2020 Corrective Action Status Evaluation Report

CLOSED LAUREL VALLEY CENTER SANITARY LANDFILL

PERMIT NUMBER 251

Prepared for:

Culpeper County
118 West Davis Street, Suite 101
Culpeper, Virginia 22701

Submitted to:

Virginia Department of Environmental Quality
Northern Regional Office
13901 Crown Court
Woodbridge, Virginia 22193

Prepared by:

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Project No. 20-145729

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EXECUTIVE SUMMARY

The Virginia Solid Waste Management Regulations (VSWMR) became effective in December 1988 and were most recently amended in February 2019 (effective date of March 6, 2019). These regulations (9VAC20-81-260.G) and Condition XIV.M.2 of the Facility's solid waste permit require Culpeper County to submit a Corrective Action Status Evaluation (CASE) Report (Report) to the Virginia Department of Environmental Quality (DEQ) on a tri-annual basis following the incorporation of groundwater corrective action provisions into the Facility's solid waste permit (November 5, 2008). The previous Report was submitted to the DEQ on November 3, 2017. This Report documents the progress of the site-wide groundwater corrective actions for the period of November 2017 through October 2020.

Culpeper County began monitoring groundwater at the landfill in July 1993 under the Detection Monitoring Program and in December 1994 the Assessment Monitoring Program was initiated. Based on the results from the Assessment Monitoring Program the DEQ amended the original 1978 Facility permit on November 18, 1998, to include Groundwater Protection Standards (GPS), which included a variance for Alternate Concentration Limits (ACLs). In May 1999, the GPS for vinyl chloride was exceeded at three downgradient monitoring wells. Consistent with the VSWMR a Nature and Extent Study (NES) and an Assessment of Corrective Measures (ACM) were completed for the Facility. In coordination with the DEQ a Corrective Action Plan (CAP) was submitted to the DEQ and on November 5, 2008, the DEQ amended the Facility's solid waste permit to include provisions of the CAP. The first semi-annual corrective action monitoring event occurred during the second 2008 groundwater monitoring event. Corrective action monitoring results have since been reported to DEQ in tri-annual Reports dated November 3, 2011, November 5, 2014, and November 3, 2017. This Report documents the sampling, analysis, and data evaluations completed for the groundwater corrective action program at the Facility in the November 2017 through October 2020 timeframe.

Based on evaluation of the monitoring results collected during the current CASE period, Golder believes that the current remedies continue to function as designed and are capable of achieving the corrective action program remediation goals within a reasonable timeframe. For the current monitoring period, there were three landfill-derived volatile organic compound (VOC) constituents of concern (COCs) with GPS exceedances documented in the past 3 years. These COCs are 1,1-dichloroethane, vinyl chloride, and trichloroethene. In addition to the VOC COCs, there was a one-time suspect GPS exceedance documented in MW-4 during the September 2018 sampling event for naphthalene (no exceedances before or since). Finally, the reducing conditions associated with the release from the landfill has created conditions that are conducive to the dissolution of iron-oxyhydroxide minerals which has released cobalt to the groundwater at concentrations that exceed its GPS, and thus cobalt is a naturally occurring release-induced COC for this Facility.

For the current CASE period, with exception of cobalt, the combination of presumptive remedies (PR) and natural biological activity has combined to reduce the observed groundwater concentrations in the CLFP-1 plume to less

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than the COC-specific GPS. These results indicate that the PR has been successful for the CLFP-1 plume and it is expected that with time, the groundwater geochemical conditions will revert to an oxidizing condition that will immobilize the residual dissolved cobalt. Continued monitoring of the CLFP-1 plume is recommended to verify that the landfill-derived COCs have been controlled and that the cobalt concentrations are naturally attenuating.

Review of the current CASE period data for the CLFP-2 plume indicates that the plume continues to expand downgradient from the closed landfill. However, the overall concentrations are reduced, and the risk is still controlled. Specifically, there was breakthrough for nested wells MW-1E and MW-1F (concentrations to be verified in 2nd semi-annual 2020 event) and in downgradient wells MW-1G and MW-1H in the CLFP-2 plume for 1,1-dichloroethane and vinyl chloride during the current CASE period. The last sentinel well MW-1I continues to be breakthrough free as of the date of this report. Evaluation of the analytical results indicates that the CLFP-2 plume continues to migrate deeper into the fractured bedrock. The depth of plume migration is expected to be limited however, since artesian aquifer conditions are documented to exist downgradient of the plume at location MW-1I. Based on evaluation of the concentration trends over the last 3 years it appears that the plume migration may have stabilized at its current limits. Continued monitoring of the CLFP-2 plume is recommended to verify that the extent of the landfill-derived COCs is stable. In the event that breakthrough in the form of a GPS exceedance is documented at MW-1I during any future events, a confirmation sample will be collected to verify the breakthrough. If verified breakthrough is confirmed, additional sentinel wells and/or implementation of the enhanced bioremediation remedy may be warranted to control the plume extent.

Review of the current CASE period MNA monitoring results for the CLFP-3 plume indicates that the MNA remedy is continuing to control the CLFP-3 plume on the southern side of the Facility. There are currently two COCs in the CLFP-3 plume, trichloroethene and 1,1-dichloroethane. The concentrations of these COCs at CLF-15A have been steady or declining since 2017 indicating that the plume is stable. Similarly, the concentration of 1,1-dichloroethane at sentinel well CLF-S3 has remained stable and less than the GPS since 2012. Trichloroethene is not detected at CLF-S3. The COC concentrations in sentinel well CLF-S1 continue to be non-detect. Continued monitoring of the CLFP-3 plume is recommended to verify that the landfill derived COCs have been controlled and that the cobalt concentrations in this area are naturally attenuating.

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LIST OF ATTACHMENTS

1.0 INTRODUCTION

The Virginia Solid Waste Management Regulations (VSWMR) became effective in December 1988 and were most recently amended in February 2019 (effective date of March 6, 2019; VWMB, 2019). Owners/operators of municipal solid waste management facilities that are performing groundwater corrective actions are required to submit a Corrective Action Status Evaluation (CASE) Report (Report) to the Department of Environmental Quality (DEQ) on a frequency that is identified in the Facility's solid waste permit. For the closed Laurel Valley Center Sanitary Landfill (Facility), solid waste permit No. 251, the required frequency is every third year on the anniversary of the permit amendment to incorporate the corrective action program provisions (November 5, 2008).

The previous Report for the Facility was submitted to the DEQ on November 3, 2017. This Report has been prepared by Golder Associates Inc. (Golder) on behalf of Culpeper County for the closed Laurel Valley Center Sanitary Landfill (Facility), Permit No. 251. The Report documents the progress of the site-wide groundwater corrective actions for the period of November 2017 through October 2020 and has been prepared consistent with industry standards and DEQ Submission Instruction No. 25 (DEQ, 2012). As such, the Report structure is presented in a format that is consistent with and cross-referenced with Form 1 [*MNA-Based Corrective Action Site Evaluation (CASE) Report Summary*] of the Submission Instruction. A copy of the completed Form 1 is presented herein in Section 2.6.

The following sections of this Report summarize general site information followed by relevant discussions pertaining to the remedy progress, sampling, risk, and data interpretations with recommendations for future action as appropriate.

Consistent with the permit requirements, a copy of the CASE has been submitted to the Corrective Action Program data repository for the Facility located at:

Culpeper County Public Library
271 Southgate Shopping Center
Culpeper, Virginia 22701

2.0 GENERAL INFORMATION

The unlined, closed Facility is owned and maintained by Culpeper County and was operated and is maintained under solid waste permit (Permit No. 251) issued by a predecessor to the DEQ on June 26, 1978. Waste disposal was primarily by the trench-fill method with above ground lifts placed over the trenches. The Facility was considered closed in November 1998.

A site location map is presented as Drawing 1 in Attachment I. As shown, the Facility is in Culpeper County, Virginia, approximately 4 miles northwest of Culpeper off Rt. 522. The Facility layout, including monitoring well locations, is presented on Drawing 2 in Attachment II. As presented, the landfill property consists of approximately 274 acres of rolling topography, of which 17 acres were used for landfill operations.

2.1 Site Topographic Conditions

Topographic elevations at the site range from approximately 400 feet above mean sea level (ft AMSL) in the northern corner of the landfill to 600 ft AMSL in the western portion of the property (Drawing 1 in Attachment I). There are two northerly draining intermittent streams located on the landfill property.

2.2 Surrounding Land Use

Land use in the vicinity of the landfill is generally rural residential in nature, with some isolated developed areas. Property to the north, east, southeast, and southwest is generally owned by Culpeper County. The properties to the northwest and near the entrance are privately owned and used as rural residential properties. A municipal solid waste transfer station (operated by Republic Services and owned by Culpeper County) and the Paul Bates Raceway are located within the larger landfill property footprint.

2.3 Geology

The Facility is in the eastern portion of the Blue Ridge physiographic province. The geology of the waste-receiving portion of the landfill is mapped as Fauquier Formation—Arkosic metasandstone, consisting of metasedimentary rock (VDMR, 1993). Other areas of the landfill property footprint are mapped as Fauquier Formation—Arkosic metasandstone; Lynchburg Group, metagraywacke; porphyoblastic biotite–plagioclase Augen gneiss; and layered biotite granulite and gneiss (VDMR, 1993).

The uppermost aquifer beneath the Facility is found in the saprolite developed in the metamorphic bedrock. The saprolite is derived from *in situ* weathered bedrock and ranges from highly weathered saprolite with no residual rock fabric to partially weathered bedrock. The saprolite transitions to weathered rock and then to relatively unweathered fractured bedrock. The uppermost aquifer transcends from the saprolite, through the weathered bedrock into the lower fractured bedrock and there are no known confining units at the Facility. In upland areas groundwater flow is vertically downward and along the stream bottom areas, groundwater flow is vertically upward, such that artesian conditions are present at the Facility locally.

