OBG

FINAL REPORT

Corrective Measures Study Report

GE Aviation – Evendale Facility
Evendale, Hamilton County, Ohio

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Evendale, Hamilton County, Ohio

Prepared for: GE Aviation

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LIST OF ACRONYMS

AOC	Area of Concern
CVOC	Chlorinated Volatile Organic Compound
COPC	Constituent of Potential Concern
CSM	Conceptual Site Model
CMO	Corrective Measures Objective
CMS	Corrective Measures Study
DNAPL	Dense Non-Aqueous Phase Liquid
DCA	1,1-Dichloroethane
DCE	1,2-Dichloroethene
GRA	General Response Action
GWTP	Groundwater Treatment Plant
HASP	Health and Safety Plan
I&EC	Institution and Engineering Control
IRM	Interim Remedial Measure
IRP	Installation Restoration Program
LDR	Land Disposal Restriction
LSG	Lower Sand and Gravel
MCL	Maximum contaminant level
mgd	million gallons per day
MNA	Monitored Natural Attenuation
OIT	Operator Interface Terminal
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
P&T	Pumping and treating
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyls
PLC	Programmable Logic Controller
PMP	Performance Monitoring Plan
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RSL	Regional Screening Level
SWMU	Solid Waste Management Unit
SWQC	Surface Water Quality Criteria
TCA	1,1,1-Trichloroethane

TCE	Trichloroethene
TPH	Total Petroleum Hydrocarbons
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
USG	Upper Sand and Gravel
UST	Underground Storage Tank
VAS	Vertical Aquifer Sampling
VC	Vinyl Chloride
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

This Corrective Measures Study (CMS) Report has been prepared for the GE Aviation facility (Facility) located in Evendale, Ohio. The CMS Report documents the development, analysis, and selection of corrective measure alternatives for soil vapor, soil, and groundwater. The CMS was conducted in accordance with the U.S. Environmental Protection Agency (USEPA)-approved *CMS Work Plan* (OBG, May 2014), and builds on the understanding of the 2008 screening of remedial technologies for the design of the groundwater Interim Remedial Measure (IRM). The recommended alternative and long-term remedy for the Facility will be protective of human health and the environment, attain applicable cleanup objectives, and control the source areas.

The CMS Report is based upon over 25 years of subsurface investigations and monitoring at onsite and offsite locations as well as technology evaluations and IRMs that have been implemented at the Facility. Throughout the CMS process, GE has worked cooperatively with USEPA to coordinate and gain input on key topics and proposals through a series of interim reports submitted to USEPA between May 2015 and November 2016. The interim reports have been finalized and included as appendices. These final reports address USEPA comments on the previously submitted (in 2015 and 2016) draft interim reports. The following is a summary of key understandings and recommended corrective actions for impacted groundwater, soil vapor, and soil media at the Facility. These understandings and recommendations are further detailed in the main body of this CMS Report.

GROUNDWATER

The recommended corrective measure for groundwater includes continued operation of the existing groundwater pump and treat system and monitored natural attenuation, with implementation of groundwater use restrictions. This corrective measure will protect receptors at potential exposure points as a short-term goal, with the longer-term goal of attaining drinking water standards and returning groundwater to its maximum beneficial use.

Background - Groundwater conditions have been investigated since 1988, and have included a comprehensive evaluation of both onsite and offsite groundwater quality. The evaluation results supported the selection and implementation of a groundwater IRM at the southern end of the Facility. A conceptual site model (CSM) has been developed from soil and groundwater monitoring data as well as information from surrounding properties and regional aquifer studies. CSM highlights include:

- Unconsolidated geologic deposits extend to depths of 200 feet beneath the Facility and consist of multiple zones of groundwater flow that are separated by low-permeability silt and clay deposits. Groundwater in the three major permeable zones generally flows to the south. Water levels indicate varying degrees of interconnection between the water-bearing zones.
- Constituents of potential concern (COPCs) in groundwater are limited to chlorinated volatile organic compounds (CVOCs). CVOCs are present in the onsite and offsite groundwater. The CVOCs consist primarily of trichloroethylene (TCE), 1,1,1-trichloroethane (TCA) and their degradation products.
- Chlorinated solvent usage, storage, or disposal is known or suspected to have occurred at several neighboring industrial/commercial properties. Groundwater analysis and regional studies indicate the existence of offsite source(s) and the occurrence of a mixed or co-mingled plume(s).
- CVOC concentrations in unconsolidated deposits indicate several zones or horizons of residual mass of sorbed CVOCs beneath the Facility, with the highest concentrations detected in fine-grained deposits underlying the two upper water-bearing units. Historical regional groundwater pumping for industrial and municipal use is likely to have contributed to the presence of CVOCs at depth. Separate-phase Dense Non-Aqueous Phase Liquid (DNAPL) has not been observed at the Facility. Collectively, these conditions are characteristic of the late-stage evolution of a chlorinated solvent release site.
- Concentrations of residual CVOC mass in fine-grained materials are indicative of residual sources created by DNAPL diffusing into lower permeability horizons or a CVOC plume diffusing into fine-grained materials; to

be followed by later diffusion back into the more permeable unit (*i.e.,* back-diffusion) to sustain a long-term groundwater plume. Back-diffusion of residual CVOC mass continues to be a principal contributor to the groundwater impacts.

- CVOCs in the groundwater are undergoing natural attenuation via mechanisms such as biodegradation, dispersion, and sorption. Intrinsic biodegradation is occurring in the three primary water-bearing units and together with other natural attenuation mechanisms, is limiting the extent of the groundwater CVOC plume.
- The overall extent of impacted groundwater is stable or decreasing, as evidenced by stable or decreasing plume mass and CVOC concentrations in most individual wells.
- The City of Wyoming is the only nearby municipality located south (downgradient) of the Facility to operate a well field and currently treats the groundwater for CVOCs as a precaution prior to distribution. No other potable uses of groundwater have been identified south (downgradient) of the Facility.

The screening of remedial technologies and design of the groundwater IRM in 2008 yielded a focused list of retained technologies such as pumping and treatment (P&T) and monitored natural attenuation (MNA). The groundwater IRM was developed to mitigate offsite migration of CVOCs and consists of strategic P&T and offsite natural attenuation. This ongoing IRM was implemented in 2011 and since then has decreased CVOC concentrations in groundwater by orders of magnitude.

The short-term cleanup goal of protectiveness has been attained. The IRM has resulted in a stable plume, and there are no unacceptable exposures to CVOCs.

Cleanup Goals - Groundwater cleanup goals were developed based on the groundwater exposure pathway evaluation and are protective of onsite and offsite potential human and ecological receptors:

- Two groundwater exposure pathways were identified in the development of cleanup goals, specifically: (1) the potential for future exposure to offsite residents via the drinking water pathway (*i.e.,* Wyoming well field) by groundwater flow to the southwest, and (2) the potential for exposure to ecological receptors via the discharge of shallow groundwater to surface water of the nearby Mill Creek to the southeast.
- Corrective measures objectives (CMOs) were developed to guide decisions about changes of remediation technology, specifically regarding whether active P&T and MNA can be replaced with MNA only. The groundwater CMOs are concentration objectives applied at the downgradient property boundary. Attainment of the CMOs indicates that groundwater has reached a condition that is protective of potential human and ecological receptors at the potential offsite exposure points (Wyoming well field and Mill Creek).
- To develop the CMOs, groundwater modeling was used to perform back-calculation of CVOC fate and transport from the potential exposure points of Wyoming Well Field and Mill Creek, toward the Facility boundary. The modeled scenarios assumed that the primary drinking water standards (USEPA Maximum Contaminant Levels [MCLs]) and surface water quality criteria (SWQC) should be applied at these potential exposure points, respectively. Using conservative biodegradation rates, the back-calculation process identified groundwater concentrations (the CMOs) at the Facility perimeter that would attenuate to below the MCLs/SWQC before migration to the potential exposure points.

Proposed Final Corrective Measure - The recommended corrective measure for the Facility includes continued operation of the groundwater pump and treat system and MNA, with implementation of groundwater use restrictions onsite. Operation of the groundwater P&T system would continue until CMOs are met. Once the CMOs are met, the remediation technology would transition from active pumping and treatment and MNA to MNA only. Groundwater use at the Facility for potable or industrial purposes will be restricted and GE will conduct annual reviews of offsite private well permits and water supply records to confirm there are no additional potable users of groundwater.

SOIL VAPOR

Monitoring data indicate that soil vapor does not pose an unacceptable risk to human health and the environment. Therefore, no further action is recommended for soil vapor other than a limited period of continued monitoring at selected locations.

Background - Since 2006, GE has been investigating the potential for environmental exposure from soil vapors associated with impacted soil and groundwater. COPCs in soil vapor are limited to CVOCs. The soil vapor pathway evaluation focused on areas having the highest CVOC concentrations in the groundwater, and included collection of shallow and deep soil vapor samples along the southern perimeter of the Facility and sub-slab soil vapor and indoor air associated with selected Facility buildings. Multiple lines of evidence support the conclusion that the soil vapor-to-indoor-air pathway is incomplete for potential offsite residential, offsite industrial, and onsite industrial receptors.

Offsite The technical approach for evaluating the offsite vapor pathway considered multiple factors, as follows. Known and suspected VOC sources are located in the area surrounding the Facility. Geotechnical samples indicate that the upper 10 to 15 feet of soil south and southwest of the Facility are primarily low-permeability silts and clays. CVOCs are present in much greater concentrations onsite than offsite; therefore, onsite vapor concentrations along the Facility perimeter resulting from diffusion from Facility groundwater are likely to be greater than offsite vapor concentrations. Based on these considerations, vapor monitoring along the Facility perimeter was conducted to provide a conservative screening approach for the offsite vapor pathway.

Soil vapor CVOC concentrations were observed to attenuate by several orders of magnitude from deep to shallow sample locations and have also decreased as much as several orders of magnitude over the history of vapor monitoring along the southern Facility boundary. It has been demonstrated that current levels of PCE and TCE in soil vapor are continuing to trend downward and have consistently been below industrial screening levels along the southeast property boundary and below residential screening levels along the southwest property boundary, with CVOCs not being detected at the majority of soil vapor sampling locations around the perimeter of the Facility. This concentration decline is attributed to the low permeability of shallow silts and clays, the effects of the groundwater IRM program (startup in 2011) and to natural attenuation of CVOCs in the shallow groundwater.

Onsite The onsite vapor pathway was evaluated with a round of subslab and indoor air samples at several buildings and seasonal monitoring at a building that would be most likely to experience indoor air issues. At buildings where vapor samples were collected, soil vapor CVOC concentrations were observed to attenuate by several orders of magnitude from shallow sub-slab soil vapor samples to indoor air. This attenuation is attributed to industrial building construction and operation (e.g., thick concrete floors, high air exchange rates).

Building 800 was identified as the building where conditions (higher groundwater concentrations, past flooding, relatively large basement area) presented the greatest potential for vapor intrusion. Seasonal sub-slab soil vapor and indoor air monitoring was performed at Building 800. Subslab soil vapor concentrations were detected above estimated subslab vapor screening levels. However, corresponding indoor air samples from that building confirmed that concentrations of CVOCs are below established indoor air screening levels. Thus, the soil-vapor-to-indoor-air pathway is incomplete under current conditions.

Proposed Final Corrective Measure – Data have demonstrated that soil vapor does not pose an unacceptable risk to human health and the environment and no further action is recommended for soil vapor. Periodic (annual) indoor air monitoring and perimeter soil vapor monitoring will be conducted for two years at selected locations to continue to demonstrate that indoor air concentrations of CVOCs remain below screening levels.

SOIL

The recommended corrective measure for impacted soil at the Facility includes implementation of various institutional and engineering controls that will be applied depending on risk assessment. Risk management options for the application of institutional and engineering controls are sufficient to control potential exposure to chemical compounds in the soil at the Facility.

Background - Soil conditions were evaluated during the USEPA-approved Resource Conservation and Recovery Act (RCRA) Facilities Investigation (RFI) and screened against regulatory action levels. Forty-nine Solid Waste Management Units (SWMUs)/Areas of Concern (AOCs) were recommended for further evaluation during the CMS. In keeping with the 2014 CMS Work Plan, soil exposure pathways were evaluated. Key understandings from these activities include:

- The property is an approximately 400-acre facility with extensive manufacturing operations and global headquarters of GE's aircraft engines business (GE Aviation).
- The property is zoned for industrial use. Access is restricted by a combination of fencing, entry guards, security patrols, and remote surveillance.
- There is no offsite soil exposure pathway since affected soil is limited to the Facility, including SWMU 17 which is located on noncontiguous property owned and controlled by GE.
- The onsite soil exposure pathway is potentially complete for site workers, construction workers, utility workers, and trespassers without the application of institutional and engineering controls.
- The majority of the areas of impacted soil are covered by buildings or pavement, or access is otherwise restricted, thereby limiting the potential for exposure to onsite workers. Worker exposure is further controlled with a combination of worker safety measures and a soil management program.
- Several SWMUs were retained (from the RFI) for further evaluation due to the presence of arsenic in soil. Arsenic is a natural constituent of soil in Ohio and in the Evendale area, with a published average background value.

