2017 RCRA Permit Application

Section C - Groundwater Monitoring

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C. GROUNDWATER MONITORING [40 C.F.R. § 270.14(C)]

This section of the permit renewal application provides information described in 40 C.F.R. § 270.14(c) for permit applications. The provisions in 40 C.F.R. § 270.14(c) are referenced in 40 C.F.R. § 270.28 (relating to information requirements for applications for post-closure permits). The information described in 40 C.F.R. § 270.14(c) generally pertains to groundwater monitoring and groundwater conditions at a facility covered by a permit application.

In accordance with the foregoing, this section of the permit renewal application provides a description of the groundwater monitoring program for the Facility. Consistent with the United States Environmental Protection Agency's ("EPA") reforms to the Resource Conservation and Recovery Act ("RCRA") corrective action process in 1999 and 2001 to promote faster and more focused cleanups, a holistic approach to site-wide groundwater monitoring will be implemented. This concept has been approved by the Environmental Protection Division ("EPD") through the Triad approach. The holistic site-wide approach will integrate post-closure activities for the closed surface impoundments with corrective action requirements for groundwater on a site-wide basis. Other elements of the post-closure plan for the closed surface impoundments are presented in Section E of this permit renewal application. The objective of the groundwater monitoring program is to continue to monitor site-specific constituents of potential concern in groundwater beneath the Facility.

C.1 INTERIM STATUS GROUNDWATER MONITORING [40 C.F.R. § 270.14(C)(1)]

The Facility is a permitted facility and has not operated under interim status since the Facility was originally issued Hazardous Waste Permit HW-052(D&S) by EPD on December 31, 1987. A description of groundwater monitoring activities performed during interim status is provided in previous permit applications.

C.2 GENERAL HYDROGEOLOGIC INFORMATION [40 C.F.R. § 270.14(C)(2)]

This section of the permit renewal application presents a description of the regional and site-specific geologic and hydrogeologic setting for the Facility consistent with the requirements of 40 C.F.R. § 2701.14(c)(2).

C.2.a Regional Geology and Hydrogeology

The Facility is located in Glynn County, Georgia. Glynn County lies in the Lower Coastal Plain geologic

province. **Figure C-1** presents a generalized geologic section of regional subsurface conditions. The strata in the Lower Coastal Plain geologic province are comprised of unconsolidated to semi-consolidated layers of sand and clay, and semi-consolidated to very dense layers of limestone and dolomite. The ages of these strata range from the Late Cretaceous Period to the Holocene Epoch. The strata can reach a maximum thickness of approximately 5,500 feet (ft.) in some areas of the Georgia coast. The strata generally strike southwest-northeast and dip to the southeast (Clarke, et. al., 1990).

The post-Miocene surficial strata consist of recent to Pliocene-age undifferentiated deposits. Miocene Epoch strata comprising a number of unconforming formations underlie the post-Miocene units to depths exceeding 500 ft. in the Brunswick area. The underlying Miocene strata include the Hawthorn Formation, which consists of clay, sandy silt, sand, limestone beds, and silty sands. (Clarke, et al., 1990). Deeper in the stratigraphic column, an Oligocene Epoch confining unit is present underlain by the Oligocene Epoch Suwannee Limestone and the Eocene Ocala Limestone.

Within these strata, there are a total of five aquifers in the Brunswick area. From shallowest to deepest, these are: (1) the surficial aquifer, which is divided into an upper unit (with shallow, intermediate and deep zones) and a lower unit; (2) the Upper Brunswick aquifer; (3) the Lower Brunswick aquifer; (4) the Upper Floridan aquifer; and (5) the Lower Floridan aquifer. The surficial aquifer occurs within the post-Miocene age deposits. The Upper Brunswick and Lower Brunswick aquifers are encountered within a series of Miocene-age formations. The Lower Brunswick aquifer is also encountered in upper Oligocene deposits. The Upper Floridan aquifer is primarily encountered in the Eocene-age Ocala Limestone, and the Lower Floridan aquifer is encountered within deeper Eocene and Paleocene units. These aquifers and corresponding lithologic units are shown on **Figure C-1**.