Residential properties in the vicinity of the landfill generally obtain their potable water from the upper aquifer beneath the study area. It is noted that the County is in the process of expanding the municipal water supply to the study area and it is expected that many of the rural residential properties will ultimately be connected to the water system in the future.

2.4 Groundwater Monitoring Program

Culpeper County began monitoring groundwater at the landfill in July 1993 under the Detection Monitoring Program and under the Assessment Monitoring Program in December 1994 (JEI, 2018). The original compliance monitoring wells for the Facility were installed in 1992. DEQ amended the Facility's original 1978 permit on November 18, 1998, to include Groundwater Protection Standards (GPS). Groundwater at the facility is currently sampled on a semi-annual basis under the Assessment Monitoring Program with additional sampling completed to support the Corrective Action Program.

2.4.1 Compliance Program

The Facility's compliance monitoring network is comprised of four downgradient monitoring wells and one background well. These wells are: MW-1B, MW-2B, MW-3A, MW-4, and MW-20 (background). The compliance well locations are shown on Drawing 2 in Attachment II. The compliance wells are sampled annually for the constituents in Table 3.1 Column B, typically in the first semi-annual period, and during the second semi-annual event for the constituents in Table 3.1 Column A plus the following Column B detections:

- mercury
- 2,4,5-trichlorophenoxyacetic acid
- dibenz(a,h)anthracene
- indeno(1,2,3-cd)pyrene
- diethyl phthalate
- sulfide
- isobutyl alcohol
- gamma chlordane
- dichlorodifluoromethane
- 4-aminobiphenyl
- di-n-butyl phthalate
- bis(2-ethylhexyl)phthalate
- tin
- endosulfan sulfate
- naphthalene

2.5 Corrective Action Program History

In May 1999, the GPS for vinyl chloride was exceeded at three downgradient monitoring wells. Consistent with the VSWMR Culpeper County completed a Nature and Extent Study (NES) and an Assessment of Corrective Measures (ACM) for the Facility. In coordination with the DEQ a Corrective Action Plan (CAP) was submitted to the DEQ and on November 5, 2008, for the four delineated groundwater plumes (CLFP-1, CLFP -2, CLFP -3, and CLFP -4) at the Facility. The DEQ amended the Facilities solid waste permit to include provisions of the CAP.

The first semi-annual corrective action monitoring event occurred during the second 2008 groundwater monitoring event. Corrective action monitoring results have since been reported to DEQ in tri-annual Reports dated

November 3, 2011, November 5, 2014, and November 3, 2017. This CASE covers the November 2017 to October 2020 monitoring period.

The DEQ has provided a guidance document for the preparation and submittal of Monitored Natural Attenuation (MNA)-based CASE reports, titled *Submission Instructions for Groundwater MNA-Based Corrective Action Site Evaluation (CASE) Reports at Solid Waste Landfills* [Submission Instruction (SI)-25] dated July 13, 2012. In accordance with SI-25, background and historical monitoring program information has been minimized, and this form-based CASE submittal has been prepared, with supporting text, tabular, and graphical information provided in referenced appendices. The following groundwater monitoring and corrective action documents may be referenced to provide up-to-date, detailed information regarding the Compliance and Corrective Action Monitoring Programs and the Corrective Action Plan for the Facility:

Department of Environmental Quality (DEQ). 2008. *Solid Waste Facility Permit, Permit No. 251*, Amendment 5, November 11.

DEQ. 2009. *Solid Waste Facility Permit, Permit No. 251*, Amendment 6, June 3.

Golder Associates Inc. 2020. *Closed Laurel Valley Center Sanitary Landfill, Permit No. 251, 2019 Annual Groundwater Monitoring Report*. March 4.

Joyce Engineering, Inc. 2004 (Revised May 2007). *Laurel Valley Center Sanitary Landfill, Permit Number 251*, *Corrective Action Plan*. January.

Joyce Engineering, Inc. 2004 (Revised May 2007, August 2010, and November 2012). *Laurel Valley Center Sanitary Landfill, Permit Number 251, Corrective Action Monitoring Plan*. January.

2.5.1 Corrective Action Program Monitoring Network

With the noted exceptions as discussed herein per DEQ approval, the corrective action monitoring program activities at this Facility are currently conducted in accordance with the provisions in the June 2009 Permit Module XIV (Amendment 6) as incorporated into the Facility's solid waste permit. An updated Corrective Action Monitoring Plan (CAMP; JEI, 2018) has been submitted to the DEQ for review and approval; however, approval of that document is pending at this time.

There are currently 18 wells that are monitored as part of the Facility's Corrective Action Program. The locations of the corrective action well locations are shown on Drawing 2 in Attachment II. Details for the corrective action areas, including wells and constituents of concern (COCs) are presented in the following sections.

2.5.1.1 CLF-1 Plume

Plume CLFP-1 is currently monitored by background well MW-20, downgradient compliance well MW-4, and presumptive remedy (PR) performance wells MW-6, MW-X1, and CLF-1. These wells are sampled semi-annually for CLF-1 COCs: naphthalene, 1,1-dichloroethane, cobalt, and the volatile organic compound daughter products.

2.5.1.2 CLF-2 Plume

Plume CLFP-2 currently monitored by background well MW-20, downgradient compliance well MW-1B, MW-2B, MW-3A, and permit required PR performance wells MW-1C, and MW-5. The County is also monitoring proposed performance wells MW-3, MW-1D, MW-1E, MW-1F, MW-1G, MW-1H, and MW-1I which have not been formally added to the permit program.

These wells are sampled semi-annually for CLF-2 COCs: 1,1-dichloroethane, trichloroethene, vinyl chloride, cobalt, and the volatile organic compound daughter products.

2.5.1.3 CLF-3 Plume

Plume CLFP-3 is monitored by background well MW-20, natural attenuation performance wells MW-X2, CLF-15A, and PZ-4E, and sentinel wells MW-X2D, CLF-S3, and CLF-S1.

The MNA performance wells are samples semi-annually for MNA parameters: dissolved oxygen, nitrate, nitrite, ferrous iron, sulfate, sulfide, dissolved methane, chloride, alkalinity, oxidation reduction potential, pH, conductivity, and temperature.

The sentinel wells are sampled semi-annually for CLF-3 COCs: 1,1-dichloroethane, trichloroethene, mercury, and the volatile organic compound daughter products.

2.5.1.4 CLF-4 Plume 4

Wells associated with Plume CLFP-4 were decommissioned following DEQ's September 28, 2012, email correspondence followed by a July 9, 2013, DEQ approval letter to cease monitoring at this plume in response to the November 10, 2011 request.

2.6 SI-25 Form-1

Please reference on the following pages Form-1 of SI-25, providing concise answers to key MNA-based CASE evaluation items. Per SI-25, answers requiring additional supporting information reference an appendix of this CASE report corresponding to the section of Form-1.

MNA-BASED CORRECTIVE ACTION SITE EVALUATION (CASE) REPORT SUMMARY

VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY	**1]** DEQ Region: NRO	**2]** Date: November 5, 2020
	3] Solid Waste Permit Number: 251	
4] Facility Name: Closed Laurel Valley Center Sanitary Landfill	**5]** Landfill Type: MSW	
6] Date of Groundwater Remedy Implementation (Permit Amendment Issuance): November 5, 2008		
7] Case Report Due Date: November 5, 2020	**8]** CASE Report Period: November 2017 – October 2020	
9] Was Public Repository copied on CASE submittal: Yes		
10] Name and location (City/Town) of Public Repository: Culpeper County Public Library, 271 Southgate Shopping Center, Culpeper, Virginia, 22701	**11]** Which groundwater CASE report submittal (circle one) is this? 1st 2nd 3rd (4th) 5th 6th 7th Other	

Section A - Remedy/Plume behavior: Please use 'Y', 'N', 'NA' - not applicable, or 'P'- possibly, where needed. Any response of Y or P should be fully explained in the associated Appendix.	
12] List the anticipated MNA completion date presented in the original CAP Submission?	2014 for Proposal for Presumptive Remedies
13] Based on CASE period data, what is the current anticipated MNA completion date?	2029
14] Were there any performance problems or Operations and Maintenance issues associated with MNA components during CASE period?'	Yes
15] (if yes to 14) Were these problems rectified during CASE period?	Yes
16] Were GPS achieved in all portions of the plume during CASE period?	No
17] (if no to 16) List any MNA wells that did achieve GPS during CASE period: MW-6, MW-X1, CLF-1, MW-1B, MW-1C, MW-2B, and CLF-15A, as well as proposed corrective action wells MW-1D, MW-1E, MW-1F, MW-1G, and MW-1H	
18] How many compliance wells continue to *exceed* GPS during CASE Period?	Three (MW-1B, MW-2B, and MW-3A)
19] Did any formerly 'clean' Compliance wells exceed GPS during this CASE period?	No
20] Compared to previous data, did GW quality improve in at least some of the Performance wells during CASE Period?	Yes, See Section 3.2
21] Compared to previous data, did the GW quality improve in at least some of the Sentinel wells during CASE Period?	No
22] Was there any evidence of lateral or vertical plume expansion during CASE Period?	Yes
23] (if yes to 22) Were any new wells installed to address expansion during CASE Period?	Yes
24] Are any MNA wells screened below the base of the GPS exceeding areas of the plume?	Yes