Cleanup Goals - Risk-based soil CMOs for selected chemicals were calculated for the industrial use scenario, for potential onsite receptors under both current and reasonably anticipated future land use. The CMOs were calculated using USEPA risk assessment guidance and conservative assumptions regarding potential exposure.

Proposed Final Corrective Measure – The 49 retained SWMUs/AOCs were screened against background concentrations, the USEPA Resident Soil Regional Screening Levels (RSLs), and the CMOs. Given the existing exposure controls, and current and reasonably anticipated future land use, the recommended corrective measures for areas of impacted soils are based on a combination of institutional and engineering controls. The Institutional and Engineering Controls Plan (I&EC Plan) was developed to specify the range of institutional and engineering controls and provide guidelines for their implementation. This Plan was previously provided to USEPA as an interim report and the final report is included as an appendix to this CMS Report. The screening of the 49 SWMUs/AOCs and recommended institutional and engineering controls are summarized below:

- SWMUs with arsenic concentrations at or below background values (*i.e.* SWMUs 86, 95, 100, 122, and 123) are recommended for no further action. There is no reported use of arsenic-containing compounds in Facility manufacturing.
- COPC soil concentrations at SWMUs 42, 61, and 67 were found to be less than USEPA RSLs for the residential use scenario. These SWMUs, along with SWMU 118, are also recommended for no further action.
- SWMUs/AOCs with COPC concentrations above the Resident Soil RSLs and at or below the CMOs are recommended for continued Facility management under the nonresidential use scenario. The restrictions of these units will be recorded in an environmental covenant.
- SWMUs/AOCs with COPC soil concentrations greater than CMOs are recommended for the same measures, plus engineering controls (cover systems) consisting of pavement, concrete, clean fill, or overlying structures. Requirements for cover systems will be formalized in an environmental covenant.

The I&EC Plan specifies that existing cover systems (*e.g.,* buildings, vegetated clean fill and pavement) and Facility fencing would be inspected and maintained on an annual basis. The results of inspections, maintenance of engineering controls, and management of soil disturbance in SWMUs/AOCs will be reported to USEPA annually.

1. INTRODUCTION

O'Brien & Gere Engineers, Inc. (OBG) has been retained by the General Electric Company (GE) to prepare a Corrective Measures Study (CMS) Report for the GE Aviation facility (Facility) located in Evendale, Ohio (**Figure 1**). This document has been prepared in accordance with the United States Environmental Protection Agency (USEPA)-approved *CMS Work Plan* (OBG, 2014). This CMS Report documents the development of corrective measure alternatives and presents the individual and comparative analysis of corrective measure alternatives considered for soil vapor, soil, and groundwater. The recommended alternative and long-term remedy for the Facility are also presented.

The approach to addressing impacted soil and groundwater is founded on several important understandings which are incorporated into relevant sections of this CMS Report:

- The Facility is a secure, highly active, long-term manufacturing facility. An Institutional and Engineering Controls Plan (I&EC Plan) (OBG, 2017a) and associated environmental covenant will be recorded to specify certain institutional and engineering controls. These controls will prevent unacceptable exposure to constituents of potential concern (COPCs) in the soil and groundwater within the boundaries of the Facility.
- Due to Facility controls and security at the Facility, the soil pathway has generally been under control since completion of the Resource Conservation and Recovery Act (RCRA) Facilities Investigation (RFI) in the early 1990s. As a result, the groundwater pathway has been the primary focus of the Corrective Action Program, particularly over the last 15 years.
- The groundwater Interim Remedial Measure (IRM) consisting of strategic pumping and natural attenuation has stabilized the groundwater plume(s) and has achieved protectiveness of human health and the environment under current conditions. The IRM is reaching a point where the remediation program can be gradually transitioned from pump and treat (P&T) to monitored natural attenuation (MNA). Groundwater corrective measure objectives (CMOs) have been developed (OBG, 2017b) as performance criteria to guide this transition.
- Remediation of chlorinated volatile organic compounds (CVOCs) in groundwater to drinking water standards is not likely to be achieved within a reasonable time frame. Active groundwater remediation is being performed to control elevated concentrations and to prevent unacceptable exposure to potential receptors.
- The Facility is in an industrial area with multiple known and potential offsite sources. CVOCs have been detected in groundwater at upgradient, sidegradient, and deep locations. These data suggest sources from offsite.
- The highest detections of CVOCs in groundwater are at the southern portion of the Facility, in the former U.S. Air Force (USAF) Plant 36 (former AFP36) property. These detections are being addressed by a groundwater IRM, consisting of strategic pumping and natural attenuation. Pending the findings of the CMS, it is anticipated that the final remedy will likely consist of the current groundwater pumping and natural attenuation, with an eventual transition from P&T and MNA to MNA only.
- Evaluation of soil vapor focused on areas having the highest CVOC concentrations in groundwater; including the southeast perimeter of the Facility and sub-slab soil vapor and indoor air in Facility buildings. Soil vapor CVOC concentrations have decreased as much as several orders of magnitude over the history of vapor monitoring along the southern Facility boundary. Groundwater as a potential source of soil vapor is being addressed by the groundwater IRM and the current vapor monitoring program. Evaluation of the onsite vapor pathway for buildings in the central area of the Facility showed CVOC concentrations to attenuate by several orders of magnitude from shallow sub-slab soil vapor samples to indoor air, with indoor air sample concentrations below indoor air screening levels.

1.1 OBJECTIVE

The objective of this CMS Report is to document the development, analysis, and selection of corrective measure alternatives that are protective of human health and the environment, and that address subsurface impacts beneath the Facility and within the study area[1].

Throughout the CMS process, GE has worked cooperatively with USEPA to coordinate and gain input on key topics and proposals through a series of interim reports submitted to USEPA between May 2015 and November 2016. The final reports were prepared based on USEPA comments on the reports. The final reports have been included in the following appendices:

- **Appendix A** – CMS Report and Updates – Soil Vapor (OBG, 2016a; OBG, 2017c)
- **Appendix B** – CMS Report - Soil (OBG, 2017d)
- **Appendix C** – CMS Report – Groundwater Corrective Measures Objectives (OBG, 2017b)
- **Appendix D** – CMS Reports – Performance Monitoring Update; Pilot Test Results (OBG, 2015; 2016b)
- **Appendix E** – CMS Report – Institutional and Engineering Controls Plan (OBG, 2017a)

Findings relevant to the analysis and selection of the recommended corrective action for impacted soil vapor, soil, and groundwater are presented in the sections that follow. Details and supporting analysis are provided in these interim reports and referenced appendices.

[1] The study area is the area of CVOCs (onsite and offsite) that are related to the Facility, including the immediately surrounding area and downgradient plume(s).

2. DESCRIPTION OF CURRENT CONDITIONS

A brief discussion of Facility background information, including site layout, surrounding property use, previous soil vapor, soil, and groundwater investigations, and estimated mass of impacted media are presented in the following sections. Additional information is included in **Appendices A through D**, including the Conceptual Site Model (CSM) provided as part of **Appendix C**.

2.1 FACILITY HISTORY

The GE Aviation facility is located in southwestern Ohio's Hamilton County. The Facility is situated in the Mill Creek Valley between the East and West Forks of the Mill Creek and generally bordered by Interstate 75 to the west, the Mill Creek and CSX-Norfolk Southern railroad tracks to the east and southeast, Glendale-Milford Road to the north, and Shepherd Lane to the south (**Figure 1**).

The GE Aviation manufacturing plant in Evendale was originally established as a World War II aircraft engine production plant in the 1940s by Wright Aeronautical and was occupied by General Electric beginning in 1948. GE acquired a major portion of the plant in 1958. GE began operations as a manufacturer of military aircraft engines, but later expanded to the manufacture of commercial engines beginning in the early 1960s. In 1989, GE acquired the adjacent Ford Motor Company warehouse (north end of current Facility) and the 66.4-acre USAF former AFP36 complex (south end of current Facility) (**Figure 1**). This AFP36 area was used to support and supplement the activities of the adjacent GE-owned property.

2.2 SURROUNDING PROPERTY USE

The surrounding area includes numerous known and suspected potential sources of CVOCs. The Interstate 75 corridor between Cincinnati and Evendale is heavily industrialized. Property use in the area surrounding the Facility includes heavy industrial and general industrial areas to the east, an independent trucking operation to the north, public facilities and general commercial and industrial areas to the south. Industrial properties located northeast to southeast of the Facility include Formica, Barrett (Cavett) asphalt plant, Dow/Rohm & Haas chemical (former Morton, Carstab), Cincinnati Drum Recycling, the City of Reading former municipal landfill, incinerator, and ash fields, and the Pristine Superfund Site. In addition, the former DuPont Lockland Works industrial development was located to the west of the Facility (**Figure 1**). Chlorinated solvent usage, storage, or disposal is known or suspected to have occurred at several of the above-listed industrial/ commercial properties as discussed in the *CMS Work Plan* (OBG, 2014). Residential properties of the City of Reading are located to the southeast, the Village of Evendale to the east, and the Village of Lincoln Heights, City of Wyoming, and Village of Lockland to the west/southwest of the Facility.

2.3 PHYSICAL SETTING AND SUBSURFACE CONDITIONS

The Facility is in the Till Plains section of the Central Lowland Province of Ohio, a broad plateau which has been dissected by a number of large valleys. Mill Creek Valley, which trends north-northeast to south-southwest, is one of these dissecting valleys. Locally, the valley is drained by the East and West Forks of Mill Creek, the confluence of which lies approximately 1.5 miles south of the Facility.

Subsurface conditions beneath the Facility and surrounding area consist of a bedrock valley filled with 90 to 200 feet of poorly-graded permeable outwash sand and gravel interbedded with layers of silt, clay, and glacial till (Spieker, 1968; Fidler, 1970). Subsurface conditions at the Facility are characterized as follows:

- Soils beneath the Facility consist of unconsolidated overburden materials composed of fill material and silty clay to an average depth of approximately 10 feet, grading into the sand and gravel of the saturated Perched zone.
- The stratigraphy underlying the study area consists of five major sedimentary facies:
  - Perched zone – groundwater flow is south-southeast

  - Upper Confining Layer[2] (discontinuous silt and clay unit)
  - Upper Sand and Gravel (USG) – groundwater flow predominately southwest with a southeast component
  - Lower Confining Layer[2] (discontinuous silt and clay unit)
  - Lower Sand and Gravel (LSG) – groundwater flow is south-southwest.
- Significant flow zones include the semi-confined lower or deep zone (*i.e.*, LSG) and an upper or shallow zone which includes clays and silts of variable extent and thickness, further subdivided into the USG and the Perched zone. The sand and gravel deposits within the Perched zone are limited in extent and are generally not considered an aquifer for potable use. The USG is thin and aerially limited as compared to the LSG and therefore provides lower yields to wells, as compared to the LSG.
- The COPCs identified in surface and shallow soils are comprised of several different chemical classes, including metals (arsenic and nickel), cyanide, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), and total petroleum hydrocarbons (TPH).
- Seven key chlorinated aliphatic hydrocarbons, referred to herein as key CVOCs, found in groundwater consist of TCE and its daughter products cis- and trans-1,2-dichloroethene (cis-1,2-DCE and trans-1,2-DCE, respectively); 1,1-dichloroethene (1,1-DCE); and vinyl chloride (VC); and 1,1,1-trichloroethane (1,1,1-TCA) and its daughter product 1,1-dichloroethane (1,1-DCA). The compound 1,1-DCE is also a daughter product of 1,1,1-TCA (via abiotic degradation).
- A comparison of the molar ratios of ethenes versus ethanes at select locations from the three water-bearing units indicates potential offsite source(s) and/or the occurrence of a mixed or co-mingled plume. The occurrence of multiple offsite groundwater plumes is supported by regional studies by the U.S. Geological Survey (Schalk and Darner, 2004).
- Observations of aquifer conditions favorable to anaerobic degradation of the parent CVOCs and of their degradation products, such as cis-1,2-DCE, VC, and 1,1-DCA, suggest that the TCE and TCA are undergoing natural attenuation via mechanisms such as biotic and abiotic degradation, dispersion, and sorption. Intrinsic biodegradation is occurring in the three water-bearing units (Perched, USG, and LSG), and together with other natural attenuation mechanisms, is affecting the overall limits of the groundwater CVOC plume. Additional information concerning the progress of MNA in the study area is provided in **Appendix C**.
- The overall extent of impacted groundwater in the Perched zone, USG, and LSG is stable or decreasing, as evidenced by stable or decreasing: 1) total mass of the plumes, 2) center of mass of the plumes and 3) CVOC concentrations in most individual wells.