The surficial aquifer is comprised of interlayered sand, clay, and thin limestone beds. The surficial aquifer is estimated to be between 65 and 230 ft. thick. Clay layers/lenses within the surficial aquifer range from 5 to 40 ft. in thickness, and where laterally extensive, create confined or semi-confined conditions in the deeper portions of the upper surficial aquifer. Aquifer tests in the Brunswick area have confirmed the presence of these confined or semi-confined conditions (Clarke, et al., 1990).

Surficial aquifer characteristics were estimated by Gregg and Zimmerman (1974) and Clarke and others (1990) from three aquifer tests conducted in Pleistocene and probable Pliocene deposits. In the shallow Pleistocene deposits, estimated transmissivity values ranged from 960 to 1,300 centimeters squared per second ("cm^2/s"). In the deeper Pliocene deposits, the transmissivity was

estimated at 6,700 cm^2/s. Storage coefficients were calculated for Pleistocene deposits. These values ranged from 0.09, which is indicative of unconfined conditions, to 0.00010, which is indicative of confined conditions (Gregg and Zimmerman, 1974; Clarke, et al., 1990).

The upper surficial aquifer is of primary relevance to the groundwater monitoring activities at the Facility. The unconfined upper surficial aquifer consists of freshwater to the west of the Facility and grades to brackish to saline groundwater beneath the salt marsh east of the Facility. In the eastern vicinity of the Facility, groundwater in the upper surficial aquifer is brackish to saline and is not currently a drinking water source. Underlying the surficial aquifer is a confining unit of silty clay and dense phosphatic limestone or dolomite (Clarke, et al., 1990). This confining unit separates the surficial aquifer from the underlying Upper Brunswick aquifer. Laboratory analysis of undisturbed core samples of this confining unit from a Brunswick area well show hydraulic conductivity values ranging from 1.9×10^{-8} to 4.6×10^{-8} centimeters per second ("cm/s") (Clarke, et al., 1990). The top of this confining unit is about 240 ft. below the ground surface in the Brunswick area.

Based on surveys of private drinking water wells and information from public water supply systems, drinking water in the Brunswick area is supplied from the underlying Floridan aquifer through the Brunswick Glynn Joint Water and Sewer Commission or private wells. The Upper Floridan aquifer is the most heavily used aquifer in the area (Clarke, et al., 1990). In Glynn County, the vertical hydraulic gradient is generally upward from the Floridan Aquifer to the Brunswick and surficial aquifers.

C.2.b Site-Specific Geology and Hydrogeology

The site layout for the Facility is presented on **Figure C-2**. Multiple geologic and hydrogeologic investigations have been performed at the Facility since the early 1980s. During these investigations, numerous soil borings and monitoring wells have been installed at the Facility, which have provided site-specific geologic and hydrogeologic information. More extensive information regarding the geology and hydrogeology at the Facility can be found in the following investigation reports and work plans:

- RCRA Facility Investigation (RFI) Phase I Work Plan, Hercules Incorporated, September 23, 1994.
- Semi-Annual Report. Monitoring Wells at Former Toxaphene Surface Impoundments, Law Environmental, Inc., August 4, 1994.

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Based on surveys of private drinking water wells and information from public water supply systems, drinking water in the Brunswick area is supplied from the underlying Floridan aquifer through the Brunswick Glynn Joint Water and Sewer Commission or private wells, from depths greater than 500 ft. The Upper Floridan aquifer is the most heavily used aquifer in the area (Clarke, et al., 1990). In Glynn County, the vertical hydraulic gradient is generally upward from the Floridan Aquifer to the Brunswick and surficial aquifers.

C.2.b Site-Specific Geology and Hydrogeology

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- RCRA Facility Investigation (RFI) Phase I Work Plan, Hercules Incorporated, September 23, 1994.
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groundwater flow within all three zones of the upper surficial aquifer (shallow, intermediate and deep zones) is southeasterly to easterly, with locally downward gradients from the shallow to deep zones in the central portion of the Facility. The figures in **Appendix C-1** show the potentiometric surfaces of the shallow, intermediate and deep zones of the upper surficial aquifer based on December 2016 groundwater elevation measurements. These measurements demonstrate that vertical hydraulic gradients between the shallow, intermediate, and deep zones within the upper surficial aquifer tend to be an order of magnitude greater than observed horizontal hydraulic gradients.