25] Are there clean sentinel wells (*i.e*. no GPS exceedance) located at the edge of the plume?	Yes
26] Was remedy protective of human health and environment during entire CASE Period?	Yes
27] Was there a remedy component in place to control source of release during CASE Period?	Yes
28] Did any MNA wells exceed MCL-based GPS during the CASE Period?	Yes
29] Did any MNA wells exceed BKG-based GPS during the CASE Period?	Yes
30] Did any MNA wells exceed ACL-based GPS during the CASE Period?	Yes
31] Are there Performance wells located downgradient from each exceeding Compliance well?	Yes
32] Was surface water sampling part of the MNA remedy?	No
33] Did surface water sampling results show concentrations in excess of GPS in surface water?	Not Applicable
Section B - Groundwater Sampling: Please use 'Y', 'N', 'NA' - not applicable, or 'P'- possibly, where needed. Any response of Y or P should be fully explained in the associated Appendix.	
34] Were all Permit-listed MNA network wells (list below) sampled during CASE period?	Yes
35] If not, list the wells which could not be sampled:	Not Applicable
36] List the reason for the non-sampling during CASE period:	Not Applicable
37] Other than issues noted above, were all Corrective Action related wells sampled at the required quarterly or semi-annual frequency outlined In Module XIV during CASE period?	Yes
38] (if no to 37) List the reason for the non-frequency sampling:	Note Applicable
39] Were all MNA related wells sampled for constituents of Module XIV during CASE period?	Yes
40] (if no to 39) List the reason for the non-sampling of Permit required constituents:	Not Applicable
41) Were all analysis during CASE period conducted by VELAP certified facilities?	Yes
42] Did analytical results support biologic destruction of the waste mass during the CASE period based on changes in downgradient parent/daughter ratios?	Yes
43] Did results of MNA performance parameter sampling support biologic destruction of waste mass based on changes in electron receptor/donors within the plume of contamination?	Yes
44] Are copies of all sampling event analytical results obtained during the CASE Period attached as an Appendix to this report in CDROM format?	Yes
Section C - Risk Exposure Factors: Please use 'Y', 'N', 'NA' - not applicable, or 'P'- possibly, where needed. Any response of Y or P should be fully explained in the associated Appendix.	
45] Does owner/operator legally own/control all areas currently underlain by landfill contaminated groundwater (*i.e.,* those portions of the plume that exceed GPS)?	Yes

46] (If no to #45) Provide the name of current ownership: Not Applicable	
47] Was there any potential for exposure of humans or environmental receptors to contaminated groundwater during the CASE Period?	Yes
48] Was there any change in adjacent property land-use during the CASE Period which could change the potential exposure risks previously defined during remedy selection?	No
49] Are source area containment components in place to prevent exposure and minimize future releases?	Yes
50] Was there any remedy related site activity which created a short-term exposure risk to workers or the environment during the CASE period?	Yes
51] Is there any potential for vapor intrusion issues above the landfill contaminant plume?	Yes
52] Is groundwater currently used (or potentially used) on site for any reason?	Yes
53] Is groundwater currently or potentially used as a potable water source in the landfill area?	Yes
54] (if needed) Is there an alternate drinking water supply in the vicinity of the landfill?	Yes
55] Is there evidence (or potential for) plume discharge (levels above LOQ) to surface water?	No
Section D - Interpretation of Analytical Results: Please use 'Y', 'N', 'NA'- not applicable, or 'P'- possibly, where needed. Any response of Y or P should be fully explained in the associated Appendix.	
56] What statistical method was used to assess groundwater trends during CASE Period: Mann-Kendall Statistical Evaluations	
57] Was prior CASE period data pooled with current CASE data to develop the time series plots?	Yes
58] Were any unusual statistical problems noted (*i.e.* outliers)?	No
59] Were time series plots provided individually for all GPS exceeding constituents in each MW they were identified in during the CASE period?	Yes
60] When looking solely at Sentinel well data during the CASE period, did any constituents show upward trending concentration behavior in any well (if so, list constituent(s) on the line below)?	No, see Section 6.3
61] When looking solely at Performance well data during the CASE period, did any constituents show upward trending concentration behavior in any well (if so, list constituent(s) on the line below)?	Yes
62] When looking solely at Compliance well data during the CASE period, did any constituents show upward trending concentration behavior (If so, list constituent(s) on the line below)?	Yes
63] Do the down-plume changes in stoichiometric Parent/Daughter ratios confirm breakdown of contaminant mass?	Yes
64] Do the results of EPA MNA performance parameter sampling (*i.e.*, redox potential, DO, manganese (II), iron (II), sulfate, methane, etc.) and electron donors vs acceptors document biological breakdown of contaminant mass?	Yes
Section E - Future Actions: Please use 'Y', 'N', 'NA' - not applicable, or 'P' - possibly, where needed. Any response of Y or P should be fully explained in the associated Appendix.	
65] Based on the data acquired during this CASE period and reviewed in context of data collected during previous CASE periods, does the Implemented remedy have the ability to achieve all GPS within a reasonable timeframe.	Yes

66] (If no to 65) Is Interim Measure use Justifiable on site?	Not Applicable
67] (if no to 65 and 66) Is Alternate Remedy application justified on site (if yes list remedy type on-line below)?	Not Applicable
68] Is the Alternate Remedy discussed in detail in the current CAP?	Yes
69] (if no to 65-67) Will owner/operator be submitting a technically infeasible demonstration (as defined in the VSWMR) to the Director?	Not Applicable
70] Are there any other actions planned for the site during the upcoming CASE period not currently covered by the existing CAP?	No
Attachments. The following attachments must be Included in the CASE in the order prescribed.	
Attachment I: Site Identified on a USGS 7 1/2-minute Topographic Map	
Attachment II: Property Map(s)	
Attachment III: Aerial Photograph(s). Please refer to Attachment II for an aerial photograph of the Facility.	
Attachment IV: GW flow rate calculations (based on most recent CASE period sampling event)	
Attachment V: Potentiometric Surface Map, scaled to fit a size no larger than 11" x 17", based on the most recent CASE period sampling event.	
Attachment VI: Table of constituents exceeding GPS, listed for each well based on all available sampling data obtained post remedy implementation.	
Attachment VII: Vertical and Horizontal Plume maps provided for each GPS exceeding constituent on site (wherever possible sized to fit on an 11" x 17" sheet)	
Attachment VIII: Complete Laboratory Analytical Reports (including Verification events) for each sampling event during the CASE period	
Attachment IX: Chain of Custody and Field Book documentation (including Verification events) for each sampling event during theCASE period	
Attachment X: Statistical Analysis and Time Series Data Plots for each GPS exceeding constituent identified within individual wells sampled during the CASE period	
Attachment XI: Parent/Daughter Ratio Evaluation (Added by the Authors)	
Attachment XII: MNA Parameter Evaluations (Added by the Authors)	
Appendices. The following should be included as needed following instructions in the SI. If an Appendix is not going to be used, insert its title page followed by the word "reserved".	
Appendix A - Remedy/Plume behavior, Detailed Discussion	

Appendix B - Groundwater Sampling, Detailed Discussion	
Appendix C - Risk Exposure Factors	
Appendix D - Interpretation of Analytical Results, Detailed Discussion	
Appendix E - Future Actions	
Responsible Official Signature	
I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.	
Name: Paul E. Howard, Jr.	Title: Director of Environmental Services
Signature: Paul E Howard	Date: 11/5/2020

3.0 REMEDY / PLUME BEHAVIOR (APPENDIX A)

The following sections of Appendix A provide additional detailed information in reference to specific line items of Section A (Remedy / Plume Behavior) of Form-1 provided in SI-25. As required by SI-25, additional information is provided below regarding "yes" or "possibly" responses provided in Form-1. Additional information is provided regarding "no" or "not applicable" responses provided in Form-1, as determined appropriate by Golder.

3.1 Performance Issues/Operations & Maintenance Issues (Section A, Questions 14 & 15)

The Facility has both passive and active landfill gas management systems, including passive gas vents, a passive gas collection trench, and active gas extraction system. On April 25, 2019, the Facility reported that gas extraction system blower was turning off unexpectedly, requiring manual restarting. On May 2, 2019, the County reported a temporary shutdown of the gas extraction system due to a malfunction of the blower, which was sent offsite for repair. A replacement blower was ultimately procured and installed on July 11, 2019. The new blower was then found to be inoperable during a daily site inspection conducted on October 28, 2019, and as a result was sent offsite for repairs. A backup blower was procured and installed on November 4 and 5, 2019, but experienced a catastrophic failure upon startup, and was also returned to the manufacturer for repairs.

The primary blower (AMTEK 3-Horse Power (HP) 3-Phase 208-volt regenerative blower) was returned to service on January 28, 2020, and the backup blower [AMTEK 5-Horse Power (HP) 3-Phase 208 volt regenerative blower] is currently staged on site to facilitate immediate installation in the event of another system upset. Subsequently during the monthly monitoring event in March 2020, an open clean out associated with the gas collection system sump was discovered which was diluting the available vacuum in the well field. This open clean out is believed to be the source of the gas exceedance documented on March 18, 2020. The clean out was sealed and the gas system has continued to operate as designed since.

3.2 Performance Well Groundwater Quality (Section A, Question 20)

As presented in the trend charts and associated Mann-Kendall statistics in Attachment X, groundwater quality improved as witnessed by decreasing COC concentrations in the following performance wells.

Performance Well	Plume	Constituent of Concern
CLF-1	CLFP-1	1,1-Dichloroethane
CLF-15A	CLFP-3	Trichloroethene
MW-1B	CLFP-2	1,1-Dichloroethane Trichloroethene Vinyl Chloride

Performance Well	Plume	Constituent of Concern
MW-1C	CLFP-2	1,1-Dichloroethane Trichloroethene
MW-1D (Proposed Well)	CLFP-2	1,1-Dichloroethane Vinyl Chloride
MW-2B	CLFP-2	1,1-Dichloroethane Trichloroethene Vinyl Chloride
MW-4	CLFP-1	1,1-Dichloroethane
MW-6	CLFP-1	1,1-Dichloroethane Vinyl Chloride

These results indicate the presumptive remedies for CLFP-1 and CLFP-2 plumes are exerting the desired effect and plume concentrations around the immediate perimeter of the closed landfill are beginning or continuing to decline. Similarly, the MNA remedy for the CLFP-3 plume is exerting the desired effect with COC concentrations either remaining steady or declining.