Historically, nearly all the groundwater pumped in the Mill Creek Valley has been from the LSG, being used for industrial and municipal purposes, with residential use comparatively insignificant (Fidler, 1970; Schalk and Schumann, 2002). The City of Wyoming continues to operate a well field that pumps approximately 1 million gallons per day (mgd), located approximately one mile to the southwest of the Facility. Vinyl chloride (VC) was detected at certain wells of the Wyoming well field at low concentrations (4 ppb or less), but was not detected in the treated water supply. Monthly sampling of the Wyoming Wells for VOC analysis was conducted by GE, beginning in September 2007 and continued until November 2010. Although VC had not been detected in the treated groundwater supply, GE worked with the City of Wyoming Water Department and Ohio Environmental Protection Agency (Ohio EPA) in the design and construction of a supplemental air stripping unit to remove VOCs that may be present in the raw groundwater. In 2011, the air stripper became operational, providing an extra layer of protection for the removal of potential VOCs before the treated drinking water is discharged to the water distribution system (City of Wyoming, 2010).

[2] Areas of thin to non-existent confining layers, referred to as communication zones, occur within the Upper and Lower Confining Layers (see **Appendix E-1** of the Groundwater CMO document included in **Appendix C**)

2.4 SUMMARY OF PREVIOUS INVESTIGATIONS

Several investigations of soil and groundwater conditions at the Facility have been completed (Geraghty & Miller, 1988), including implementation of an *RFI* (OBG, 1995). In 1985, the USAF initiated a concurrent environmental assessment and characterization of the former AFP36 property (**Figure 1**), conducted under the USAF Installation Restoration Program (IRP). The USAF assessments included a number of investigations to identify source areas and associated environment impacts (Engineering-Science, 1985; Chem-Nuclear Geotech, 1993; Earth Tech, 1998; Earth Tech 2003; and Earth Tech, 2004). In addition, OBG completed a treatability study, evaluation of IRM alternatives, source area investigation, aquifer performance testing, groundwater sampling and conceptual site model updates between 2006 and 2008.

As a result of investigative activities by GE Aviation, the focus of environmental investigations shifted toward developing a better understanding of the nature and extent of COPCs in the subsurface beneath the Facility, and in particular, the groundwater migrating offsite from the southern end of the Facility.

2.4.1 Interim Remedial Measures

In the early 1990s, several IRMs were undertaken to assess the need for, or to initiate, remedial measures for selected areas identified by GE, USAF and the USEPA. These IRMs include (**Figure 2**):

- Implementation of soil and groundwater treatment in two product release areas
- Implementation of groundwater treatment for containment purposes at two perimeter locations
- Investigation of an abandoned fuel transfer line of suspect integrity, including remediation of soils along one section of the pipeline in a suspected release area
- Facility-wide inventory of underground storage tanks (USTs)
- Investigation and remediation of sediments in the Facility drainage ditch for VOCs and metals.

In 2009, a groundwater IRM was initiated to address offsite migration of CVOCs in the southern (downgradient) portion of the Facility within the area of former AFP36 (OBG, 2009a). The groundwater IRM consists of strategic pumping (P&T) and MNA. The objective of the groundwater IRM is to mitigate offsite migration of CVOCs, while minimizing the risk of cross-contamination and/or reducing the effectiveness of natural degradation processes. The P&T system consists of seven groundwater extraction wells and a groundwater treatment plant (GWTP). Operation of the GWTP was started on July 11, 2011, following construction and commissioning of the system. Groundwater monitoring activities, including baseline monitoring and MNA sampling, have been conducted since startup in accordance with the approach and methods outlined in the *IRM Performance Monitoring Plan (PMP)* (OBG 2010).

In addition, cleanup activities of PCBs within the Facility drainage ditch and a select number of storm sewer manholes were undertaken in cooperation with the Ohio Environmental Protection Agency in 2000.

2.4.2 SWMUs/AOCs Retained for Further Evaluation

Based on USEPA's Facility-wide *RCRA Facility Assessment* (RFA) conducted in the summer of 1989 (A.T. Kearny, 1990), there were 135 solid waste management units (SWMUs) and 20 areas of concern (AOCs) identified at the Facility. As described in the CMS Report – Soil (**Appendix B**), there are 49 SWMUs/AOCs remaining that require further evaluation based on data collected during the RFI. Those remaining SWMUs/AOCs are listed in **Table 1** and identified on **Figure 3**.

The CMS is based on the understandings of the *RFI Report* (OBG, 1995), taking into consideration (1) additional data collected since *RFI Report* approval, (2) current USEPA RCRA strategy and updates to Regional Screening Levels (RSLs), and (3) current and reasonably anticipated future use, and other controls in place at the Facility. Due to continued future industrial use, the application of engineering controls, in combination with institutional controls (*e.g.,* Facility procedures and notifications, environmental covenant, *etc.*), are anticipated to be sufficient to control potential exposure to chemical constituents in the soil, soil vapor and groundwater

exposure pathways within the boundaries of the Facility.

2.5 IMPACTED ENVIRONMENTAL MEDIA

Impacted environmental media associated with the remaining SWMUs/AOCs at the Facility include soil vapor, soil, and groundwater. Details are provided in **Appendices A through C**, respectively. The following is a summary of relevant findings derived from these appended reports.

2.5.1. Soil Vapor

Since 2006, GE has been assessing the potential for environmental exposure from soil vapors associated with impacted soil and groundwater. COPCs in soil vapor include CVOCs, particularly tetrachloroethylene (PCE) and TCE. A large part of these investigations has included the collection of shallow (5 to 8 feet (ft) below ground surface (bgs)) and deep (12 to18 ft bgs) soil vapor samples along the southern perimeter of the Facility and sub-slab soil vapor and indoor air associated with Facility buildings. Multiple lines of evidence support the conclusion that the soil vapor-to-indoor air pathway is incomplete for potential offsite residential, offsite industrial, and onsite industrial receptors (OBG, 2016a; OBG, 2017c).

2.5.1.1 Offsite Vapor Pathway

The technical approach for evaluating the offsite vapor pathway considered multiple factors, as follows. Known and suspected VOC sources are in the area surrounding the Facility. Geotechnical samples indicate that the upper 10 to 15 feet of soil south and southwest of the Facility are primarily low permeability silts and clays. CVOCs are present in much greater concentrations onsite than offsite; therefore, onsite vapor concentrations along the Facility perimeter resulting from diffusion from site groundwater are likely to be greater than offsite vapor concentrations. Based on these considerations, vapor monitoring along the Facility perimeter was conducted to provide a conservative screening approach for the offsite vapor pathway.

Assessments have revealed that soil vapor CVOC concentrations attenuated by several orders of magnitude from deep to shallow sample locations and have also decreased as much as several orders of magnitude over the history of vapor monitoring along the southern Facility boundary. It has been demonstrated that current levels of PCE and TCE in soil vapor are continuing to trend downward and have consistently been below industrial screening levels along the southeast Facility boundary and below residential screening levels along the southwest Facility boundary, with CVOCs not being detected at the majority of soil vapor sampling locations around the perimeter of the Facility. This concentration decline is attributed to the low permeability of shallow silts and clays, the effects of the groundwater IRM program (in operation since 2011) and to natural attenuation of CVOCs in the shallow groundwater.

2.5.1.2 Onsite Vapor Pathway

The onsite vapor pathway was evaluated with a round of subslab and indoor air samples at several buildings and seasonal monitoring at a building that would be most likely to experience indoor air issues. Assessments have revealed:

- Soil vapor CVOC concentrations were observed to attenuate by several orders of magnitude from shallow sub-slab soil vapor samples to indoor air within several of the buildings at the Facility. This attenuation is attributed to industrial building construction and operation (e.g., thick concrete floors, high air exchange rates).
- Seasonal sub-slab soil vapor concentrations in the building most likely to experience indoor air issues (*i.e.,* Building 800) were detected above soil vapor screening values. However, corresponding indoor air samples from that building confirmed that concentrations of CVOCs are below established indoor air screening levels. Thus, the soil-vapor-to-indoor-air pathway is incomplete.

2.5.2 Soil

A review of surface and subsurface (less than 12 feet depth) soil data was conducted in 2015 as part of the soil exposure pathway evaluation, with results provided in the CMS Report – Soil (OBG, 2017b). The Facility data were compared to current USEPA Resident Soil RSLs and background soil concentrations of metals for each of

the Facility SWMUs and AOCs retained from the RFI for additional evaluation. Highlights of the soil pathway evaluation (OBG, 2017b) include:

- Nine SWMU/AOCs were eliminated from further evaluation due to soil concentrations below USEPA Resident Soil RSLs or background, with a total of 40 SWMUs/AOCs retained for further action
- Within the 40 SWMUs/AOCs retained for further action, a total of 18 COPCs were identified in soil, including metals (arsenic, cadmium, cobalt, copper, lead, manganese, and vanadium), cyanide, PAHs (benzo[a] anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene, and naphthalene), PCBs, VOCs (TCE, vinyl chloride), and TPH.
- Several SWMUs were retained for further evaluation due to the presence of arsenic in soil. Arsenic is a natural constituent of soil in Ohio and in the Evendale area, with a published average background value.

Potential receptors included indoor/outdoor industrial workers, construction workers, utility workers and adult/adolescent trespassers. Using exposure dose/concentration and toxicity data, risk-based soil cleanup goals were calculated for each COPC for these potential receptors. Values for soil cleanup goals were lowest (most conservative) for the outdoor industrial worker or construction worker given the higher intensity of potential soil exposure by these potential receptors. These soil cleanup goals formed the basis for the development of soil CMOs and the rationale for their development is further discussed in **Section 3**.

2.5.3 Groundwater

Groundwater conditions have been investigated since 1988, including routine RCRA groundwater monitoring, offsite investigations, and focused performance monitoring of the groundwater IRM since its startup in 2011. As discussed below, the overall extent of impacted groundwater in the Perched zone, USG, and LSG is stable or decreasing. Isoconcentration contour maps for select time periods and concentration trends for individual monitoring wells are provided in **Appendix C**. A review of groundwater concentrations of CVOCs since 2007 for these water-bearing units indicates:

- ***Perched Zone*** - isoconcentration maps for the Perched zone for 2009, 2011 and 2013 indicate an overall decreasing extent of the Perched zone plume(s), especially downgradient of the Perched zone extraction wells. Concentrations along the downgradient portion of the Perched zone dropped from highs of over 1,700 micrograms per liter (µg/L) total CVOCs to 577 µg/L by 2013, and have continued to drop to 193 µg/L by the third quarter of 2016 (3Q 2016)(see **Appendix C**).
- ***Upper Sand and Gravel -*** concentrations along the eastern portion of the USG plume(s) have dropped from highs of over 3,700 µg/L total CVOCs to approximately 1,400 µg/L by 2013, and have continued to drop to 1,100 µg/L by 3Q 2016 (**Appendix C**). The overall size of the USG plume(s) along the western portion of the Facility has remained stable, with concentrations decreasing from highs of over 500 µg/L total CVOCs to less than 50 µg/L.
- ***Lower Sand and Gravel*** - concentrations within the LSG plume(s) have dropped from highs of over 1,500 µg/L total CVOCs to generally less than 500 µg/L, and most of the LSG wells have decreasing trends. The only apparent exceptions to this trend are observed at wells OSMW-8D and OSMW-6D, where VC concentrations have increased due to degradation of the key CVOCs. Despite these two exceptions, the overall size and mass of the LSG plume(s) has decreased (see **Appendix C**). It is believed that the trends in OSMW-6D and OSMW-8D are, at least in part, indicative of degraded background groundwater quality in the study area due to potential offsite source(s) and/or the occurrence of co-mingled plumes.