Hydraulic conductivity data collected at the Facility are summarized on **Table C-1**. The data range from 3.4 to 32 ft./day in the shallow zone of the upper surficial aquifer, 8.4 to 46 ft./day in the intermediate zone of the upper surficial aquifer, and 0.80 to 84 ft./day in the deep zone of the upper surficial aquifer. This variability is attributable to the different test methods employed for the evaluation of hydraulic conductivity (e.g., solid slug test, pneumatic slug test, pump test, and use of a hydraulic profiling tool), and to heterogeneities that exist across the Facility in all zones of the upper surficial aquifer.

Using December 2016 water level measurements, the horizontal hydraulic gradients of the shallow and deep zones of the upper surficial aquifer were calculated (**Tables C-2 and C-3**). The horizontal hydraulic gradients calculated for the shallow and deep zones of the upper surficial aquifer were 0.0014 and 0.0008 ft./ft., respectively, using the December 2016 water level measurements. Based on the range of conductivities and gradients across the footprint of the Facility, groundwater velocities range from approximately 1.0 to 180 ft. per year, averaging approximately 21 ft./year (0.057 ft./day) across the shallow zone and approximately 43 ft./year (0.12 ft./day) across the deep zone of the upper surficial aquifer.

C.3 TOPOGRAPHIC MAP AND PLUME DESCRIPTION REQUIREMENTS [40 C.F.R. §§ 270.14(C)(3) AND (4)]

40 C.F.R. §§ 270.14(c)(3) and (4) describe information that is to be included in narrative form and on figures or maps relating to groundwater conditions in connection with permit applications. In this particular case, the relevant requirements of 40 C.F.R. § 270.14(c)(3) and (4) have been addressed through the following figures or appendices and the description of groundwater conditions set forth below:

- Delineation of Waste Management Area **Figure C-2**
- Property Boundary **Figure C-2**
- Location of Groundwater Monitoring Wells **Figure C-2**

- Groundwater Flow Direction **Figure C-2**
- Horizontal Extent of Groundwater Impacts **Appendix C-2, Figures C-10, C-11, C-12, C-13, C-14, C-15, and C-16**

Groundwater sampling and analysis for hazardous constituents has been conducted at the Facility since 1993. Historically, concentrations of volatile organic compounds ("VOCs"), semi-volatile compounds ("SVOCs"), pesticides, herbicides, and metals have been detected at the Facility. **Table C-4.1** summarizes all of the groundwater sampling results obtained at the Facility, sorted by monitoring well and date of sampling. **Table C-4.2** summarizes the same results, but includes only those specific analytes that were detected. **Table C-4.3** summarizes the same results as **Table C-4.2**, but has been adjusted to form the basis of the list of compounds to be included in the Facility's groundwater monitoring program (discussed later in Section C.4). In preparing **Table C-4.3**, the following adjustments were made to the sampling results presented in **Table C-4.2**:

- The sample collection dates were filtered to include only samples collected between December 2013 and December 2016;
- Sampling results were filtered to remove sampling locations not listed on **Table 6** (Groundwater Monitoring Program Well Construction Details);
- Sampling results were filtered to remove compounds that are not listed in Appendix IX of 40 C.F.R. 264;
- Sampling results were sorted by analytes alphabetically; and
- Sampling results were sorted for particular analytes by laboratory analytical method.

The December 2015 and 2016 semi-annual groundwater monitoring events and the Draft Groundwater Technical Summary Report provide additional groundwater hydrogeologic and chemical information.