3.3 Plume Expansion (Section A, Line 22)

As presented in the trend chart and associated Mann-Kendall statistics in Attachment X, evidence of plume expansion during the current CASE period is observed in the following wells.

Well	Plume	Constituent of Concern
MW-1E	CLFP-2	Vinyl Chloride
MW-1F	CLFP-2	1,1-Dichloroethane Trichloroethene Vinyl Chloride
MW-1G	CLFP-2	Cobalt
MW-1H	CLFP-2	1,1-Dichloroethane Trichloroethene Vinyl Chloride

These results indicate that the residuals of the CLFP-2 volatile organic compound plume, which is attenuating, are migrating further downgradient in the fractured bedrock beneath the Facility. Based on the expected fate and transport behavior for the COCs in a fractured bedrock regime, some plume migration is expected as the concentrations are attenuated, and the observed migration is not presenting additional risk nor is it migrating off site.

3.4 New Wells Installed for Plume Expansion (Section A, Line 23)

In response to the CLFP-2 plume expansion, no new wells were installed; however, the County has been voluntarily monitoring additional downgradient wells. These wells include MW-1D, MW-1E, MW-1F, MW-1G, MW-1H, and MW-1I. Inclusion of these additional wells as performance wells in the corrective action program was proposed in the 2018 updated CAMP that was submitted to the DEQ for review and processing in 2018. As of the date of this report the updated CAMP has not been approved by DEQ.

3.5 Vertical Delineation of Above-GPS COCs (Section A, Line 24)

As presented on the isoconcentration maps and cross sections in Attachment VII (Drawings 5-16), there are “clean” sentinel or performance wells screened beneath the base of the three groundwater plumes as follows.

Plume	Remedy	Unimpacted Wells
CLFP-1	Presumptive Remedies	MW-1I
CLFP-2	Presumptive Remedies	MW-1I
CLFP-3	Monitored Natural Attenuation	CLF-S1

As defined in the CASE submission instruction, clean refers to wells with no GPS exceedances.

3.6 Sentinel Well Exceedances (Section A, Line 25)

As presented on the isoconcentration maps in Attachment VII there are “clean” sentinel or performance wells on the downgradient perimeter of the three groundwater plumes as follows.

Plume	Remedy	Unimpacted Wells
CLFP-1	Presumptive Remedies	CLF-1 and MW-X1
CLFP-2	Presumptive Remedies	MW-1I
CLFP-3	Monitored Natural Attenuation	CLF-S3 and CLF-S1

As defined in the CASE submission instruction, clean refers to wells with no GPS exceedances.

3.7 Risk Evaluation (Section A, Line 26)

Based on the information presented on the isoconcentration maps and cross sections, the three groundwater plumes are limited to property that is owned by Culpeper County. Therefore, the current remedies which are based on presumptive remedies for the CLFP-1 and CLFP-2 plumes and MNA for the CLFP-3 plume are considered to be protective of human health and the environment for the CASE period covered by this Report.

3.8 Source Control (Section A, Line 27)

As detailed in the revised *Corrective Action Plan* prepared for the Facility (JEI, 2007), the remedies for the three groundwater plumes include controls that are designed to control the source of the release. These controls include a cap on the waste disposal units and a landfill gas collection and control system that has been installed on the main closed fill area. Site observations during the CASE reporting period indicate that these controls continue to be in place and are operated and maintained in a manner that controls the potential for future releases from the closed landfill.

3.9 MCL-Based GPS Exceedances (Section A, Line 28)

As presented in Table 2 in Attachment VI, and as summarized below, the following wells had Maximum Contaminant Level (MCL)-based GPS exceedances during the current CASE reporting period.

Constituent of Concern	Performance Monitoring Wells
Trichloroethene	CLF-15A
Vinyl Chloride	MW-1B, MW-1C, MW-1D, MW-1E, MW-1F, MW-1G and MW-1H

3.10 Background-Based GPS Exceedances (Section A, Line 29)

As presented in Table 2 in Attachment VI, and as summarized below, the following wells had background-based GPS exceedances during the current CASE reporting period.

Constituent of Concern	Performance Monitoring Wells
Cobalt	MW-1B, MW-2B, MW-3A, MW-1C, MW-5, MW-6, MW-X1, and CLF-1

3.11 ACL-Based GPS Exceedances (Section A, Line 30)

As presented in Table 2 in Attachment VI, and as summarized below, the following wells had Alternate Concentration Limit (ACL)-based GPS exceedances during the current CASE reporting period.

Constituent of Concern	Performance Monitoring Wells
1,1-Dichloroethane	MW-1B, MW-2B, MW-4, MW-1C, MW-1E, MW-1F, MW-1G, MW-1H, CLF-15A
Naphthalene	MW-4 (one-time suspect exceedance)

The naphthalene GPS exceedance occurred at MW-4 during the second semi-annual 2018 sampling event. The exceedance has not been confirmed during subsequent sampling events and is considered a suspect exceedance potentially associated with a false-positive laboratory analysis or field sampling error.

3.12 Performance Monitoring Network (Section A, Line 31)

As summarized in the following table, existing permitted or proposed performance wells are located downgradient from compliance wells with GPS exceedances.

Compliance Well	Performance Monitoring Wells
MW-1B	MW-3, MW-1D, MW-1F, MW-1G, MW-1H, and MW-1I
MW-2B	MW-3, MW-1D, MW-1F, MW-1G, MW-1H, and MW-1I
MW-3A	MW-3, MW-1D, MW-1F, MW-1G, MW-1H, and MW-1I
MW-4	MW-3, MW-1D, MW-1F, MW-1G, MW-1H, and MW-1I

4.0 GROUNDWATER SAMPLING (APPENDIX B)

The following sections of Appendix B provide additional detailed information in reference to specific line items of Section B (Groundwater Sampling) of Form-1 provided in SI-25. As required by SI-25, additional information is provided below regarding "yes" or "possibly" responses provided in Form-1. Additional information is provided regarding "no" or "not applicable" responses provided in Form-1, as determined appropriate by Golder.

4.1 MNA Sampling (Section B, Line 34)

As presented in Table 2 in Attachment VI, the permit-required and proposed performance and sentinel wells were sampled during each semi-annual event covered by the CASE period for required COCs. A summary of the wells and COCs is presented in the following table.

Plume	Performance Wells	Sentinel Wells
CLFP-1	MW-20, MW-4, MW-6, MW-XI, and CLF-1	None
CLFP-2	MW-20, MW-1B, MW-1C, MW-2B, MW-3A, and MW-5	None
	Proposed Wells: MW-D, MW-1E, MW-1F, MW-1G, and MW-1H	Proposed Well: MW-1I
CLFP-3	MW-X2, CLF-15A, PZ-4E	MW-X2D, CLF-S1, CLF-S3

4.2 Corrective Action Sampling (Section B, Line 37)

As presented in Table 2 in Attachment VI and the laboratory certificates of analysis in Attachment VIII, the corrective action program wells in the permit including the proposed new performance wells and sentinel wells in the updated 2018 CAMP were sampled on a semi-annual basis with the compliance monitoring wells for the Facility during the current 3-year CASE period covered by the Report.

4.3 Sampling Constituents (Section B, Line 39)

As presented in Table 2 in Attachment VI, the laboratory certificates of analysis in Attachment VIII, and as summarized below, the corrective action program wells in the permit including the proposed new performance wells and sentinel wells in the updated 2018 CAMP were sampled on a semi-annual basis for permit required constituents during the current 3-year CASE period covered by the Report.

Plume	Performance and Sentinel Wells	Monitoring Parameters
CLFP-1	MW-20, MW-4, MW-6, MW-XI, and CLF-1	Naphthalene, 1,1-dichloroethane, cobalt, and methane

Plume	Performance and Sentinel Wells	Monitoring Parameters
CLFP-2	MW-20, MW-1B, MW-1C, MW-2B, MW-3A, and MW-5; Proposed Wells: MW-D, MW-1E, MW-1F, MW-1G, MW-1H, and MW-1I	Cobalt, 1,1-dichloroethane, trichloroethene, vinyl chloride, and VOC daughter products
CLFP-3	MW-X2, CLF-15A, PZ-4E, MW-X2D, CLF-S1, and CLF-S3	1,1-Dichloroethane, Trichloroethene, Mercury, VOC daughter products, and the following MNA parameters: Dissolved Oxygen, nitrate/nitrite, ferrous iron, sulfate, sulfide, dissolved methane, chloride, alkalinity, oxidation-reduction potential, conductivity, and temperature

4.4 VELAP Accreditation (Section B, Line 41)

As presented in Attachments VIII and IX, the analyses required by the corrective action program were either completed in the field (field parameters) or by Air, Water & Soils Laboratories, now Enthalpy Analytical.

4.5 Parent/Daughter Ratios (Section B, Line 42)

The remaining three corrective action areas at the Facility contain four volatile organic compounds (VOCs) COCs (underlined constituents in the series) that may represent parent and daughter biodegradation series for which the ratios of parent/daughter molar concentrations may be evaluated as an indicator of the effectiveness of the MNA corrective action. The following table shows the potential degradation series.

Corrective Action Areas with Parent / Daughter Biodegradation Products

Corrective Action Area	Parent Product(s)	Sequential Biodegradation Product(s)		
CLFP-2 and CLFP-3	Tetrachloroethene (and potentially Trichloroethene)	Trichloroethene	cis-1,2-Dichloroethene	Vinyl Chloride
CLFP-2 and CLFP-3	1,1-Dichloroethane	Chloroethane	Ethane (Reductive Dechlorination)	Ethanol (Hydrolysis)

The remaining COC, cobalt is naturally occurring, and the source of the currently observed GPS exceedances is attributed to mobilization via reductive dissolution of iron and other minerals that provide cation sorption sites.