Since startup on July 11, 2011, the IRM groundwater P&T system continues to operate and the groundwater is monitored in accordance with the USEPA-approved *IRM PMP* (OBG, 2010). The IRM performance monitoring includes influent and effluent concentrations as well as groundwater quality and hydraulic (water level) monitoring. A summary of groundwater performance monitoring results since initiation of the groundwater IRM was provided in a June 2015 CMS Interim Report-*Performance Monitoring Update & Pilot Test Plan* (OBG, 2015) (**Appendix D**) and subsequent *CMS Report – Groundwater Corrective Measures Objectives* (OBG, 2017b) (**Appendix C**). A review of water quality data for the IRM extraction wells indicates steady-state or decreasing

concentrations of CVOCs, with fluctuations associated with plume movement within the capture zone. Monitoring well hydraulic and chemical data do not indicate significant trends in vertical hydraulic gradients or VOC concentrations that are indicative of cross-contamination. Groundwater will continue to be monitored to evaluate the effectiveness of the IRM to mitigate offsite migration of CVOCs. Natural attenuation of CVOCs in groundwater will also continue to be monitored for its potential to mitigate offsite concentrations of dissolved CVOCs (**Appendix C**).

Additional details on addressing groundwater and the development of groundwater CMOs are presented in the Groundwater CMOs document included in **Appendix C** and discussed in **Section 3**.

2.5.3.1 Groundwater P&T System

The groundwater P&T system consists of seven groundwater extraction wells and a groundwater treatment plant (GWTP). Operation of the GWTP was started on July 11, 2011, following construction and commissioning of the system. The P&T system extracts groundwater impacted with CVOCs from the Perched zone, USG, and LSG. The average operational flow of the groundwater extraction system is approximately 280 gallons per minute (gpm) since startup and over 500 million gallons of groundwater have been extracted by the P&T system since startup (OBG, 2015).

The extracted groundwater is pumped to the GWTP which treats the groundwater through filtration, sequestering, air stripping, and pH adjustment. Filtration is performed using 10-micron bag filters which achieve approximately 75% removal of suspended solids. The sequestering agent is metered through the influent pipeline to the air stripper holding tank to keep over 80% of the iron concentration and other metals in a dissolved state. The air stripper is the primary treatment and removes greater than 90% of the VOCs. The pH adjustment is performed using sulfuric acid. The treated groundwater is discharged to Mill Creek in accordance with NPDES Permit OH0010286. Sampling and analyses of the treated discharge at internal monitoring station 601 (outfall IN00006601) is performed in accordance with the permit requirements.

The GWTP is controlled and monitored by field devices (instruments), a process logic controller (PLC), and an operator interface terminal (OIT). The field devices include level sensors, level switches, flow meters, pressure switches, and pH sensors. The level sensors, flow meters, and pH sensors transmit 4 to 20 mA signals back to the PLC where the ladder logic programmed into the PLC compares them to the set points input into the OIT to determine what action to take. A complete list of system interlocks and the control sequence is provided in the *Operations & Maintenance (O&M) Manual* (OBG, 2009b).

3. CORRECTIVE MEASURES OBJECTIVES

The broad goals of the RCRA Corrective Action Program include (USEPA, 1996; 2004):

- Protect human health and the environment
- Control sources of hazardous constituents
- Achieve media-specific CMOs

GE has developed soil and groundwater CMOs to be applied during the development, evaluation, and selection of the corrective measures alternative for the Facility.

The development of CMOs considers the relationships between land use patterns, chemical source areas, and human exposure pathways. A human health CSM is typically used to describe the linkages between possible sources of COPCs and potentially exposed human receptors. The human health CSM for the Facility was updated to include human health and ecological receptors as part of the groundwater pathway analysis. The human health and ecological CSM for the Facility is presented in **Figure 4** and summarizes the key exposure pathways and potential receptors identified during development of the CMOs.

The development of soil and groundwater CMOs are explained in detail in **Appendix B and C**, respectively, and is summarized in the following sections. A brief discussion of the soil vapor pathway is also presented. However, the soil vapor-to-indoor air pathway was concluded to be incomplete under current conditions; therefore, soil vapor CMOs were not developed.

3.1 SOIL VAPOR

The development of risk-based soil CMOs, as discussed further below in Section 3.2, does not consider potential vapor emissions from soil into the indoor spaces of worker-occupied buildings. The soil vapor-to-indoor air pathway was evaluated separately and is provided in **Appendix A**. Multiple lines of evidence support the conclusion that the soil vapor-to-indoor-air pathway is incomplete under current conditions for potential offsite residential, offsite industrial, and onsite industrial receptors. Monitoring data indicate that soil vapor does not pose an unacceptable risk to human health and the environment. Therefore, soil vapor CMOs are not developed, and no further action is recommended for soil vapor other than a limited period of continued monitoring at selected locations. Future construction or repurposing of portions of the Facility will be evaluated to assure that construction activities and changes in occupancy and operations do not present unacceptable risks from the soil vapor pathway.

3.2 SOIL CORRECTIVE MEASURES OBJECTIVES

A review of surface and subsurface (<12 ft depth) soil data was conducted as part of the soil exposure pathway evaluation (**Appendix B**). As an initial step in the soil CMOs development process, the Facility data were compared to current USEPA Resident Soil RSLs and background soil concentrations of metals for each of the Facility SWMUs and AOCs retained from the RFI for additional evaluation. Results from this initial screening process include:

- 40 SWMUs/AOCs (*i.e.,* designated SWMUs/AOCs) were retained for further evaluation of soil during the CMS.
- A total of 18 COPCs were identified in soil, including metals, cyanide, PAHs, PCBs, VOCs, and TPH.

Using this information, the next step in the development of soil CMOs included the calculation of risk-based soil cleanup concentrations for these COPCs for the industrial use scenario, given the current and reasonably anticipated future industrial/commercial land use. The CMOs were calculated using USEPA risk assessment guidance and conservative assumptions regarding potential exposure. The development of risk-based soil CMOs incorporates considerations of several factors, including the nature and magnitude of COPCs, current and future land use, exposure pathways and receptors, toxicity information, and target hazard and risk levels. Soil CMO development focused on the protection from direct contact exposure to soil, and does not incorporate

consideration of potential groundwater impacts to human health. The groundwater exposure pathway is addressed by the groundwater corrective measure objectives (CMOs) discussed in Section 3.3 below.

A summary of the approach used to develop site-specific, risk-based soil CMOs is as follows:

- Current and reasonably anticipated future potential receptors were identified based on current land use practices and best professional judgment regarding future use. Given the industrialized nature of the Facility, the following potential receptors were identified: indoor/outdoor industrial workers, construction workers, utility workers and adult/adolescent trespassers.
- Relevant soil exposure routes for the identified potential receptors at this Facility were identified and included incidental ingestion, dermal contact, inhalation of fugitive (soil) dust emissions, and inhalation of volatile emissions from soil.
- Using exposure dose/concentration and toxicity data, site-specific numerical estimates of carcinogenic risk and non-carcinogenic hazard were developed via USEPA risk assessment guidance.
- The equations used to quantify human exposures and risks were then re-arranged to back-calculate soil concentrations that are protective of potential site-specific human receptors (*i.e.*, soil CMOs). Parameters used in the development of the risk-based CMOs for Facility soils include: receptor-specific parameters, air emission rates, chemical-specific parameters, and target hazard and risk levels. Additional details regarding these parameters are provided in **Appendix B**.

Using this approach, risk-based soil CMOs were calculated for the selected potential receptors and for the individual chemicals identified as COPCs in soil. For each COPC, the lower (more conservative) of the two values for carcinogenic and non-carcinogenic endpoints was selected as the soil CMO. Values for soil CMOs were lowest for the outdoor industrial worker or construction worker given the greater potential for soil exposure by these potential receptors. CMOs for soil at the Facility are summarized in **Table 2**. The soil CMOs are based on industrial use of the property currently and in the reasonably foreseeable future.

There is no offsite soil exposure pathway since affected soil is limited to the Facility, including SWMU 17 which is located on noncontiguous property owned and controlled by GE. Onsite, the surface soil pathway is potentially complete for site workers, construction workers, utility workers, and trespassers without the application of institutional and engineering controls. The subsurface soil pathway is potentially complete for onsite construction or utility workers without the application of institutional and engineering controls. The potential for such onsite exposures is low, however, given site controls, as outlined in the *I&EC Plan* (**Appendix E**). The *I&EC Plan* specifies the range of institutional and engineering controls and provides guidelines for their implementation. Most of the SWMUs and AOCs are covered by buildings or pavement and affected surface soil is not exposed in most locations. Where the SWMUs and AOCs are not covered by buildings or pavement, access is restricted, which limits the potential for exposure to onsite workers. A summary of background information and the extent of institutional and engineering controls for select SWMUs/AOCs is included in **Appendix F**.

3.3 GROUNDWATER CORRECTIVE MEASURES OBJECTIVES

Groundwater conditions beneath the facility and surrounding area have been investigated and monitored since1988. The highest detections of CVOCs are at the southern portion of the Facility. Since 2011, a groundwater Interim Remedial Measure (IRM) of strategic pumping and natural attenuation has stabilized the groundwater plume(s) and has achieved protectiveness of human health and the environment under current conditions. The IRM is reaching a point where the remediation program can be gradually transitioned from pump and treat (P&T) to Monitored Natural Attenuation (MNA).

Groundwater CMOs were developed as performance criteria to guide technology selection and monitoring to support the transition from P&T to MNA. Background and details of groundwater CMO development are provided in **Appendix C**. Development of groundwater CMOs used the following general three-step approach:

- Identify the primary COPCs

- Identify and evaluate migration pathways, potential exposure routes and potential receptors
- Calculate concentration objectives at the Facility boundary to guide transition from active to passive remediation

Highlights of this three-step process are presented in the following subsections.

3.3.1 Identify the Primary COPCs

A comparison of perimeter and off-site groundwater data with USEPA Tapwater RSLs and MCLs identified groundwater COPCs with concentrations above screening levels. Because of the screening process, groundwater CMO development focused on seven key CVOCs consisting of TCE and its daughter products (cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and VC) and TCA and its daughter products (1,1-DCE and 1,1-DCA). These seven key CVOCs represent a subset of the highest priority COPCs needed to effectively manage exposure and risk.

3.3.2 Identify and Evaluate Migration Pathways, Potential Exposure Routes and Potential Receptors

The human health and ecological CSM was used to assist in identifying potential groundwater receptors and exposure routes (dermal, inhalation, ingestion) under current and reasonably anticipated future land use. Groundwater beneath the Facility is not currently used and on-site groundwater direct exposure pathways are considered incomplete. Construction or utility workers are not reasonably expected to be exposed to affected groundwater (at depths of 12 ft or less). Groundwater beneath the Facility will be restricted from future use by an environmental covenant and implementation of an I&EC Plan.

The development of groundwater CMOs considered two migration and exposure pathways:

- ***The potential for future exposure to off-site residents via the drinking water pathway*** - groundwater from the Facility migrates in the southerly direction, may migrate toward the Wyoming well field, and could potentially be used in future by off-site residents for agricultural, industrial, or potable purposes. The City of Wyoming is the only nearby downgradient municipality to operate a well field and currently treats extracted groundwater for VOCs as a precaution prior to distribution. Except for the City of Wyoming, no other potable uses of groundwater have been identified within two miles south of the Facility. The nearby population depends on the public water system for drinking water.
- ***The potential for future exposure to recreational users and ecological receptors via the discharge of shallow groundwater to the nearby Mill Creek*** - the primary route of potential human exposure is incidental ingestion of surface water. The Mill Creek is not designated as a public water supply and use as a recreational watershed is minimal. Ecological exposure routes include direct contact with Mill Creek surface water and sediment by benthic invertebrates and fish, and ingestion of surface water and incidental ingestion of sediment by wildlife receptors. The surface water pathway is characterized by minimal recreational use and relatively poor water quality due to urban runoff and industrial/municipal discharge.

3.3.3 Calculate Concentration Objectives to Guide Transition from Active to Passive Remediation

The groundwater CMOs include on-site concentration objectives at the downgradient property boundary that are protective of potential receptors at the potential off-site exposure points: Wyoming Well Field (to southwest) and Mill Creek (to southeast). The concentration objectives were derived using analytical groundwater modeling to perform back-calculation of CVOC fate and transport from the potential exposure points of Wyoming Well Field and Mill Creek. The modeled scenarios assumed that the primary drinking water standards (USEPA MCLs) and surface water quality criteria should be applied for the theoretical potential receptors. The back-calculation process utilized a calibrated model to evaluate Facility perimeter concentrations that would be protective of water quality at the potential exposure points (Wyoming Well Field and Mill Creek). Back calculation relied on the calibrated model, a reduced (by 50%) biodegradation rate, and several other conservative, simplifying assumptions.