The plume of constituents of potential concern ("COPCs") in groundwater underlying the Facility was completely defined during the Phase III RCRA Facility Investigation ("RFI") for the Facility. The results of the Phase III RFI were presented in a report that was finalized in February of 2015 and titled *Brunswick Groundwater RFI III Report* (the "Phase III Groundwater RFI Report"). The Phase III Groundwater RFI Report was approved by EPD on April 29, 2015. In its approval letter, EPD concluded that releases at the Facility had caused groundwater conditions to exceed background concentrations for certain COPCs, which would need to be addressed through corrective measures. Copies of the Phase III Groundwater RFI Report and EPD's approval letter are included in **Appendix C-2**. Maps

showing the recent distribution of VOCs in groundwater beneath the Facility are included as **Figures C-10, C-11,** and **C-12**. Maps showing the recent distribution of the other constituents routinely monitored, including SVOCs, pesticides, metals and formaldehyde, in each zone of the upper surficial aquifer, are included as **Figures C-13**, **C-14**, **C-15**, and **C-16**.

Extensive groundwater monitoring results collected from 2011 through 2016 confirm that VOCs detected in the shallow zone of the upper surficial aquifer in the vicinity of the closed surface impoundments attenuate to below background levels before leaving the Facility. Additional VOCs found in the deep zone of the upper surficial aquifer underlying the central portion of the Facility attenuate as they move horizontally to the east within the deep zone. In the southern source area, VOCs appear to migrate downward from the shallow zone through the intermediate zone and into the deep zone of the upper surficial aquifer where they encounter a confining unit between the upper and lower surficial aquifer and then migrate eastward. Site-specific data indicate that biodegradation is occurring in portions of the plume, both on-site and off-site. Based on attenuation modeling presented in the Draft Groundwater Technical Summary Report and further evaluations of groundwater data, site COPCs are predicted to attenuate in the deep surficial aquifer east of the Facility beneath the salt marsh where brackish to saline conditions dominate.

Recent detections of total toxaphene (chlorinated camphenes) and technical toxaphene in groundwater have been limited to two shallow monitoring wells (POC-2S and POC-3S) located near the closed surface impoundments. Alpha-BHC and delta-BHC have also been detected during recent monitoring events. However, there is little correlation between historical analytical results for alpha-BHC and delta-BHC and the current results that have been obtained.

SVOCs have generally not been detected during recent groundwater monitoring events, and no trend is evident based on a review of historic results. SVOCs are not persistent in groundwater at the Facility.

Groundwater Protection Standards ("GWPSs") have been developed for metals that have been detected at the closed surface impoundments based on historical sampling results at background monitoring wells UP-1S and UP-1D(R). Recent sampling results indicate that only barium and vanadium have been found in excess of GWPSs. Metals do not occur as a plume at the Facility and concentrations of metals align well with those observed in the background monitoring wells, which indicates that the detected metals are naturally occurring.

Similar to metals, formaldehyde and sulfide have been detected in groundwater at the Facility at concentrations that align well with the concentrations of those analytes observed in background monitoring wells UP-1S and UP-1D(R).

C.4 GROUNDWATER MONITORING PROGRAM [40 C.F.R. § 270.14(C)(5)]

This section of the permit renewal application describes the proposed groundwater monitoring program to be implemented at the Facility consistent with the requirements of 40 C.F.R. § 270.14(c)(5).

General Approach for Groundwater Monitoring Program:

Consistent with EPA's reforms to RCRA corrective action in 1999 and 2001 to promote faster, and more focused cleanups, a holistic approach to site-wide groundwater monitoring is proposed. This concept has been approved by EPD through the Triad approach as noted above. The holistic site-wide approach for groundwater monitoring will integrate post-closure activities for the closed surface impoundments with corrective action requirements for groundwater underlying the Facility. The primary objective of the holistic site-wide groundwater monitoring program is to monitor the extent and stability of site-specific COPCs.

Evaluation of Historic Groundwater Analytical Results:

Groundwater conditions at the Facility have been evaluated for over 25 years, including analyzing groundwater samples for compounds used as raw materials or maintenance based on the operational history of the Facility. In addition, as discussed in Section F of this permit renewal application, 39 solid waste management units ("SWMUs") and one area of concern ("AOC") have been identified and investigated at the Facility as part of the corrective action process. Groundwater samples have also been analyzed for a broad universe of hazardous constituents set forth in 40 C.F.R. Part 264, Appendix IX. The compounds associated with past activities at the Facility have been identified and confirmed through repeated groundwater sampling events.