As presented in the parent/daughter ratio evaluations for chlorinated VOC COCs in Attachment XI, strong evidence of biodegradation (*i.e.*, destruction) of COCs is present at the Facility as discussed in the following sections.

4.5.1 1,1-Dichloroethane Daughter Product Ratios

As presented in Chart 1 in Attachment XI, Golder evaluated the available 1,1-dichloroethane and associated daughter product chloroethane concentrations from the available sentinel and performance wells over the 2016 through 2020 timeframe. The data were evaluated on a molar mass basis (microMoles). Assuming constant rates of degradation for the parent and daughter products, the expected ratio would be 1:1 between the two compounds. As presented in Chart 1, the analysis indicates that data plot on a 1,1-dichloroethane rich trend with an approximate ratio of 3:1 (1,1-dichloroethane to chloroethane).

The 3:1 ratio could be due to a number of factors, including a difference in the degradation rate between the parent and daughter product such that the degradation rate for chloroethane via hydrolysis to ethanol and/or reductive dechlorination to ethane is greater than the rate from 1,1-dichloroethane to chloroethane; or, due to an accumulation of 1,1-dichloroethane resulting from a reduced rate of degradation from 1,1-dichloroethane to chloroethane. Based on review of the concentration trend charts in Attachment X and the historical analytical results in Table 2 (Attachment VI), with the exception of CLF-15A and MW-1H, the 1,1-dichloroethane concentrations have been decreasing across the board suggesting that attenuation of 1,1-dichloroethane is occurring. Therefore, the absence of a correlating chloroethane daughter product at a 1:1 ratio is attributed to the more rapid attenuation of the daughter product and not a stall in the 1,1-dichloroethane attenuation rate.

4.5.2 Tetrachloroethene Daughter Product Ratios

As presented in Chart 2 in Attachment XI, Golder evaluated the available tetrachloroethene and associated daughter product trichloroethene concentrations from the available sentinel and performance wells over the 2016 through 2020 timeframe. The data were evaluated on a molar mass basis (microMoles). Assuming constant rates of degradation for the parent and daughter products, the expected ratio would be 1:1 between the two compounds. As presented in Chart 2, the analysis indicates that data plot on a trichloroethene rich trend with an approximate ratio of 1:9 (tetrachloroethene to trichloroethene).

The 1:9 ratio could be due to a number of factors, including a difference in the degradation rate between the parent and daughter product such that the degradation rate for tetrachlorethene to trichloroethene via reductive dechlorination is greater than the rate from trichloroethene to dichloroethane (1,2-cis, 1,2-trans, or 1,1-) resulting in an accumulation of trichloroethene. Based on review of the concentration trend charts and the historical analytical results in Table 2 (Attachment VI), with the exception of MW-1H, the trichloroethene concentrations have been decreasing across the board suggesting that attenuation of trichloroethene is occurring. Therefore, the 1:9 ratio is largely attributed to the lack of detectable concentrations of parent product (tetrachloroethene) in the majority of the samples analyzed during the timeframe considered (*i.e.*, the trichloroethene data were plotted against a concentration of 0.0 uMoles for tetrachloroethene in samples where tetrachloroethene has not been detected recently, and against a concentration of 0.2 uMoles (half of the method detection limit) for locations where tetrachloroethene has been detected at low concentrations).

4.5.3 Trichloroethene Daughter Product Ratios

As presented in Chart 3 in Attachment XI, Golder evaluated the concentrations of trichloroethene and associated daughter products isomers cis- and trans-1,2-dichloroethene, as well as 1,1-dichloroethene, from the available sentinel and performance wells over the 2016 through 2020 timeframe. The data were evaluated on a molar mass basis (microMoles). As with previous parent/daughter discussions, assuming constant rates of degradation for the parent and daughter products, the expected ratio would be 1:1 between the two compounds. As presented in Chart 3, the analysis indicates that data plot on a dichloroethene isomer (primarily cis-1,2-dichloroethene) rich trend with an approximate average ratio of 1:4 (trichloroethene to dichloroethene isomer). Of interest, there are two apparent trends, one trending with a ratio of approximately 1:2.5 and a second trending approximately 1:10. The differences are likely associated with concentrations with the higher ratio expected in higher COC concentration areas due to higher biological activity rates.

As with the tetrachloroethene to trichloroethene degradation process, the 1:4 average ratio could be due to a number of factors, including a difference in the degradation rate between the parent and daughter product such that the degradation rate for trichloroethene to an isomer of dichloroethene via reductive dechlorination is greater than the rate from dichloroethene (1,2-cis, 1,2-trans, or 1,1-) to vinyl chloride. This condition, typically referred to as a “cis”stall is common and can result in an accumulation of dichloroethene. Based on review of the historical analytical results in Table 2 (Attachment VI) and the Mann-Kendall statistics in Attachment X, with the exception of MW-1E, MW-1F, MW-1G, MW-1H, and PZ-4E, the dichloroethene isomer concentrations have been decreasing across the board suggesting that attenuation of dichloroethene isomers is occurring. Therefore, the 1:10 ratio is attributed to the more rapid attenuation of the parent product (trichloroethene) and not a stall in the daughter product attenuation rate.

Monitoring wells MW-1E, MW-1F, MW-1G, MW-1H, and PZ-4E all have increasing cis-1,2-dichloroethene concentrations at the 80% or 90% level of confidence, however, the cis-1,2-dichlorethene concentrations in these wells are all currently significantly less than the GPS based on the EPA’s Maximum Contaminant Level of 70 micrograms per liter (ug/L).

4.5.4 Dichloroethene Daughter Product Ratios

As presented in Chart 4 in Attachment XI, Golder evaluated the concentrations of isomers cis- and trans-1,2-dichloroethene, as well as 1,1-dichloroethene, and associated daughter product vinyl chloride from the available sentinel and performance wells over the 2016 through 2020 timeframe. The data were evaluated on a molar mass basis (microMoles). As with previous parent/daughter discussions, assuming constant rates of degradation for the parent and daughter products, the expected ratio would be 1:1 between the two compounds. As presented in Chart 4, the analysis indicates that data plot on a dichloroethene isomer (primarily cis-1,2-dichloroethene) rich trend with an approximate average ratio of 4:1 (dichloroethene isomer to vinyl chloride). Of interest, there are two apparent trends, one trending with a ratio of approximately 6:1 and a second trending approximately 2.5:1. The differences are likely associated with concentrations with the higher ratio expected in higher COC concentration areas due to higher biological activity rates.

As with the previous evaluations, the average 4:1 ratio could be due to a number of factors, including a difference in the degradation rate between the parent and daughter product such that the degradation rate for dichloroethene isomers via reductive dechlorination to vinyl chloride is lower than the degradation rate for vinyl chloride to methane. Based on review of the historical analytical results in Table 2 (Attachment VI) and the Mann-Kendall statistics in Attachment X, with the exception of MW-1E, MW-1F, and MW-1H the vinyl chloride concentrations have been decreasing across the board suggesting that vinyl chloride is not accumulating significantly. Therefore, the 4:1 ratio is attributed to the more rapid attenuation of the parent product (dichloroethene) and not a stall in the daughter product attenuation rate.

Monitoring wells MW-1E, MW-1F, and MW-1H have increasing vinyl chloride concentrations at the 90%, 95%, and 99% levels of confidence, respectively. Review of the trend charts in Attachment X indicates that the vinyl chloride concentrations at these three wells have increased to above GPS concentrations over the last 3 years. These three wells are located on the periphery of the CLFP-2 plume, such that continued monitoring of the concentration trends is warranted to determine if conditions for excessive risk develop that could warrant additional remedial actions.

4.6 MNA Indicators (Section B, Line 43)

The available MNA parameter results were evaluated using the United States Environmental Protection Agency MNA evaluation protocol (EPA, 1988). Specifically, the MNA performance indicator data for the performance and sentinel wells at the Facility were evaluated as presented in Attachment XII using the EPA-supplied thresholds for optimum conditions. As presented, monitoring data indicate that conditions continue to be conducive for MNA at MW-1B, MW-1D, MW-1E, MW-1H, MW-2B, MW-6, CLF-1, and CLF-S3.

In summary, the limited MNA indicator parameter data that is collected for the Facility generally supports conditions that are conducive for biodegradation of the primary COCs and associated daughter products. Additionally, perhaps the strongest evidence for biological natural attenuation lies in the measured concentrations of biodegradation daughter products, the indicators of full COC mass biodegradation assessed by parent/daughter ratios (see Section 4.5 of this report), and the documented protection of sensitive receptors provided by the current site-wide Presumptive Remedies/MNA remedy.

4.7 Analytical Data (Section B, Line 44)

Electronic copies of laboratory analytical reports for monitoring conducted during the CASE period are presented in Attachment VIII.

5.0 RISK EXPOSURE FACTORS (APPENDIX C)

The following sections of Appendix C provide additional detailed information in reference to specific line items of Section C (Risk Exposure Factors) of Form-1 provided in SI-25. As required by SI-25, additional information is provided below regarding "yes" or "possibly" responses provided in Form-1. Additional information is provided regarding "no" or "not applicable" responses provided in Form-1, as determined appropriate by Golder.

5.1 Legal Control (Section C, Line 45)

As shown on Drawings 1 and 3 in Attachments I and III, Culpeper County legally controls as part of the Facility boundary or subsequent property acquisitions all of the areas for which groundwater has been impacted above the GPS concentrations.

5.2 Receptor Exposure (Section C, Line 47)

The potential for human exposure to COCs is present during each groundwater sampling event. To control the risks associated with the groundwater sampling events, the sampling crew wears appropriate personal protective equipment (PPE) and uses appropriate engineering controls, including purge water management, to control the exposure to COCs during the sampling events.