The back-calculation results were then used to develop the groundwater CMOs at the downgradient property boundary. Recent groundwater concentrations at key perimeter monitoring wells completed in the three water-bearing units beneath the Facility are generally at or below the groundwater CMOs. Groundwater will continue to be monitored to evaluate the effectiveness of the P&T system to mitigate the potential for offsite migration of

CVOCs. Natural attenuation of CVOCs in groundwater will also continue to be monitored for its potential to mitigate offsite migration of dissolved CVOCs. As detailed in **Appendix C**, a process has been developed for evaluating groundwater CMO attainment, concentration rebound, and decisions about technology transition from combined P&T and MNA technologies to MNA only. Groundwater CMOs are summarized in **Table 3**.

Groundwater use restrictions in the form of an environmental covenant will control potential exposure to CVOCs in the groundwater within the boundaries of the Facility. The groundwater CMOs were developed based on a groundwater exposure pathway evaluation and are protective of onsite and offsite potential human and ecological receptors. Also, the combined effect of local ordinances, availability of public water supply, and well permitting requirements serve to prevent local groundwater use. As outlined in the I&EC Plan, GE will conduct annual reviews of offsite private well permits and water supply records to confirm there are no additional potable users of groundwater.

4. DEVELOPMENT OF CORRECTIVE MEASURE ALTERNATIVES

This section documents the development of corrective measure alternatives for the Facility, and describes the following:

- Estimated volume/mass of impacted environmental media
- Identification, screening and evaluation of corrective measure technologies
- Assembly of corrective measure alternatives

4.1 ESTIMATED VOLUME/MASS OF IMPACTED ENVIRONMENTAL MEDIA

The nature and extent of COPCs and media-specific CMOs were used to identify the estimated volume of impacted soil and groundwater for those areas retained for further evaluation, including cost analysis. These estimates were used to support evaluation of technologies.

4.1.1 Soil

An evaluation of the approximate volume of impacted soil within the SWMUs/AOCs retained for further evaluation (see Section 2.4.2) was conducted utilizing the nature and extent of COPCs and CMOs for soil. The available analytical data presented in the CMS Report - Soil (OBG 2017d, **Appendix B**) were utilized to determine the COPCs for each of these SWMUs/AOCs and the approximate areal and vertical extent of soil exceeding the soil CMOs at depths of 12 feet or less (**Table 2**). Some SWMUs/AOCs were divided into subareas to differentiate the areal locations of impacts within the SWMU/AOC, or more specifically because the analytical data indicated varying depths of impacts within definable subareas of the SWMU/AOC. For estimating the volume of soil exceeding CMOs for this CMS, the vertical extent of soil exceedances was based on the maximum depth of impacts. Additionally, available soil data below existing Facility buildings was included in impacted soil estimates.

As presented on **Table 4**, approximately 1.4 acres and 31,600 cubic yards of Facility soil exceed CMOs for soil at depths up to 22 feet. SWMUs/AOCs which only contained arsenic above the screening levels were eliminated from the analysis because the arsenic concentrations were only slightly above the screening values, including Hamilton County, Ohio soil background values (range of 4.1 mg/kg to 14.3 mg/kg), and are likely associated with an elevated background. Therefore, only arsenic concentrations of equal to or greater than 20 µg/kg were evaluated. Similarly, other metal concentrations that were less than their respective Hamilton County, Ohio soil background values were eliminated from consideration in this evaluation.

4.1.2 Groundwater

Evaluation of CVOC concentrations in unconsolidated deposits indicates several zones or horizons of residual mass of sorbed CVOCs beneath the Facility[3]. Three broad horizons of residual mass have been identified, along with multiple individual locations of elevated concentrations outside of the three horizons:

- The highest concentrations of residual mass of sorbed CVOCs have been detected at the base of the Perched zone and USG and the upper two feet of the underlying clay confining layers (O'Brien & Gere, 2008). The Perched zone and underlying clay unit are estimated to contain approximately 2,700 lbs of CVOCs over an

[3] CVOC downward migration as DNAPL is well-documented in the literature. At this Facility, historical groundwater drawdown is likely to have increased the likelihood of vertical cross-contamination. For example, the observation of petroleum hydrocarbons at the base of the Perched and USG is a strong indication of vertical cross-contamination due to lower historical groundwater levels.

approximate 17-acre area from the southeast portion of the Site north through the center of Buildings B and C (**Figure 5**)[4].

- The residual mass of sorbed CVOCs in the unconsolidated deposits of the USG and upper 2 feet of the LCL are estimated at approximately 890 lbs of CVOCs, located northeast of former Building D (**Figure 6**)[4].
- In the LSG, the residual mass of sorbed CVOCs is estimated at approximately 770 lbs, within the mid-section of the unit in the south area of the Site (**Figure 7**)[4].

Separate-phase, DNAPL has not been observed at the Site; however, the historical onsite use of these compounds and presence of persistent, high concentrations below the water table suggests that DNAPLs were historically released. Historical regional groundwater pumping for industrial and municipal use is likely to have further contributed to the presence of CVOCs at depth. Current conditions are characteristic of the late-stage evolution of a chlorinated solvent release site. Concentrations of residual mass of sorbed CVOCs in fine-grained materials are indicative of residual sources created by DNAPL diffusing into lower permeability horizons or a CVOC plume diffusing into fine-grained materials; only to be followed by later diffusion back into the water-bearing unit (*i.e.,* back-diffusion) to sustain a long-term groundwater plume. Back-diffusion of residual CVOC mass continues to be a principal contributor to the groundwater impacts.

The results of the groundwater mass estimation analyses are summarized in **Table 5.** The mass of groundwater CVOCs for the Perched zone, USG, and LSG was estimated by multiplying the area times the thickness of CVOC impacts to obtain the volume of impacted groundwater. Groundwater concentrations (in µg/L) were used to estimate the mass of impacts. The area of CVOC-impacted groundwater was estimated or defined by the different isoconcentration contours intervals within the isoconcentration maps previously developed for each water-bearing unit (see **Appendix C**). The area for each concentration zone (10 – 100 µg/L, 100 – 500 µg/L, 500 – 1000 µg/L, and greater than 1000 µg/L) was calculated using GIS techniques, and the thickness estimated from the top and bottom elevation data for each water-bearing unit developed during 3D visualization and groundwater flow modeling for the study area (OBG, 2011). The median concentration used for each concentration zone was 55 µg/L, 300 µg/L, 750 µg/L, and 1250 µg/L.

Using this approach, initial volume estimates overestimated CVOC mass, in part because the Perched Zone is not entirely saturated, and that the impacted zones within each water-bearing unit are not uniform (*i.e.*, there is vertical stratification or preferential pathways of impacts as alluded to previously). Therefore, for both the Perched Zone and USG, one half of the aquifer thickness was utilized (10 to 12 feet for the Perched Zone and 7 to 12 feet for the USG); whereas, one third of the aquifer thickness (approximately 30 feet) was utilized for the LSG. In the LSG, vertical aquifer sampling (VAS) conducted during the installation of monitoring wells indicated that the zone of greatest impact is situated predominantly in the middle third of the LSG.

4.2 IDENTIFICATION, SCREENING, AND EVALUATION OF CORRECTIVE MEASURE TECHNOLOGIES

This section documents the identification, screening and evaluation of corrective measure technologies for soil and groundwater at the Facility. Consistent with the *CMS Work Plan* (OBG, 2014), this section identifies specific remedial technologies that, following screening, were used to develop the range of corrective measure alternatives evaluated in this CMS. The identification and screening of corrective measure technologies for impacted groundwater is built on the understanding of the 2008 screening of remedial technologies for the design of the groundwater IRM (*2008 IRM Technology Screening Matrix*, included in **Appendix B** of the *CMS Work Plan* (OBG, 2014)).

4.2.1 Identification and Screening of Corrective Measure Technologies

General response actions (GRAs) are media-specific actions which may, either alone, or in combination, form alternatives to satisfy CMOs. Potentially applicable corrective measure technologies and process options for

[4] Note: **Figures 5 through 7** (circa 2009) are intended to provide historical context for the development of the groundwater IRM and corrective action alternatives. Mass estimates are based on the 2008 O'Brien & Gere investigation and represent pre-IRM P&T conditions.

each GRA were identified and screened based on technical implementability. Technical implementability for each identified process option was evaluated with respect to contaminant information, physical characteristics, and areas and volumes of affected media summarized in **Section 4.1**. Descriptions for technologies and process options identified for soil and groundwater are presented in **Tables 6 and 7**, respectively.

Technologies and process options that were viewed as not implementable were not considered further in the CMS. GRAs identified for soil and groundwater, based on the CMOs, and the associated technologies and process options retained for further consideration are presented below.

Soil

Potential corrective measure technologies applicable to impacted soil include the following:

- ***No action.*** *No action is considered in the CMS as a benchmark for the evaluation of corrective measures.*
- ***Institutional controls.*** *Actions that provide site access and use restrictions and provisions for corrective measure operation and maintenance (O&M).*
  - Proprietary controls (access/use restriction; environmental covenant)
  - Site controls (I&EC Plan)
  - Periodic reviews
- ***Natural recovery.*** *Actions that rely on natural processes to degrade constituents in soil.*
  - Natural attenuation
- ***Containment.*** *Actions that minimize the potential for direct contact with and erosion of soil.*
  - Capping (vegetated soil/asphalt/concrete/building cover, low permeability cover)
- ***In situ treatment.*** *Actions that treat COPCs in soil in place.*
  - Physical (soil vapor extraction)
  - Chemical (chemical oxidation, flushing)
  - Biological (enhanced bioremediation, bioventing)
  - Thermal (soil heating, hot air or steam injection)
- ***Removal.*** *Actions to excavate impacted soil.*
  - Excavation (mechanical excavation)
- ***Disposal.*** *Actions that include the disposal of soil onsite or offsite.*
  - Offsite treatment/disposal (disposal at a commercial facility)

The screening and evaluation of remedial technologies and process options addressing soil is summarized in **Table 6**.

Groundwater

Potential groundwater technologies were evaluated during the 2008 evaluation of interim groundwater corrective measures. The IRM evaluation, documented in **Appendix B** of the *Hydraulic Control IRM Work* Plan (OBG, 2009a), resulted in a focused list of retained technologies. Considering the success of the groundwater IRM, additional groundwater corrective measure technologies were evaluated and considered during the CMS, including the following:

- ***No action.*** *No action is considered in the CMS as a benchmark for the evaluation of corrective measures. O&M of the groundwater IRM would be discontinued.*

- ***Institutional Controls.*** *Actions that provide site access and use restrictions, provisions for O&M of the existing groundwater IRM, and monitoring of corrective measure effectiveness.*
  - Monitoring (groundwater monitoring)
  - Proprietary controls (access/use restriction; environmental covenant)
  - Site controls (I&EC Plan)
  - Periodic site reviews
- ***Natural recovery.*** *Actions that rely on natural processes to degrade constituents in groundwater.*
  - Natural attenuation

The screening and evaluation of remedial technologies and process options addressing groundwater, including those evaluated during the development of the groundwater IRM, are summarized in **Table 7**.

4.2.2 Evaluation of Corrective Measure Technologies

Corrective measure technologies remaining after the initial screening were evaluated according to the criteria of implementability, effectiveness, and cost. The effectiveness criterion included the evaluation of:

- Potential effectiveness of the process option in meeting the CMOs and handling the estimated areas, volumes, and/or mass of COPCs in media summarized in **Section 4.1**
- Potential effects on human health and the environment during implementation (including, as appropriate, construction and operation)
- Reliability of the process options for Site COPCs and conditions.

Technical and institutional aspects of implementing the process options were assessed for the implementability criterion. The capital and O&M costs of each process option were evaluated as to whether they were high, medium, or low relative to the other process options of the same technology type. Based on the evaluation, the more favorable process options of each technology type were chosen as representative process options. The selection of representative process options simplifies the assembly and evaluation of corrective measures alternatives, but does not eliminate other process options for consideration. The representative process option provides a basis for conceptual design during the CMS, without limiting flexibility during the design phase. An alternative process option may be selected during the design phase as a result of design evaluations or testing. The screening and evaluation of technologies for soil and groundwater is summarized in **Tables 6 and 7**, respectively**.**

Soil

Because of the screening and evaluation of technologies, *in situ* physical, chemical, biological, and thermal treatment technologies/process options were not retained for soil. *In situ* physical treatment (soil vapor extraction) was not retained due to the limited radius of influence and effectiveness due to low permeability soils and heterogeneous subsurface conditions. *In situ* chemical and biological treatment technologies were not retained due to limited effectiveness of amendment distribution due to low permeability soils and subsurface heterogeneity. *In situ* thermal treatment technologies were not retained for further consideration due to limited effectiveness of hydraulic/vapor control systems in low permeability conditions and limited implementability of thermal treatment infrastructure in an active industrial setting.