Specific Elements of Groundwater Monitoring Program:

The groundwater monitoring program that will be implemented at the Facility will consist of analyzing groundwater samples for those hazardous constituents set forth in Appendix IX of 40 C.F.R. Part 264

that have been detected in groundwater at the closed surface impoundments and downgradient areas at concentrations exceeding GWPSs during the last three years of routine groundwater monitoring. VOCs and toxaphene are the primary COPCs in groundwater at the Facility and will be monitored at background locations, source areas, in interior portions of the contaminant plume, and at the perimeter of the contaminant plume.

Additional compounds that have been detected in groundwater at the closed surface impoundments and at downgradient locations, including SVOCs and pesticides, are also proposed for inclusion in the groundwater monitoring program. These compounds were evaluated to determine whether they have been detected in groundwater over the last three years of routine groundwater monitoring at concentrations exceeding GWPSs. Monitoring wells where SVOCs and pesticides have been detected within the last three years will be used to assess the current extent of these compounds in groundwater, and are included in the groundwater monitoring program.

Metals, formaldehyde, and sulfide are also proposed for inclusion in the groundwater monitoring program. These compounds will be analyzed in groundwater samples collected at and immediately downgradient of the closed surface impoundments. A limited areal extent for sampling of metals, formaldehyde and sulfide is warranted because these compounds are naturally occurring, do not manifest as plumes in groundwater beneath the Facility, and occur at the closed surface impoundments and at downgradient locations at concentrations similar to those observed in background locations.

During the June 2016 semi-annual groundwater sampling event for the Facility, dioxins and furans were detected at monitoring well POC-2S during the annual sampling event for all constituents set forth in Appendix IX of 40 C.F.R. Part 264. Dioxins and furans have also been included in the groundwater monitoring program to assess these detections, and to determine the potential extent of dioxins and furans in groundwater downgradient of monitoring well POC-2S.

To determine on an annual basis whether additional constituents set forth in Appendix IX of 40 C.F.R. Part 264 may be present in groundwater, one monitoring well in the group of three monitoring wells consisting of monitoring wells POC-1S, POC-2S, and POC-3S will be sampled for all constituents contained in Appendix IX of 40 C.F.R. 264 annually. The monitoring well to be sampled and analyzed will rotate each year among monitoring wells POC-1S, POC-2S, and POC-3S, resulting in sampling of each of these three monitoring wells every three years.

Modifications to the groundwater monitoring program will be made, as needed, as part of ongoing

implementation of the corrective action program.

C.4.a Monitoring Wells for Groundwater Monitoring Program

A total of 29 monitoring wells are proposed for inclusion in the site-wide groundwater monitoring program. The 29 monitoring wells are listed below and were selected to monitor, among other things, concentration trends of COPCs, potential migration of COPCs, and attenuation and containment of source zones. Two monitoring wells (UP-1S and UP-1DR) are proposed for inclusion to evaluate background groundwater quality. Fourteen monitoring wells (MW-3S, MW-9S, MW-12S, MW-12D, MW-13, MW-25S, MW-39I, MW-39D, MW-41I, MW-42I, MW-51D, MW-52D, MW-55I, and MW-55D) are proposed for inclusion to help evaluate the extent of COPCs above background conditions. Thirteen monitoring wells are proposed for inclusion to continue to monitor groundwater quality directly downgradient of the closed surface impoundments (POC-1S, POC-2S, POC-2D, POC-3S, and POC-3D), to monitor areas with elevated concentrations of COPCs (MW-23) or to monitor plume trends (MW-1D, MW-2D, MW-11DD, MW-15D, MW-28D, MW-43D, and MW-44D).

The site-wide holistic groundwater monitoring approach presented above will continue to evaluate potential impacts to groundwater from SWMUs, the one AOC, and the closed surface impoundments.