A potential for environmental receptor exposure exists to the north of the plume (on Culpeper County property) where artesian groundwater conditions exist. As of the date of this report there have been no GPS exceedances for the COCs documented at MW-1I. Performance well MW-1I is the most downgradient of the performance wells at the Facility and is an artesian well that would be indicative of potential environmental exposure.

5.3 Exposure and Release Controls (Section C, Line 49)

As discussed in the Facility's Corrective Action Plan (JEI, 2007), the following engineering controls are in place as presumptive remedies to prevent exposure and minimize future releases.

- Landfill Cap
- Landfill Gas Collection and Control System

Based on the available information, including more than 12 years of post-remediation program implementation groundwater monitoring data, Golder believes that the engineering controls at this Facility are effective in helping to control and prevent current and future impacts to groundwater beneath the Facility.

5.4 Short-Term Exposure (Section C, Line 50)

As discussed in Section 5.2, sampling of the groundwater and operation of the landfill gas collection and control system creates the potential for short-term exposure of site workers to the COCs. However, the site workers are trained to be aware of the COCs and potential exposure routes and use appropriate engineering controls and PPE to minimize the exposure.

5.5 Vapor Intrusion (Section C, Line 51)

There is a potential for vapor intrusion in the vadose zone above the groundwater plume. However, other than the Facility's on-slab open-air Quonset hut that is used for storage of equipment, there are no receptor structures overlying the groundwater plumes or within a near vicinity of the plume that could reasonably be expected to be impacted by vapor emissions from the groundwater plumes.

5.6 Current or Potential Groundwater Use (Section C, Line 52)

As discussed in previous CASE Reports Culpeper County maintains one well on site that is used for non-potable water use at the transfer station. This well is located to the south of the CLFP-1, CLFP-2, and CLFP-3 groundwater plumes and is not located in an area that has impacted groundwater. There are no known at-risk potable-use water supply wells located within the immediate vicinity of the Facility downgradient from one of the delineated plumes.

5.7 Potable Groundwater Use (Section C, Line 53)

As discussed in Section 5.6, there are no known at-risk potable-use water supply wells located within the immediate vicinity of the Facility downgradient from one of the delineated plumes. The County continues to monitor the extent of the groundwater impacts at the Facility with clean sentinel/performance wells and should one or more off-site potable water supply wells be identified as being at risk in the future, Culpeper County operates a municipal water supply system in the vicinity of the Facility that can be used to provide clean portable water if needed.

5.8 Alternate Drinking Water Supply (Section C, Line 54)

As discussed in Section 5.7 Culpeper County operates a municipal water supply system in the vicinity of the Facility that can be used to provide clean portable water if needed.

6.0 INTERPRETATION OF ANALYTICAL RESULTS (APPENDIX D)

The following sections of Appendix D provide additional detailed information in reference to specific line items of Section D (Interpretation of Analytical Results) of Form-1 provided in SI-25. As required by SI-25, additional information is provided below regarding “yes” or “possibly” responses provided in Form-1. Additional information is provided regarding “no” or “not applicable” responses provided in Form-1, as determined appropriate by Golder.

6.1 Pooling of Data (Section D, Line 57)

The trend charts in Attachment X show the available data for the COCs extending back to the mid-1990s for some wells. The Mann-Kendall statistical analyses presented in Attachment X were prepared with the most recent eight data points for each COC at each well. In most cases that is the last eight semi-annual sampling events that covers 4 years of monitoring.

6.2 Time-Series Plots (Section D, Line 59)

The trend charts in Attachment X show the available data for the COCs extending back to the mid-1990s for some wells. As presented, solid symbols represent detections of the COCs and the open symbols represent non-detects at the indicated concentrations.

6.3 Sentinel Well Trends (Section D, Line 60)

Trend charts for the sentinel wells are presented in Attachment X. The CLFP-3 plume is the only plume at the Facility that has sentinel wells. The other two plumes (CLFP-1 and CLFP-2) are monitored with performance wells only. Details regarding observed trends are discussed in the following sections.

6.3.1 Sentinel Well CLF-S1

As presented on the trend chart for sentinel well CLF-S1 in Attachment X, a suggested increasing trend appears to be present for the COCs; however, the suggested trends are associated with changes in laboratory quantitation limits and not detected results. Additionally, the visually suggestive trends are not confirmed statistically as presented in the Mann-Kendall summary statistics in Attachment X.

6.3.2 Sentinel Well CLF-S3

As presented on the trend chart for sentinel well CLF-S3 in Attachment X, there is a visually apparent declining trend for 1,1-dichloroethane with concentrations that are currently less than 1 ug/L.

6.3.3 Sentinel Well MW-X2D

Similar to sentinel well CLF-S1, the trend chart for sentinel well MW-X2D in Attachment X has suggested increasing trends for the COCs; however, the suggested trends are associated with changes in laboratory quantitation limits and not detected results. Additionally, the visually suggestive trends are not confirmed statistically as presented in the Mann-Kendall summary statistics in Attachment X.

6.4 Performance Well Trends (Section D, Line 61)

Trend charts for the performance wells are presented in Attachment X. Details regarding observed trends are discussed in the following sections.

6.4.1 Performance Well MW-4

Performance well MW-4 is used to monitor the CLFP-1 plume. As presented on the trend chart in Attachment X, there are no visually apparent increasing trends in the historical data for the well. Review of the Mann-Kendall statistical evaluations for the last 4 years in Attachment X also confirms that there are no statistically significant increasing trends with a 99% level of confidence. It is noted that a statistically significant decreasing trend is present for trichloroethene at a 99% level of confidence and a decreasing trend for 1,1-dichloroethane is present at an 80% level of confidence.

6.4.2 Performance Well MW-6

Performance well MW-6 is used to monitor the CLFP-1 plume. As presented on the trend chart in Attachment X, with the exception of cobalt, there are no visually apparent increasing trends in the historical data for the well. Review of the Mann-Kendall statistical evaluations for the last 4 years in Attachment X indicates that the cobalt trend is statistically significant at the 80% level of confidence but not at higher levels. The cobalt trend correlation is weak and is likely within the normal and expected variation associated with the sampling and analysis program. There is a statistically significant decreasing trend at the 90% level of confidence for vinyl chloride.

6.4.3 Performance Well MW-X1

Performance well MW-X1 is used to monitor the CLFP-1 plume. As presented on the trend chart in Attachment X, there are no visually apparent increasing trends in the historical data for the well. Review of the Mann-Kendall statistical evaluations for the last 4 years in Attachment X indicates that a statistically significant increasing trend at the 80% level of confidence is present for cobalt. The cobalt trend correlation is weak and is likely within the normal and expected variation associated with the sampling and analysis program.

6.4.4 Performance Well CLF-1

Performance well CLF-1 is used to monitor the CLFP-1 plume. As presented on the trend chart in Attachment X, there are no visually apparent increasing trends in the historical data for the well. Review of the Mann-Kendall statistical evaluations for the last 4 years in Attachment X indicates that a statistically significant increasing trend at the 80% level of confidence is present for cobalt. The cobalt trend correlation is weak and is likely within the normal and expected variation associated with the sampling and analysis program. There is also a statistically significant decreasing trend at the 80% level of confidence for 1,1-dichloroethane.

6.4.5 Performance Well MW-1B

Performance well MW-1B is used to monitor the CLFP-2 plume. As presented on the trend plot for this well in Attachment X, with exception of the highly variable cobalt concentrations there are no visually increasing trends in the recent (2010 to date) data for this well. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X the variable cobalt concentrations are not present at a statistically significant trend. There are statistically significant declining trends for 1,1-dichloroethane (90% confidence), trichloroethene (99% confidence), and vinyl chloride (80% confidence).

6.4.6 Performance Well MW-1C

Performance well MW-1C is used to monitor the CLFP-2 plume. As presented on the trend plot for this well in Attachment X, with exception of the highly variable cobalt concentrations there are no visually increasing trends in the recent (2010 to date) data for this well. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X the variable increasing cobalt concentrations are present at a statistically significant trend (80% confidence). The increasing cobalt trend correlation is weak and is likely within the normal and expected variation associated with the sampling and analysis program. There are statistically significant declining trends for 1,1-dichloroethane (80% confidence) and trichloroethene (99% confidence).

6.4.7 Performance Well MW-2B

Performance well MW-2B is used to monitor the CLFP-2 plume. As presented on the trend plot for this well in Attachment X, there are no visually increasing trends in the recent (2010 to date) data for this well. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X the variable cobalt concentrations are present at a statistically significant increasing trend (95% confidence). There are statistically significant declining trends for 1,1-dichloroethane (99% confidence), trichloroethene (95% confidence), and vinyl chloride (99% confidence).

6.4.8 Performance Well MW-3A

Performance well MW-3A is used to monitor the CLFP-2 plume. As presented on the trend plot for this well in Attachment X, there is a visually decreasing trends in the recent (2010 to date) cobalt data for this well. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X the variable cobalt concentrations are not present at a statistically significant trend. There is a weak statistically significant increasing trend for 1,1-dichloroethane (90% confidence).

6.4.9 Performance Well MW-5

Performance well MW-5 is used to monitor the CLFP-2 plume. As presented on the trend plot for this well in Attachment X, there are no visually apparent trends although some variable swings in cobalt concentrations are present over the last 5 years. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X the variable cobalt concentrations are not present at a statistically significant trend.

6.4.10 Performance Well MW-X2

Performance well MW-X2 is used to monitor the CLFP-3 plume. As presented on the trend plot for this well in Attachment X, other than some detection limit associated visually apparent trends, there are no trends in detected concentrations for the COCs. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X there are no statistically significant trends in the COC data for this well with an 80% level of confidence.