Groundwater

The screening and evaluation of remedial technologies completed during the development of the groundwater IRM yielded a focused list of retained technologies, including P&T and MNA (OBG; 2009a). The summary of treatment technologies considered in that evaluation is detailed in **Appendix B** of the *Hydraulic Control IRM Work Plan* (OBG, 2009a) and included in **Table 7**. Since that evaluation, there are no recently developed technologies that should be added to this summary. Moreover, site conditions have not changed in a manner that would warrant re-evaluation of rejected technologies. The ongoing IRM, implemented in July 2011, has

since achieved significant decrease of CVOC concentrations in groundwater in all three groundwater flow zones. The IRM has resulted in a stable plume, and there are no unacceptable exposures to CVOCs.

4.2.3 Summary of Retained Corrective Measure Technologies

Following is a description of the representative process options for retained technologies by GRA and technology for soil and groundwater.

No Action

The no action alternative was identified as a representative process option for soil and groundwater and will be utilized as a benchmark for the evaluation of active corrective measures. O&M of the groundwater IRM components (P&T and MNA) would not be included under this corrective measure alternative.

Institutional Controls

Access and site use restrictions, environmental covenant, I&EC Plan (including items such as worker notification, safety measures, and SWMU/AOC management program), and periodic EC inspections and site reviews were identified as a representative process option associated with the institutional controls GRA for soil and groundwater.

- ***Access/Use restrictions.*** This option is applicable to all SWMUs/AOCs with COPC soil concentrations above Resident Soil RSLs. Access/use limitations would be recorded for these SWMU/AOCs documenting continued industrial property use and restricted groundwater use.
- ***Environmental covenant.*** This option is applicable to SWMUs/AOCs with COPC soil concentrations above Resident RSLs as well as CMOs. Access/use limitations would also be recorded for these SWMUs/AOCs documenting continued industrial property use and restricted groundwater use, and requiring that activities that would disturb engineering controls and potentially expose impacted materials (and require health and safety precautions) be performed in accordance with the I&EC Plan.
- ***Institutional and Engineering Controls Plan.*** An I&EC Plan (**Appendix E**) documents Facility institutional and engineering controls and physical components of the selected remedy requiring operation, maintenance, and monitoring to provide for continued effectiveness of the remedy. The document includes procedures for the handling and management of soil within identified SWMU/AOCs during remedial, maintenance, and Facility development activities, as well as provisions for periodic site reviews.
- ***Periodic site reviews.*** Periodic reviews would be conducted to evaluate the Facility with regard to continuing protection of human health and the environment and to document remedy effectiveness.

Groundwater monitoring was also identified as a representative process option associated with the institutional controls GRA for groundwater.

- ***Groundwater monitoring.*** Groundwater monitoring would involve periodic sampling and analysis of groundwater in accordance with the approach and methods outlined in the *IRM PMP* (OBG, 2010). Groundwater monitoring includes influent and effluent concentrations as well as groundwater quality and hydraulic (water level) monitoring. Groundwater monitoring would provide a means of detecting changes in constituent concentrations in Perched, USG, and LSG groundwater. Groundwater monitoring also provides a means of evaluating the effectiveness of the selected corrective measure, including MNA.

Natural Recovery

Natural attenuation was identified as the representative process option associated with the natural recovery GRA for soil and groundwater.

- ***Natural attenuation***. Natural attenuation relies on naturally occurring attenuation processes to degrade the mass, mobility, volume, or concentration of organic constituents in soil and groundwater over time. Natural attenuation of groundwater concentrations would be verified with periodic groundwater monitoring.

Hydraulic Control

Extraction wells were identified as a representative process option associated with the hydraulic control GRA for groundwater. A hydraulic control system is an engineered system that is designed to intercept and collect groundwater.

- ***Extraction wells.*** Impacted groundwater would be collected by pumping from vertical and/or horizontal extraction wells. The collected groundwater would require separate management. As described in **Section 2.5.3.1,** a groundwater P&T system, consisting of seven extraction wells and GWTP, was operated since July 2011 to address offsite migration of CVOCs in the southern portion of the Facility.

***Ex situ* Treatment**

Onsite treatment at the Facility GWTP was identified as the representative process option associated with the *ex situ* treatment GRA for groundwater.

- ***Facility GWTP.*** Collected groundwater would be conveyed to the Facility GWTP for physical and chemical treatment. As described in **Section 2.5.3.1**, the GWTP was constructed to treat groundwater as part of the IRM groundwater hydraulic control system. The Facility GWTP provides treatment of groundwater through filtration, sequestration, air stripping and pH adjustment. Effluent from the GWTP is subsequently discharged to Mill Creek.

Removal

Mechanical excavation was identified as the representative process option associated with the removal GRA for soil.

- ***Mechanical excavation.*** Mechanical excavation of soil would be implemented using construction equipment such as backhoes and front-end loaders. Excavated areas are backfilled, graded and restored with vegetation, concrete and/or asphalt based on Facility area and restoration requirements. Excavation may be hindered by nearby active operations and proximity of utilities and other structures.

Disposal

Disposal at an offsite commercial facility was identified as the representative process option associated with the disposal GRA for soil.

- ***Disposal at a commercial facility***. Coupled with mechanical excavation, soil would be transported to regulated, commercial offsite facilities for subsequent treatment/disposal. Excavated soil identified as non-hazardous would be disposed at an offsite facility. Excavated soil that may be characterized as hazardous and does not meet land disposal restrictions would require treatment prior to disposal.

4.3 ASSEMBLY OF CORRECTIVE MEASURE ALTERNATIVES

Three corrective measure alternatives were developed to address soil and groundwater by assembling GRAs and representative process options into combinations that address CMOs for soil and groundwater. The three corrective measure alternatives discussed in this section of the CMS are as follows:

- Alternative 1 is the no action alternative. This alternative serves as a benchmark for the evaluation of action alternatives. Under this corrective measure, O&M of the P&T system and MNA would be discontinued.
- Alternative 2 is continued O&M of existing P&T system (including operation of seven recovery wells and Facility GWTP), monitored natural attenuation and institutional and engineering controls, and includes access/use restrictions and/or environmental covenant, implementation of an I&EC Plan, and periodic reviews.
- Alternative 3 includes excavation and offsite disposal of Facility soil exceeding CMOs, continued O&M of existing P&T system (including operation of seven recovery wells and Facility GWTP), monitored natural attenuation, and institutional and engineering controls consisting of access/use restrictions and/or environmental covenant, implementation of an I&EC Plan, and periodic reviews.

A description of each corrective measure alternative is included in the following subsections.

4.3.1. Alternative 1 – No Action

Alternative 1 is the no action alternative. The no action alternative serves as a benchmark for the evaluation of action alternatives. This alternative provides for an assessment of the environmental conditions if no corrective measures are implemented and existing/ongoing actions are ceased. Under Alternative 1, it is assumed that O&M of the existing P&T system and MNA would cease.

4.3.2 Alternative 2 – Continued O&M of P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls

Alternative 2 would involve the continued O&M of the P&T system and MNA, with institutional and engineering controls. In July 2011, GE initiated operation of the IRM groundwater extraction system at the southern (downgradient) portion of the GE Aviation manufacturing facility for mitigating offsite migration of CVOCs. Operation of the groundwater IRM (P&T and MNA) would continue under Alternative 2. If shut down of the groundwater IRM is warranted based on groundwater CMOs attainment and the approach outlined in **Appendix C**, MNA would continue to be used to address residual CVOC concentrations in groundwater. Potential concerns associated with exposure to and erosion of surface soil would be addressed through maintenance of existing cover systems (*i.e.,* pavement, vegetation and buildings), institutional and engineering controls. Institutional and engineering controls would include access/use restrictions, an environmental covenant, implementation of an I&EC Plan, groundwater monitoring, and periodic reviews. An illustration of the general components of Alternative 2 is depicted on **Figure 8**. The corrective measure components of Alternative 2 are described below.

Continued O&M of Groundwater P&T

The groundwater P&T is described in detail in **Section 2.5.3.1**. The P&T system consists of seven groundwater extraction wells and a GWTP. Operation of the GWTP was started on July 11, 2011. The GWTP consists of filtration, sequestering, air stripping, and pH adjustment. Treated groundwater is discharged to Mill Creek in accordance with an NPDES Permit.

The groundwater IRM (strategic P&T and MNA) successfully addresses offsite migration of CVOCS in the southern (downgradient) portion of the Facility within the area of former AFP36 (OBG, 2009a). The groundwater IRM objective is to mitigate offsite migration of CVOCs, while minimizing the risk of cross-contamination and/or reducing the effectiveness of the biodegradation processes. The overall extent of impacted groundwater is stable or decreasing, as evidenced by stable or decreasing plume mass and CVOC concentrations in most individual wells. This ongoing IRM was implemented in 2011 and since then has decreased CVOC concentrations in groundwater by orders of magnitude.

Access/Use Restriction and Environmental Covenant

Access will be restricted to designated SWMUs/AOCs with COPC soil concentrations above Resident Soil RSLs. A combination of worker safety measures, worker notification and restriction signage, and a management program will be included as part of the institutional controls program to minimize exposure to construction and utility workers. An environmental covenant will be prepared to specify exposure controls over these areas. The covenant will include legal descriptions and American Land Title Association (ALTA) survey metes and bounds of the designated SWMUs/AOCs, with the specification that these areas will be restricted to industrial use. The covenant will specify that excavations or other disturbances of soils in these areas follow the provisions of the I&EC Plan.

For the subset of these SWMUs/AOCs with COPC soil concentrations greater than CMOs, an environmental covenant will specify areas that require a cover system and require that excavations or other disturbance of soils in these areas follow the provisions of an I&EC Plan. Background information and the extent of institutional and engineering controls for designated SWMUs/AOCs are provided in **Appendix F**.

The covenant will also prohibit potable use of groundwater at the Facility.

Institutional and Engineering Controls Plan

An I&EC Plan has been prepared (**Appendix E**) for establishing the procedures to prevent exposure to subsurface impacted media (soil, groundwater and soil vapor) at the Facility. Under Alternative 2, institutional and engineering controls will be implemented to minimize exposure to impacted media. The approach to meet this objective includes:

- Application of institutional and engineering controls to protect Facility employees and workers from exposure to subsurface impacted media;
- Use of risk assessment results to identify the appropriate mix of institutional and engineering controls at each SWMU/AOC where the implementation of corrective action is warranted; and
- Establishment of work procedures that should be followed to maintain compliance with safety and environmental regulations.

The I&EC Plan outlines management procedures, including the handling and management of soil during intrusive remedial, maintenance, utility installation/repair, or Facility repurposing activities within impacted areas. Potential exposure to COPCs in groundwater will be controlled by restricting the potable use of groundwater from the Facility as well as by: the groundwater remedy and monitoring; the availability of municipal water supply; and well permitting regulations. The plan addresses the implementation of health and safety procedures, contractor and Facility coordination requirements, and materials handling procedures to ensure the protection of human health and the environment.

In addition, the I&EC Plan will include provisions for periodic review of institutional and engineering controls to verify continued protection of human health and the environment and provide recommendations for changes to the corrective measures program, as appropriate.

Periodic Site Reviews

Site reviews would be conducted in accordance with the I&EC Plan to evaluate the designated SWMUs/AOCs with regard to continuing protection of human health and the environment as evidenced by documentation of field inspections and monitoring data.

Groundwater Monitoring

Periodic sampling and analyses of groundwater would be implemented as a means of detecting changes in constituent concentrations in groundwater and for evaluating effectiveness of the groundwater IRM. Groundwater monitoring activities, including baseline monitoring, have been conducted at the Site since startup of the IRM in accordance with the approach and methods outlined in the *IRM PMP* (OBG, 2010). The IRM performance monitoring includes influent and effluent concentrations as well as groundwater quality and hydraulic (water level) monitoring. The monitoring program is designed to adapt to conditions and the data needs of decision-making. For the purpose of developing CMS cost estimates, and consistent with the current groundwater monitoring program, it is assumed that groundwater sampling would consist of quarterly sampling of 45 Perched/USG/LSG monitoring wells with analyses for VOCs using Method 8260. A summary of analytical data generated during groundwater monitoring events would be submitted to USEPA.