Table C-5 summarizes the proposed groundwater monitoring program, including the monitoring wells to be sampled, the frequency of sampling for each monitoring well, the rationale for inclusion in the groundwater monitoring program and the compound groups to be analyzed in groundwater samples from a particular monitoring well. **Table C-6** includes construction details for each monitoring well included in the groundwater monitoring program, as well as all other monitoring wells associated with the Facility. All constituents set forth in 40 C.F.R. Part 264, Appendix IX that have been detected at the closed surface impoundments, along with their respective GWPSs, are included on **Table C-7**. The basis for the list of constituents found on **Table C-7** is **Table C-4.3**. Several constituents included on **Table C-4.3** are not included on **Table C-7**. These constituents and the rationale for exclusion from the groundwater monitoring program are as follows:

- Arsenic has not been detected in excess of its GWPS of 50 micrograms per liter during the last three years of monitoring.
- Aldrin was detected at monitoring well POC-3S on June 12, 2014. In accordance with Permit Condition IV.D.8, the monitoring well was resampled on July 16, 2014. Aldrin was not detected in the subsequent sample (**Table 4.1**).

- Beta-BHC and benzyl alcohol were detected at monitoring well POC-2D on June 15, 2016. In accordance with Permit Condition IV.D.8, the well was resampled on August 11, 2016. Beta-BHC and benzyl alcohol were not detected in the subsequent sample (**Table 4.1**).

Table C-7 also includes a breakdown of the various compound groups that are included in the sampling program described on **Table C-5**. **Figure C-2** shows the monitoring well locations. All available monitoring well boring logs are included in **Appendix C-3**.

C.4.b Description of Sampling and Analysis Procedures

Groundwater samples will be collected and analyzed from the monitoring wells listed on **Table C-6** as part of the proposed groundwater monitoring program in accordance with the procedures presented in the Groundwater Sampling Plan that is included in **Appendix C-4**. Groundwater elevation measurements will be collected from monitoring wells on a semi-annual basis, and the groundwater flow rate and direction of flow will be evaluated at least annually.

C.4.c Procedures for Establishing Background Water Quality

Monitoring wells UP-1S and UP-1D-R are currently being used to provide upgradient, background water quality with respect to the closed surface impoundments. These monitoring wells have been sampled for more than 20 years and will continue to be sampled as part of the proposed groundwater monitoring program. Statistical analysis of the data obtained from these background monitoring wells will be used to evaluate background conditions at the Facility in accordance with the procedures set forth in 40 C.F.R. § 264.97(h).

C.4.d Statistical Procedures

The groundwater quality monitoring data from the monitoring wells listed in **Table C-6** and any future monitoring wells will be reviewed for quality assurance/quality control prior to being reported to EPD. A database for the management of groundwater quality data has been developed. Statistical procedures used to evaluate groundwater quality monitoring data relative to compliance with or attainment of GWPSs will be in accordance with 40 C.F.R. §§ 264.97(h) and (i). The statistical procedure will be selected from the described methods, or an alternative method approved by EPD, based on the characterization of each dataset.

C.5 CORRECTIVE ACTION PROGRAM [40 C.F.R. § 270.14(C)(8)]

In its letter approving the Phase III Groundwater RFI Report dated April 29, 2015, EPD confirmed that the RFI process was complete. EPD also concluded that releases at the Facility had caused groundwater conditions to exceed background levels for certain COPCs and therefore, corrective action was necessary. The corrective action process for the Facility is ongoing and specific corrective measures for groundwater have not yet been selected. A risk assessment for groundwater is in the process of being completed which will bear on the selection of corrective measures. Upon completion of the risk assessment process, corrective measures for groundwater (including the establishment of alternate concentration levels for COPCs) will be selected.

Because COPCs have been identified in groundwater at concentrations exceeding background levels, the requirements under 40 C.F.R. §§ 270.14(c)(6) and (7) are inapplicable. By contrast, the requirements of 40 C.F.R. § 270.14(c)(8) appear to be applicable. However, a number of those requirements cannot currently be addressed given the status of the corrective action process. For example, as indicated above, corrective measures for groundwater have not yet been proposed and approved by EPD. By the same token, groundwater conditions have been fully characterized as discussed in the Phase III Groundwater RFI Report, COPCs in groundwater have been identified, and a groundwater monitoring program has been developed as described in the preceding sections of this permit renewal application. Hercules anticipates that the groundwater monitoring program will be implemented while corrective measures for groundwater are selected. Depending on the nature of those corrective measures, the groundwater monitoring program may be modified as appropriate.

C.6 REFERENCES

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Tables