6.4.11 Performance Well CLF-15A

Performance well CLF-15A is used to monitor the CLFP-3 plume. As presented on the trend plot for this well in Attachment X, there are no visually apparent trends for the COCs over the last 10 years. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X, other than a statistically significant decreasing trend for trichloroethane at the 99% level of confidence, there are no statistically significant trends in the COC data for this well.

6.4.12 Performance Well PZ-4E

Performance well PZ-4E is used to monitor the CLFP-3 plume. As presented on the trend plot for this well in Attachment X, there are no visually apparent trends for the COCs over the last 10 years. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X other than a statistically significant increasing trend for trichloroethane at the 90% level of confidence, there are no statistically significant trends in the COC data for this well. The statistically significant trend for trichloroethene is associated with data with reported concentrations that are less than 1 ug/L and thus no additional actions are warranted at this time.

6.5 Compliance Well Trends (Section D, Line 62)

Trend charts for the compliance wells are presented in Attachment X. Details regarding observed trends are discussed in the following sections.

6.5.1 Compliance Well MW-1B

Compliance well MW-1B is also a performance well used to monitor the CLFP-2 plume. As presented on the trend plot for this well in Attachment X, with exception of the highly variable cobalt concentrations there are no visually increasing trends in the recent (2010 to date) data for this well. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X the variable cobalt concentrations are not present at a statistically significant trend. There are statistically significant declining trends for 1,1-dichloroethane (90% confidence), trichloroethene (99% confidence), and vinyl chloride (80% confidence).

6.5.2 Compliance Well MW-2B

Compliance well MW-2B is also used as a performance well to monitor the CLFP-2 plume. As presented on the trend plot for this well in Attachment X, there are no visually increasing trends in the recent (2010 to date) data for this well. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X the variable cobalt concentrations are present at a statistically significant increasing trend (95% confidence). There are statistically significant declining trends for 1,1-dichloroethane (99% confidence), trichloroethene (95% confidence), and vinyl chloride (99% confidence).

6.5.3 Compliance Well MW-3A

Compliance well MW-3A is also used as a performance well to monitor the CLFP-2 plume. As presented on the trend plot for this well in Attachment X, there is a visually decreasing trends in the recent (2010 to date) cobalt data for this well. As presented in the Mann-Kendall statistics for the last 4 years in Attachment X the variable cobalt concentrations are not present at a statistically significant trend. There is a weak statistically significant increasing trend for 1,1-dichloroethane (90% confidence).

6.5.4 Compliance Well MW-4

Compliance well MW-4 is used as a performance well to monitor the CLFP-1 plume. As presented on the trend chart in Attachment X, there are no visually apparent increasing trends in the historical data for the well. Review of the Mann-Kendall statistical evaluations for the last 4 years in Attachment X also confirms that there are no statistically significant increasing trends with a 99% level of confidence. It is noted that a statistically significant decreasing trend is present for trichloroethene at a 99% level of confidence and a decreasing trend for 1,1-dichloroethane is present at an 80% level of confidence.

6.6 Contaminant Mass Destruction (Section D, Line 63)

As discussed previously herein in Section 4.5, and as presented in Charts 1 through 4 in Attachment XI, the available stoichiometric data for COC masses supports a determination of COC mitigation through either biodegradation and/or abiotic (hydrolysis) degradation. Details are discussed in the following sections.

6.6.1 1,1-Dichloroethane Daughter Product Ratios

As presented in Chart 1 in Attachment XI, Golder evaluated the available 1,1-dichloroethane and associated daughter product chloroethane concentrations from the available sentinel and performance wells over the 2016 through 2020 timeframe. The data were evaluated on a molar mass basis (microMoles). Assuming constant rates of degradation for the parent and daughter products, the expected ratio would be 1:1 between the two compounds. As presented in Chart 1, the analysis indicates that data plot on a 1,1-dichloroethane rich trend with an approximate ratio of 3:1 (1,1-dichloroethane to chloroethane).

The 3:1 ratio could be due to a number of factors, including a difference in the degradation rate between the parent and daughter product such that the degradation rate for chloroethane via hydrolysis to ethanol and/or reductive dechlorination to ethane is greater than the rate from 1,1-dichloroethane to chloroethane; or, due to an accumulation of 1,1-dichloroethane resulting from a reduced rate of degradation from 1,1-dichloroethane to chloroethane. Based on review of the concentration trend charts in Attachment X and the historical analytical results in Table 2 (Attachment VI), with the exception of CLF-15A and MW-1H, the 1,1-dichloroethane concentrations have been decreasing across the board suggesting that attenuation of 1,1-dichloroethane is occurring. Therefore, the absence of a correlating chloroethane daughter product at a 1:1 ratio is attributed to the more rapid attenuation of the daughter product and not a stall in the 1,1-dichloroethane attenuation rate.

6.6.2 Tetrachloroethene Daughter Product Ratios

As presented in Chart 2 in Attachment XI, Golder evaluated the available tetrachloroethene and associated daughter product trichloroethene concentrations from the available sentinel and performance wells over the 2016 through 2020 timeframe. The data were evaluated on a molar mass basis (microMoles). Assuming constant rates of degradation for the parent and daughter products, the expected ratio would be 1:1 between the two compounds. As presented in Chart 2, the analysis indicates that data plot on a trichloroethene rich trend with an approximate ratio of 1:9 (tetrachloroethene to trichloroethene).

The 1:9 ratio could be due to a number of factors, including a difference in the degradation rate between the parent and daughter product such that the degradation rate for tetrachlorethene to trichloroethene via reductive dechlorination is greater than the rate from trichloroethene to dichloroethane (1,2-cis, 1,2-trans, or 1,1-) resulting in an accumulation of trichloroethene. Based on review of the concentration trend charts and the historical analytical results in Table 2 (Attachment VI), with the exception of MW-1H, the trichloroethene concentrations have been decreasing across the board suggesting that attenuation of trichloroethene is occurring. Therefore, the 1:9 ratio is attributed to the more rapid attenuation of the daughter product (trichloroethene) and not a stall in the daughter product attenuation rate.

6.6.3 Trichloroethene Daughter Product Ratios

As presented in Chart 3 in Attachment XI, Golder evaluated the concentrations of trichloroethene and associated daughter products isomers cis- and trans-1,2-dichloroethene, as well as 1,1-dichloroethene, from the available sentinel and performance wells over the 2016 through 2020 timeframe. The data were evaluated on a molar mass basis (microMoles). As with previous parent/daughter discussions, assuming constant rates of degradation for the parent and daughter products, the expected ratio would be 1:1 between the two compounds. As presented in Chart 3, the analysis indicates that data plot on a dichloroethene isomer (primarily cis-1,2-dichloroethene) rich trend with an approximate average ratio of 1:4 (trichloroethene to dichloroethene isomer). Of interest, there are two apparent trends, one trending with a ratio of approximately 1:2.5 and a second trending approximately 1:10. The differences are likely associated with concentrations with the higher ratio expected in higher COC concentration areas due to higher biological activity rates.

As with the tetrachloroethene to trichloroethene degradation process, the 1:4 average ratio could be due to a number of factors, including a difference in the degradation rate between the parent and daughter product such that the degradation rate for trichloroethene to an isomer of dichloroethene via reductive dechlorination is greater than the rate from dichloroethene (1,2-cis, 1,2-trans, or 1,1-) to vinyl chloride. This conditions, typically referred to as a “cis”stall is common can result in an accumulation of dichloroethene. Based on review of the historical analytical results in Table 2 (Attachment VI) and the Mann-Kendall statistics in Attachment X, with the exception of MW-1E, MW-1F, MW-1G, MW-1H, and PZ-4E, the dichloroethene isomer concentrations have been decreasing across the board suggesting that attenuation of dichloroethene isomers is occurring. Therefore, the 1:9 ratio is attributed to the more rapid attenuation of the parent product (trichloroethene) and not a stall in the daughter product attenuation rate.

Monitoring wells MW-1E, MW-1F, MW-1G, MW-1H, and PZ-4E all have increasing cis-1,2-dichloroethene concentrations at the 80% or 90% level of confidence, however, the cis-1,2-dichlorethene concentrations in these wells are all currently significantly less than the GPS based on the EPA's Maximum Contaminant Level of 70 ug/L.

6.6.4 Dichloroethene Daughter Product Ratios

As presented in Chart 4 in Attachment XI, Golder evaluated the concentrations of isomers cis- and trans-1,2-dichloroethene, as well as 1,1-dichloroethene, and associated daughter product vinyl chloride from the available sentinel and performance wells over the 2016 through 2020 timeframe. The data were evaluated on a molar mass basis (microMoles). As with previous parent/daughter discussions, assuming constant rates of degradation for the parent and daughter products, the expected ratio would be 1:1 between the two compounds. As presented in Chart 4, the analysis indicates that data plot on a dichloroethene isomer (primarily cis-1,2-dichloroethene) rich trend with an approximate average ratio of 4:1 (dichloroethene isomer to vinyl chloride). Of interest, there are two apparent trends, one trending with a ratio of approximately 6:1 and a second trending approximately 2.5:1. The differences are likely associated with concentrations with the higher ratio expected in higher COC concentration areas due to higher biological activity rates.

As with the previous evaluations, the average 4:1 ratio could be due to a number of factors, including a difference in the degradation rate between the parent and daughter product such that the degradation rate for dichloroethene isomers via reductive dechlorination to vinyl chloride is lower than the degradation rate for vinyl chloride to methane. Based on review of the historical analytical results in Table 2 (Attachment VI) and the Mann-Kendall statistics in Attachment X, with the exception of MW-1E, MW-1F, MW-1H the vinyl chloride concentrations have been decreasing across the board suggesting that vinyl chloride is not accumulating significantly. Therefore, the 4:1 ratio is attributed to the more rapid attenuation of the parent product (dichloroethene) and not a stall in the daughter product attenuation rate.