Natural Attenuation of CVOCs in Groundwater

Natural conditions are affecting a decrease in CVOCs via physical, chemical and biological processes. These processes include intrinsic biodegradation, advection and hydrodynamic dispersion (dilution) and other chemical reactions (abiotic transformation of CVOCs). Monitored natural attenuation (MNA) adds a monitoring and evaluation component to natural attenuation and would involve the implementation of a long-term program to monitor the effectiveness of natural attenuation to mitigate offsite migration of CVOCs and achieve groundwater remediation goals. The MNA sampling program, including baseline monitoring, bioattenuation screening, microcosm studies, and groundwater sampling and analysis has been conducted since 2010, the results of which are included in **Appendix C**. The natural attenuation monitoring program is designed to adapt to conditions and the data needs of decision-making. For the purpose of developing CMS cost estimates, and consistent with the current MNA program, it is assumed that groundwater sampling would consist of annual

sampling of 27 Perched/USG/LSG monitoring wells with analyses for VOCs, geochemical parameters, and metabolic by-products. A summary of analytical data generated during groundwater monitoring events would be submitted to USEPA.

4.3.3 Alternative 3 – Soil Excavation/Disposal, Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls

Alternative 3 would involve the excavation of soil exceeding CMOs, continued O&M of the groundwater P&T system and MNA, with institutional and engineering controls. Excavation of soil in Alternative 3 would include the excavation of surface and subsurface soil with concentrations exceeding CMOs. Operation of the groundwater IRM (P&T and MNA) at the southern (downgradient) portion of the GE Aviation manufacturing facility would continue under Alternative 3 for mitigating offsite migration of CVOCs. If shut down of the groundwater IRM is warranted based on groundwater CMOs and the approach outlined in **Appendix C**, MNA would continue to be used to address residual CVOC concentrations in groundwater. For Facility areas not addressed by excavation, potential concerns associated with exposure to and erosion of surface soil would be addressed through maintenance of existing site cover systems (*i.e.,* pavement, vegetation and buildings), institutional and engineering controls. Consistent with Alternative 2 components, institutional and engineering controls would include access/use restrictions, an environmental covenant, implementation of an I&EC Plan, groundwater monitoring, and periodic reviews. An illustration of the general components of Alternative 3 is depicted on **Figure 9**. The corrective measure components of Alternative 3 are described below.

Common Components

Alternative 3 includes several common components previously described above for Alternative 2 (**Section 4.3.2)**. Components that are common to corrective measures Alternatives 2 and 3 are as follows:

- Continued O&M of groundwater P&T system
- MNA
- Groundwater monitoring
- Access/use restriction and an environmental covenant
- I&EC Plan
- Periodic site reviews

In addition to the common components of Alternative 2, the following corrective actions are included in Alternative 3:

Excavation and Offsite Treatment/Disposal of Soil

Under Alternative 3, the mechanical excavation of soil would be conducted to remove soil exceeding CMOs. The delineation of these areas is described above in **Section 4.1.1**. Alternative 3 would include the excavation of soil with SWMUs/AOCs identified for further evaluation. The total volume of soil associated with excavation in Alternative 3 is estimated at approximately 36,100 cubic yards. The assumed areas of excavation at the Facility are depicted on **Figure 9**. It is assumed that a combination of excavation and sloping techniques and/or sheet piles would be implemented during excavation, based on the target depth and location of the proposed excavation. Excavations near Facility roadways and adjacent to buildings would include, for estimating costs, sheet piles to maintain the stability of the building and/or adjacent roadway. Additionally, for cost estimate purposes, it was assumed that soil beneath existing buildings would not be excavated. Potential exposure to impacted soil below existing buildings is addressed in the I&EC Plan (**Appendix E**). The excavated areas would be backfilled with clean backfill to restore the area to existing grade. Surface cover would also be restored with vegetation or asphalt, based on existing conditions. It was assumed that select excavations would require dewatering and subsequent water management. For the purpose of CMS cost estimates, use of temporary piping, pumps, tanks and a treatment facility was assumed for management of excavation water. The limits of excavation, sloping/sheeting, and water management could be further refined during pre-design activities.

For corrective measure cost estimate purposes, it was assumed that 23,900 cubic yards of soil and 800 cubic yard of asphalt would be transported offsite for disposal as non-hazardous waste. It was also assumed, for cost estimate purposes, that 12,200 cubic yards of soil would be transported offsite as hazardous waste for subsequent treatment and disposal. Excavated soil that does not meets land disposal restrictions (LDRs) would be transported offsite to a commercial permitted hazardous treatment facility for treatment to LDRs prior to disposal. Excavated soil that meets LDRs would be transported to a hazardous waste landfill for disposal. Characterization of soil proposed for excavation and offsite management would be required during pre-design, in addition, identification of a disposal facility/facilities with adequate treatment and capacity would be required during pre-design. For the purpose of developing CMS cost estimates, treatment and disposal rates were assumed based on engineering and industry standards.

5. DETAILED ANALYSIS OF CORRECTIVE MEASURE ALTERNATIVES

This section documents the detailed analysis of the three corrective measure alternatives that were developed during the CMS for soil and groundwater. The detailed analysis of corrective measure alternatives was conducted consistent with the RCRA Permit (ID No. OHD 000817312), the RCRA Corrective Action program (USEPA, 1996; 2004), and the USEPA-approved *CMS Work Plan* (OBG 2014). This section describes the individual and comparative analysis of the alternatives with respect to three threshold criteria and five decision factors to analyze and present sufficient information to allow the alternatives to be compared and a corrective measure recommended.

5.1 INDIVIDUAL ANALYSIS OF CORRECTIVE MEASURE ALTERNATIVES

The RCRA Corrective Action program (USEPA, 1996; 2004) identifies that during remedy selection, three threshold criteria should be satisfied in order for an alternative to be eligible for selection. The threshold criteria evaluated in the CMS include:

- Protection of human health and the environment
- Attainment of applicable cleanup standards
- Control the source(s) of release(s) to reduce or eliminate further releases of hazardous wastes and hazardous constituents that may pose a threat to human health and the environment

The objective of the detailed analysis of alternatives was to analyze and present sufficient information to allow the alternatives to be compared and a remedy selected. The analysis consisted of an individual assessment of each alternative with respect to the evaluation criteria that encompass statutory requirements and overall feasibility and acceptability. The following evaluation/balancing criteria used in the detailed analysis of alternatives for this CMS include:

- Short-term and long-term effectiveness
- Reduction of toxicity, mobility, and/or volume through treatment
- Long-term reliability
- Implementability
- Cost.

In the individual analysis of alternatives, each alternative was evaluated with respect to the above-listed evaluating criteria. The criteria are described below and the summary of the analysis is presented in **Table 8**.

5.1.1. Protection of Human Health and the Environment

Human health and environmental assessment evaluates the extent to which each alternative protects human health and the environment and a description of how site risks would be eliminated, reduced, minimized or controlled through treatment, engineering, or institutional controls. This criterion considers the classes and concentrations of contaminants allowed to leave the site (if any), potential exposure routes, and potentially affected populations or adverse impacts to environmentally sensitive areas. The evaluation of each alternative with respect to overall protection of human health and the environment is presented in **Table 8.**

5.1.2. Attainment of Applicable Cleanup Standards

Each corrective measure alternative is evaluated to assess whether it would attain applicable cleanup standards. The development of media-specific CMOs is described above in **Section 3.** CMOs for soil and groundwater are presented on **Tables 2 and 3**, respectively. The evaluation of each alternative with respect to attainment of applicable CMOs is presented in **Table 8.**

5.1.3. Control Source(s) of Release(s)

Control sources of releases evaluates the extent to which the alternative would reduce or eliminate, to the extent practicable, further releases of hazardous waste or hazardous constituents that may pose a threat to human health and the environment. The short- and long-term effects of the alternative on the environment and whether the alternative controls releases to the environment would also be described. The evaluation of each alternative with respect to control of source(s) of release(s) is presented in **Table 8**.

5.1.4. Short- and Long-term Effectiveness

Each alternative was evaluated to assess the short-term and long-term effectiveness it would afford. The short-term effectiveness and impacts of each alternative are assessed, considering the following:

- Magnitude of reduction of existing risks
- Potential short-term risks that might be posed to the community, workers, or the environment during implementation of the corrective measure
- Length of time from implementation of the alternative until protection is achieved

Each alternative is evaluated to assess the long-term effectiveness it would afford. Factors considered, as appropriate, include:

- Magnitude of potential residual risk from materials remaining at the conclusion of the corrective measure
- Potential for exposure of humans and environmental receptors to wastes remaining onsite

The evaluation of each alternative with respect to short- and long-term effectiveness is presented in **Table 8**.

5.1.5. Reduction in the Toxicity, Mobility or Volume of Impacts

For each alternative, the degree to which the alternative results in the reduction of toxicity, mobility or volume of COPC impacts is assessed. Factors considered, as appropriate, include:

- Treatment processes employed and the materials it would treat
- Amount of wastes that would be treated
- Degree to which the treatment is irreversible
- Type and quantity of residuals that would remain following treatment, considering the persistence, toxicity, and mobility

The evaluation of each alternative with respect to reduction in toxicity, mobility or volume is presented in **Table 8**.

5.1.6. Long-Term Reliability

Each alternative is evaluated to assess the long term reliability and permanence it would afford. Factors considered, as appropriate, include:

- Adequacy and reliability of institutional and engineering controls, implemented for the purpose of managing materials left in-place at the Facility
- Type and degree of long-term management required, including operation, maintenance and monitoring
- Potential need for replacement of the remedy

5.1.7. Implementability

Each alternative is assessed relative to the ease or difficulty of executing the alternative by considering the following factors, as appropriate:

- Technical feasibility, including constructability, operational reliability of the corrective measure, and availability of materials

- Expected operational reliability of the technologies
- Administrative feasibility, including activities needed to coordinate with other agencies or entities and ability and time to obtain necessary approvals and permits
- Availability of services and material, including the availability of offsite treatment, storage, and disposal facilities, and necessary equipment and specialists to implement the corrective measure.

5.1.8. Cost

For the cost analysis, estimates were prepared for each corrective measure alternative based on cost estimating guides, experience, and available operation and maintenance information. Cost estimates were prepared for the purpose of alternative comparison and were based on facility-specific information, when available. The cost estimates include capital costs, annual O&M costs, and present worth costs. The present worth costs for the alternatives were calculated based on the expected/assumed duration of the remedy using a 7% discount rate. The individual cost estimates for Alternatives 2 and 3 are included in **Tables 9 and 10**, respectively.

5.2 COMPARATIVE ANALYSIS OF CORRECTIVE MEASURE ALTERNATIVES

The detailed analysis of corrective measure alternatives includes a comparative evaluation designed to consider the relative performance of the alternatives and identify major trade-offs among them. The comparative evaluation of alternatives is presented in the following subsections. In the comparative analysis of alternatives, the performance of each alternative relative to the others was evaluated for each criterion.

As discussed in the following subsections, with the exception of Alternative 1, each alternative would satisfy the threshold criteria by providing protection to human health and the environment, attaining applicable CMOs, and controlling the source of releases. Therefore, Alternatives 2 and 3 would be eligible for selection as the final remedy.

As described in **Section 5.1**, the detailed evaluation with respect to the CMS criteria for each of the alternatives is presented in **Table 8**.

5.2.1. Protection of Human Health and the Environment

Human Health

Alternative 1, the no action alternative, is only partially protective of human health over the long-term, whereas Alternatives 2 and 3 would both be protective of human health through continued operation of the groundwater P&T and MNA, with institutional and engineering controls. Potential exposure to Facility groundwater is not addressed in Alternative 1; however, potable water is supplied in Butler and Hamilton counties. Additionally, exposures to impacted site surface soil is minimized in Alternative 1 through existing pavement and building cover and perimeter fencing; however, Alternative 1 does not provide a means of inspecting and maintaining existing Facility fencing and covers and maintaining groundwater use restrictions. Alternative 1 would rely on natural attenuation (without monitoring and evaluation) to address offsite migration of COPCs in groundwater. Operation of the groundwater IRM in Alternatives 2 and 3 would mitigate offsite migration of COPCs in groundwater allowing for natural attenuation of downgradient COPC concentrations over the long-term. Groundwater performance monitoring and MNA would provide a means of monitoring groundwater concentrations and continued protection of potential receptors.

