23-544	1770	14.3-78	11.2-96.1	34-5728	143-4740
MW-24	638 - 758	22 - 28	26 - 34	1309 - 1704	2207 - 2807	463 - 578	158-230	2824 - 3015	1901-8267
W-03	253	6.6	4.2	237	415	70	116.7	1209	
W-04	604	21	21	1012	1472	288	69.8	2440	
W-05	418	14	11	573	838	159	147.7	1635	
W-11	424	17	13	516	680	170	234.4	1817	

Table 2 Summary of ambient water quality for major constituents (mg/L)

Location	Calcium	Boron	Lithium	Sodium	Chloride	Potassium	Magnesium	Sulfate	TDS
MW-10	0 - 37	ND	0.02 - 0.2	1.2 - 10	2--28	0.7 - 4.3	0.004-5.2	18-601	36-357
MW-11	6.9-14.3	ND	0 - 0.1	5.7 - 8.5	9-98	2.2 - 5.8	4.2-6.7	29-75	64-288
MW-17	11- 13	ND	0 - 0.03	23 - 27	23-83	3.5 - 4.4	5.9-6.7	10-25	50-305
MW-18	2.5-7.1	ND	0 - 0.7	3.6 - 4.8	23-83	0.8 -1.8	1.1-2.9	21-39	36-188
MW-25	22 -27	0 - 0.2	0 - 0.5	15 - 22	30-40	3.6 -6.3	18-21	114-150	209-246

The available site specific data in Tables 1 and 2 show that chloride concentration is in the range of 2 to 98 mg/L (milligrams per liter) in ambient groundwater whereas chloride in coal ash leachate is in the range of 415 to 2807 mg/L. Boron is essentially not detected (<0.1 mg/L) in ambient groundwater whereas in the coal ash leachate boron concentration is in the range of 5 to 28 mg/L. Sulfate in ambient groundwater is in the range of 10 to 75 mg/L (by removing outliers) whereas in the ash leachate sulfate concentration is in the range of 1209 to 5728 mg/L. Lithium in ambient groundwater is in the range of 0.02 to 0.7 mg/L whereas lithium is in the range of 4 to 34 mg/L in ash leachate. Similarly calcium, sodium, TDS, magnesium and potassium are about an order of magnitude or more higher in the coal ash leachate than in the ambient groundwater. Furthermore, boron, lithium and chloride are equally mobile in groundwater as sulfate. Chloride is not readily contributed by the black soils in the area.

The proposed primary and secondary indicator parameters attenuate differently in groundwater. The primary indicator parameters (sulfate, boron, chloride, and lithium) are the most mobile of all the indicator parameters and are equally mobile in groundwater. Simply put, if these four constituents would travel through the groundwater from the coal ash placement location, they would be expected to travel together at the same rate. Therefore, the presence together of all four constituents

(sulfate, boron, chloride and lithium) at requisite levels is primary determinant of coal ash leachate in groundwater.

As further explanation of the mobility of sulfate, boron, chloride, and lithium, they attenuate by dilution caused by dispersion processes. The secondary parameters can attenuate to varying extents by chemical reactions in combination with the dispersion processes and may retard somewhat during migration with groundwater flow. Therefore, sulfate, boron, chloride, and lithium would be expected to be found in down-gradient wells that are impacted by ash leachate migration based on the advection and dispersion processes of the groundwater flow system. Because of the relative mobility of sulfate, chloride, boron and lithium, we would expect to see these parameters as establishing the leading edge of the leachate plume. However, calcium, sodium, magnesium, and potassium would also be found at increased concentrations due to ash leachate migration down-gradient from the Waugh Chapel Pit and Turner Pit structural fills. Depending on the years of travel time and hydrodynamic dispersion involved, the dissolved concentrations of the indicator chemicals will undergo dilution and some attenuation during their migration from the release source.

Since TDS is the sum of dissolved constituents in groundwater including calcium, sulfate, chloride, sodium, potassium, and magnesium, it should also serve as a useful indicator parameter for leachate migration. However, it should be always remembered that for the BBSS site, the black soils also contribute sulfate and therefore TDS to the groundwater levels and can be erroneously identified as impact from ash leachate migration.

To verify inferences from primary parameters, this methodology requires consideration of: 1) other ash leachate signature chemicals as secondary indicator parameters (calcium, sodium, total dissolved solids (TDS), potassium, and magnesium), 2) background water quality (temporal and spatial variability), 3) physical location of the well in relationship to the Site, and 4) information from other wells that are being used to track the extent of the contamination. Data developed pursuant to groundwater monitoring and characterization conducted pursuant to Paragraph 33 of the Consent Decree should be used as part of an evaluation of potential impact to any well. This data should help to define trends in how the ash leachate chemicals move in groundwater over time, and the overall groundwater quality taking into consideration spatial and temporal variability.

Components of the proposed methodology:

- Compare sulfate in the private water supply well to the relative background/ambient sulfate level in the applicable sentinel well. If the sulfate in the water supply well appears to be elevated, analyze the well water for the following indicator parameters:
    - Primary indicators --sulfate, boron, chloride, and lithium
    - Secondary indicators – calcium, sodium, total dissolved solids (TDS), magnesium, and potassium

- Compare the primary indicator results to the criteria in Table 3. If the primary indicator parameters exceed the criteria concentrations, the secondary indicator constituents should be utilized to confirm the inference derived from the primary indicator constituents. If primary indicator constituents do not exceed the criteria concentrations then ash leachate impact is not proven and secondary indicator constituents are not utilized for further evaluation. No single indicator parameter shall be considered determinative.

- Evaluate primary and secondary indicator constituents, well locations relative to the extent of groundwater contamination determined using the methodology presented in the response to Consent Decree paragraph 33 ("CD33"), and the potential for other possible contaminant sources to determine if data a particular location indicates impact from coal ash leachate. A well must be located within the defined plume area or at least within the distance between the ash fill area and an un-impacted sentinel well to be in a location that could potentially be impacted by ash leachate from the Turner Pit or Waugh Chapel Pit areas.

Table 3 summarizes the primary and secondary indicator parameters and their respective concentration ranges to trigger identification of additional impacted private water supply wells. The monitoring data developed under paragraph 33 will be utilized for the paragraph 42 evaluation purpose.

Table 3 Criteria for evaluation of groundwater impact from ash leachate

Primary Indicator Parameters			
	Concentration in well	**Time and Spatial trends**	**Sentinel wells (Anticipated)**
Sulfate	50 to 100 mg/L depending on the initial concentration at the sentinel well	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31
Boron	Exceeding PQL (Practical Quantitation Limit)	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31
Chloride	50 to 100 mg/L depending on the initial concentration at the sentinel well	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31
Lithium	0.5 to 0.7 mg/L depending on the initial concentration at the sentinel well	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31
Secondary Indicator Parameters			
Calcium	25 to 40 mg/L depending on the initial concentration at the sentinel well	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31
Sodium	50 to 80 mg/L depending on the initial concentration at the well	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31
Total Dissolved Solids (TDS)	200 to 400 mg/L depending on the initial concentration at the sentinel well	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31
Magnesium	10 to 20 mg/L depending on the initial concentration at the sentinel well	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31
Potassium	15 to 25 mg/L depending on the initial concentration at the sentinel well	An increasing time trend and two fold increase from initial concentration	For TP MW-33 For WC 2530 For Jackson Road MW-31