Monitoring wells MW-1E, MW-1F, and MW-1H have increasing vinyl chloride concentrations at the 90%, 95%, and 99% levels of confidence, respectively. Review of the trend charts in Attachment X indicates that the vinyl chloride concentrations at these three wells have increased to above GPS concentrations over the last 3 years. These three wells are located on the periphery of the CLFP-2 plume, such that continued monitoring of the concentration trends is warranted to determine if conditions for excessive risk develop that could warrant additional remedial actions.

6.7 Performance Parameters (Section D, Line 64)

As presented in Attachment XII, the MNA performance indicator data for the performance and sentinel wells at the Facility were evaluated using the EPA-supplied thresholds for optimum conditions. As presented, monitoring data indicate that conditions continue to be conducive for MNA at MW-1B, MW-1D, MW-1E, MW-1H, MW-2B, MW-6, CLF-1, and CLF-S3.

7.0 APPENDIX E – FUTURE ACTIONS

The following sections of Appendix E provide additional detailed information in reference to specific line items of Section E (Future Actions) of Form-1 provided in SI-25. As required by SI-25, additional information is provided below regarding "yes" or "possibly" responses provided in Form-1. Additional information is provided regarding "no" or "not applicable" responses provided in Form-1, as determined appropriate by Golder.

7.1 Ability to Achieve GPS (Section E, Question 65)

Based on evaluation of the current CASE period data, Golder believes that the combination of presumptive remedies and MNA are sufficient to achieve all GPS at this Facility within a reasonable timeframe.

7.2 Alternate Remedy (Section E, Question 68)

The 2007 CAP (JEI, 2007) includes the use of enhance bioremediation as an alternative remedy should GPS be exceeded in downgradient sentinel wells associated with the CLFP-3 groundwater plume on the southern side of the Facility. As presented herein, none of the GPS for the COCs have been exceeded in the CLFP-3 sentinel wells CLF-S1 or CLF-S-3.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Culpeper County initiated a groundwater corrective action program at the Facility in 1999 in response to GPS in downgradient compliance wells for VOCs. In response to these exceedances Culpeper County submitted a Nature and Extent Study (NES) and a NES Addendum to the DEQ in December 1999, and April 2002, respectively. In support of the groundwater Corrective Action Program (CLFP-2 plume) Culpeper County submitted a *Proposal for Presumptive Remedies* (PPR) for the closed permitted landfill to the DEQ in June 2002. In response to groundwater impacts associated with two pre-1988 disposal units at the Facility, Culpeper County completed additional investigations in 2002 and 2003, including a site-wide *Quantitative Risk Assessment* (QRA) that was completed for the four delineated plumes at the Facility (CLFP-1 through CLFP-4) in October 2003. The QRA supported the use of a PPR for plumes CLFP-1 and CLFP-2 and recommended MNA for CLFP-3 and CLFP-4. With DEQ concurrence the final groundwater Corrective Action Program was formalized in the site-wide *Corrective Action Plan* dated January 2004 (JEI, 2004), and a supporting *Corrective Action Monitoring Plan* dated January 2004 (JEI, 2004). These documented were incorporated by DEQ into the Facility's solid waste permit in November 2008.

Subsequent to incorporation of the corrective action provisions Culpeper County has completed required quarterly and semi-annual groundwater monitoring, including data evaluations and reporting of the results in tri-annual CASE Reports. The CASE Reports have been submitted to the DEQ in 2011, 2014, and 2017. Based on the monitoring results and data evaluations, monitoring of the CLFP-4 plume was discontinued with DEQ verbal approval in a September 28, 2012, email followed by letter approval on July 9, 2013. This Report documents the sampling, analysis, and data evaluations completed for the groundwater corrective action program at the Facility in the November 2017 through October 2020 timeframe.

Based on evaluation of the monitoring results collected during the current CASE period, Golder believes that the current remedies continue to function as designed and are capable of achieving the corrective action program remediation goals within a reasonable timeframe. For the current monitoring period, there were three landfill-derived VOC COCs with GPS exceedances documented in the past 3 years. These COCs are 1,1-dichloroethane, vinyl chloride, and trichloroethene. In addition to the VOC COCs, there was a one-time suspect GPS exceedance documented in MW-4 during the September 2018 sampling event for naphthalene (no exceedances before or since). Finally, the reducing conditions associated with the release from the landfill has created conditions that are conducive to the dissolution of iron-oxyhydroxide minerals which has released cobalt to the groundwater at concentrations that exceed its GPS, and thus cobalt is a naturally occurring release-induced COC for this Facility.

For the current CASE period, with exception of cobalt, the combination of presumptive remedies and natural biological activity has combined to reduce the observed groundwater concentrations in the CLFP-1 plume to less than the COC-specific GPS. These results indicate that the PPR has been successful for the CLFP-1 plume and it is expected that with time, the groundwater geochemical conditions will revert to an oxidizing condition that will immobilize the residual dissolved cobalt. Continued monitoring of the CLFP-1 plume is recommended to verify that the landfill-derived COCs have been controlled and that the cobalt concentrations are naturally attenuating.

Review of the current CASE period data for the CLFP-2 plume indicates that the plume continues to expand downgradient from the closed landfill. However, the overall concentrations are reduced, and the risk is still controlled. Specifically, there was breakthrough for nested wells MW-1E and MW-1F (concentrations to be verified in 2nd semi-annual 2020 event) and in downgradient wells MW-1G and MW-1H in the CLFP-2 plume for 1,1-dichloroethane and vinyl chloride during the current CASE period. The last sentinel well MW-1I continues to be breakthrough free as of the date of this report. Evaluation of the analytical results indicates that the CLFP-2 plume continues to migrate deeper into the fractured bedrock. The depth of plume migration is expected to be limited however, since artesian aquifer conditions are documented to exist downgradient of the plume at location MW-1I. Based on evaluation of the concentration trends over the last 3 years it appears that the plume migration may have stabilized at its current limits. Continued monitoring of the CLFP-2 plume is recommended to verify that the extent of the landfill-derived COCs is stable. In the event that breakthrough in the form of a GPS exceedance is documented at MW-1I during any future events, a confirmation sample will be collected to verify the breakthrough. If verified breakthrough is confirmed, additional sentinel wells and/or implementation of the enhanced bioremediation remedy may be warranted to control the plume extent.

Review of the current CASE period MNA monitoring results for the CLFP-3 plume indicates that the MNA remedy is continuing to control the CLFP-3 plume on the southern side of the Facility. There are currently two COCs in the CLFP-3 plume, trichloroethene and 1,1-dichloroethane. The concentrations of these COCs at CLF-15A have been steady or declining since 2017 indicating that the plume is stable. Similarly, the concentration of 1,1-dichloroethane at sentinel well CLF-S3 has remained stable and less than the GPS since 2012. Trichloroethene is not detected at CLF-S3. The COC concentrations in sentinel well CLF-S1 continue to be non-detect. Continued monitoring of the CLFP-3 plume is recommended to verify that the landfill derived COCs have been controlled and that the cobalt concentrations in this area are naturally attenuating.

9.0 SIGNATURE SECTION

This Report has been prepared on behalf of Culpeper County, Virginia, for the closed Laurel Valley Center Sanitary Landfill, Permit No. 251 to satisfy the reporting requirements specified in 9VAC20-81-260 *et seq.* of the VSWMR and the Facility's solid waste permit. This document was prepared by qualified groundwater scientists and engineers who have received baccalaureate and/or post-graduate degrees in the natural sciences or engineering and who have sufficient training and experience in groundwater hydrology, engineering, statistical evaluations, and related fields as demonstrated by state professional registrations and completion of an accredited university program that enables sound professional judgments consistent with the industry standard of care for groundwater monitoring, contaminant fate and transport, environmental corrective actions, and cost estimate development.

GOLDER ASSOCIATES INC.

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10.0 REFERENCES

Department of Environmental Quality (DEQ). 2008. *Solid Waste Facility Permit, Permit No. 251*, Amendment 5, November 11.

DEQ. 2009. *Solid Waste Facility Permit, Permit No. 251*, Amendment 6, June 3.

DEQ. 2012. *Submission Instruction for Groundwater MNA-Based Corrective Action Site Evaluation (CASE) Reports at Solid Waste Landfills* (LPR-SW-SI-25). July 13.

DEQ. 2012. *FW: Culpeper – Plume CLFP-4*, email correspondence. September 28.

DEQ. 2013. *Corrective Action Completed – Plume CLFP-4.* July 9.

Environmental Protection Agency (EPA), United States. 1988. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water. Office of Research and Development. EPA/600/R-98/128. September.

Golder Associates Inc. (Golder). 2019a. *Laurel Valley Center Sanitary Landfill, Permit No. 251, Notification of Groundwater Protection Standard Exceedance, 2nd Semi-Annual 2019 Event.* November 14.

Golder. 2019b. *Laurel Valley Center Sanitary Landfill, Permit No. 251, Notification of Groundwater Protection Standard Exceedance, 2nd Semi-Annual Verification 2019 Event.* December 20.

Golder. 2020. *Closed Laurel Valley Center Sanitary Landfill, Permit No. 251, 2019 Annual Groundwater Monitoring Report*. March 4.

Joyce Engineering, Inc (JEI). 2004 (Revised May 2007). *Laurel Valley Center Sanitary Landfill, Permit Number 251*, *Corrective Action Plan*. January.

JEI. 2004 (Revised May 2007, August 2010, and November 2012). *Laurel Valley Center Sanitary Landfill, Permit Number 251, Corrective Action Monitoring Plan*. January.

https://golderassociates.sharepoint.com/sites/130478/Project Files/6 Deliverables/2020 CASE Report/2020-11-05 - 2020 Laurel Valley LDF CASE.docx