In both Alternatives 2 and 3, access/use limitations and/or environmental covenant, I&EC Plan and periodic reviews would limit site use, groundwater use, establish provisions to monitor and review corrective measure protectiveness, and minimize potentially unacceptable risks to human health associated with soil and groundwater exceeding CMOs. Additionally, implementation of an I&EC Plan in Alternatives 2 and 3 would address potential soil exposures to construction and utility workers. Alternative 3 would provide protection of construction and utility workers through targeted excavation of soils exceeding CMOs. Short-term risk to construction workers during remedial excavation would be addressed by utilization of personal protective equipment and trained personnel. Continued operation of the groundwater IRM components would provide for

mitigation of potentially unacceptable effects of impacted groundwater to human health and reduce offsite migration of groundwater.

Environment

Alternative 1, the no action alternative, is only partially protective of the environment over the long-term. Existing Facility pavement and buildings reduce erosion of impacted surface soils; however; Alternative 1 does not provide a means of inspecting and maintaining existing covers. Alternatives 2 and 3 would both be protective of the environment through institutional controls and continued O&M of the groundwater P&T and MNA. Alternative 1 would rely on natural attenuation (without monitoring and evaluation) to address COPC concentrations exceeding criteria in soil and groundwater and offsite migration of impacted groundwater. Alternative 3 would provide added long-term protectiveness as compared to Alternative 2 through targeted removal of impacted soil.

In both Alternatives 2 and 3, continued operation of the existing groundwater IRM (P&T and MNA) would provide for mitigation of potentially unacceptable effects of contaminated groundwater to the environment. Operation of the groundwater IRM would reduce offsite migration of COPCs in groundwater allowing for natural attenuation of downgradient COPC concentrations over the long-term. Groundwater performance monitoring and MNA would provide a means of monitoring groundwater concentrations and IRM effectiveness.

In summary, Alternative 1 provides partial long-term protection of human health associated with hypothetical exposures to groundwater and exposure to site soil exceeding criteria. Alternative 1 relies solely on natural attenuation to address offsite migration of COPC in groundwater and does not include monitoring to evaluate attenuation. Alternatives 2 and 3 would both be protective of human health and the environment through institutional and engineering controls and continued implementation of the groundwater IRM. Alternative 3 would provide protection of human health and the environment at selected locations through targeted removal of soil exceeding CMOs; however, the extent and depth of secondary sources may preclude significant improvement of site-wide environmental conditions.

5.2.2. Attainment of Applicable Cleanup Standards

Alternative 1, the no action alternative, may attain applicable CMOs for groundwater over the long term through natural attenuation; however, would not achieve applicable CMOs for soils. COPC concentrations in groundwater would likely be reduced to below CMOs with a combination of the continued operation of the P&T system, and MNA within each of the three hydrogeologic units at the Site under both Alternatives 2 and 3. Alternatives 2 and 3 would address potential exposure to soil and groundwater exceeding CMOs through institutional and engineering controls, site management, and monitoring. Excavation of impacted soil with offsite disposal in Alternative 3 would allow for attainment of soil CMOs within areas where target excavation is completed however, the extent and depth of COPCs precludes site-wide attainment of cleanup standards through soil excavation.

5.2.3. Control Source(s) of Release(s)

Alternative 1, the no action alternative, would not control sources of releases to the environment. Hydraulic control via use of the IRM recovery wells, common to both Alternatives 2 and 3, would mitigate the sources of releases by capturing the highest concentrations in groundwater prior to leaving the site within each of the three hydrogeologic units. Hydraulic control and MNA would have short-term and long-term effects on the environment to reduce COPC concentrations to acceptable standards at or slightly downgradient of the property boundary, if properly implemented. Alternative 2 provides some degree of soil source control while Alternative 3 provides control of soil COPC sources at selected locations through targeted excavation. However, impacted shallow soils above CMOs are not significant sources of groundwater impacts, particularly compared with residual sources of sorbed CVOCs located deep within the water-bearing units in the southern area of the Facility. Institutional and engineering controls, site management and monitoring in Alternatives 2 and 3 provide a means to prevent potential exposures to soil and groundwater impacted by sources of COPCs.

5.2.4. Short- and Long-Term Effectiveness

Short-Term Effectiveness

Alternative 1, the no action alternative, relies on natural attenuation (without monitoring and evaluation) and would not achieve site objectives in the short-term. Existing surface covers (*i.e.,* buildings, asphalt, and vegetation) and Facility fencing and availability of public water supply reduce human exposures to soil and groundwater, respectively in the short-term.

For Alternatives 2 and 3, the short-term effectiveness is supported through continued O&M of the P&T system and MNA and implementation of institutional and engineering controls. Alternatives 2 and 3 would effectively mitigate potential exposures to COPCs in soil and groundwater and reduce offsite groundwater migration upon implementation. Limited excavation of impacted soil in Alternative 3 would also be effective for addressing soils exceeding CMOs at selected locations upon implementation in the short-term, but may not significantly contribute to near-term goals at the Facility level. Limited soil removal, backfill and surface restoration of select SWMUs/AOCs is assumed to be completed in approximately one year.

Since there is no construction associated with continued operation of the P&T system (components are already in place), there would be no impacts to the community as a result of construction. Compliance with Occupational Safety and Health Administration (OSHA) requirements and a Health and Safety Plan (HASP) during operation of the GWTP will be required during groundwater IRM O&M activities (Alternatives 2 and 3) and during limited soil excavation (Alternative 3). The short-term risks to personnel operating the treatment system, waste transporters, and disposal facility personnel would be present due to handling, transport, and disposal of treatment residuals. Operation of the groundwater P&T system and MNA is an effective alternative to mitigate groundwater contaminant exposure to human health and the environment at and downgradient of the property boundary. Operation of the IRM and MNA are estimated to meet the CMOs for groundwater within the next three to five years (see **Appendix C**).

Minimal short-term impacts to the community are anticipated during excavation activities under Alternative 3. Dust and volatile emissions, if any, would be monitored and controlled during construction activities. Limited soil removal, backfill and surface restoration of select SWMUs/AOCs would be completed in approximately less than a year.

Long-Term Effectiveness

Alternative 1 has no active components and would rely solely on natural attenuation to achieve site objectives over the long-term. Existing surface covers (*i.e.,* buildings, asphalt, and vegetation) and Facility fencing and availability of public water supply reduce human exposures to soil and groundwater, respectively; however Alternative 1 does not provide for maintenance and monitoring to evaluate long-term effectiveness.

Long-term effectiveness would be provided under Alternatives 2 and 3 through continued operation of the groundwater P&T system and MNA and implementation of institutional and engineering controls. Continued implementation of the groundwater IRM would address offsite migration of groundwater over the long-term, with the potential to phase shutdown of the P&T system over the next several years, followed by MNA only, upon attainment of performance criteria and CMOs. Institutional and engineering control components of Alternatives 2 and 3 would effectively reduce potential for exposures to impacted soil and groundwater over the long-term, while providing a means of monitoring corrective measure effectiveness through monitoring and periodic site reviews. Excavation of soil within targeted areas onsite would effectively reduce COPC concentrations in soil over the long-term at selected locations in Alternative 3, but would not significantly improve conditions site-wide.

Community impacts as a result of the long-term implementation of Alternatives 2 or 3 are not anticipated. The potential for community exposure to impacted groundwater exists in Alternative 1 due to the absence of measures to address groundwater usage and offsite migration.

Compliance with OSHA requirements and a HASP during operation of the GWTP will be required during groundwater O&M activities (Alternatives 2 and 3). Operation of the P&T system has the potential to result in

remedial worker exposure (*e.g.*, dermal, incidental ingestion and inhalation) related to sampling and management of recovered groundwater and during IRM system maintenance. Long-term risks to personnel operating the treatment system, waste transporters, and disposal facility personnel would require management, particularly during handling, transport, and disposal of treatment residuals. Compliance with OSHA and HASP requirements would reduce exposure risks to remedial workers. Continued implementation of the groundwater IRM is an effective alternative to mitigate groundwater contaminant exposure to human health and the environment at and downgradient of the property boundary. Operation of the P&T system and MNA is expected to meet the cleanup goals for groundwater over the long-term.

5.2.5. Reduction in the Toxicity, Mobility or Volume of Impacts

Alternative 1, the no action alternative, has no treatment components and therefore, no reduction of toxicity, mobility, and/or volume through treatment. Reduction of COPC toxicity and/or volumes relies solely on natural attenuation in Alternative 1. Mobility of COPCs in surface soils would be reduced by existing Facility pavement and buildings under Alternative 1 (without monitoring and evaluation). Operation of the existing P&T system and MNA, common to both Alternatives 2 and 3, would reduce the mass and toxicity of CVOCs in groundwater by removing impacted groundwater from the water-bearing units at the Facility and reduce offsite/downgradient concentrations. The hydraulic control system (recovery wells) would remove groundwater with CVOCs. Since the groundwater IRM was initiated in 2011, over 500 million gallons of groundwater have been extracted and treated and CVOC concentrations in groundwater have been reduced by orders of magnitude.

The groundwater P&T system consists of filtration, sequestering, air stripping, and pH adjustment. Air stripping removes CVOCs from the groundwater, with resulting vapor discharge to the ambient air in accordance with applicable air permit and monitoring requirements. Additionally, groundwater P&T system effluent would discharge to Mill Creek in accordance with a NPDES permit. Treatment system residuals would require off-site management and pose a potential exposure risk during handling, transport and disposal. Compliance with a HASP during operation of the GWTP will be required.

Alternative 2 does not include soil treatment or removal measures and would rely solely on natural attenuation to reduce the toxicity and volume of impacted soil. Mobility of COPCs in surface soils would be reduced by existing Facility pavement and buildings under Alternative 2. Alternative 3 involves the targeted removal of soil exceeding cleanup criteria which will reduce the toxicity and volume, but without significant site-wide decrease of mobility. Approximately 36,100 cubic yards of soil is included for removal and offsite treatment/disposal under Alternative 3.

5.2.6. Long Term Reliability

Alternative 1 does not include active corrective measure components; however, existing pavement, buildings and fencing provide effective means of reducing exposure to impacted soil. Alternative 1 does not provide for maintenance and monitoring of these controls to ensure long-term reliability. Alternatives 2 and 3 involve institutional and engineering controls which are an adequate and reliable means of controlling Site use and direct contact with Site soil. Continued operation and maintenance of the groundwater IRM would be an adequate and reliable control to support the effectiveness of the groundwater corrective measure. The O&M manual and *IRM PMP* will be followed to maintain the operational performance of the P&T system and groundwater monitoring program. Excavation and proper offsite management in Alternative 3 is an adequate and reliable means for addressing soil exceeding CMOs and reducing the potential for construction and utility worker exposure at selected locations where excavation is feasible. Alternatives 2 and 3 provide adequate and reliable means to ensure long-term corrective measure effectiveness.

5.2.7. Implementability

Each alternative would be implementable. Alternative 1 is readily implementable as there are no technologies to be constructed. For Alternatives 2 and 3, the groundwater IRM is currently being successfully implemented. Monitoring the effectiveness of the groundwater IRM through groundwater monitoring, inspection and maintenance, and effectiveness of MNA through Site monitoring are implementable. Institutional and engineering controls and MNA in Alternatives 2 and 3 are readily implementable.

Excavation and offsite disposal of 36,100 cubic yards of material is implementable. Location and capacity of offsite treatment/disposal facilities would be confirmed during the design phase. Dewatering and stabilization of excavated materials may be required and would be further evaluated during the design phase. Implementability challenges would exist during Alternative 3 excavation activities due to nearby active operations and proximity of utilities and other structures. Excavations would require phasing and coordination due to active industrial operation of the Facility.

Coordination with USEPA, GE Aviation facilities, local and county agencies would potentially be required for Alternatives 2 and 3. The necessary equipment, specialists, and materials would be readily available for implementation of O&M in Alternatives 2 and 3 and excavations of soil in Alternative 3.

5.2.8. Cost

Cost estimates for Alternatives 2 and 3 are included in **Tables 9 and 10**, respectively. The costs associated with Alternatives 1, 2, and 3 and are summarized as follows:

Corrective Measure Alternative	Total estimated capital present worth cost	Total estimated present worth cost of O&M (30 years)	Total estimated net present worth cost
Alternative 1 -No Action	$0	$0	$0
Alternative 2 - Continued O&M of Groundwater P&T System, Monitored Natural Attenuation with Institutional and Engineering Controls	$ 134,000	$11,629,000	$11,763,000
Alternative 3 – Soil Excavation/Disposal, Continued O&M of Groundwater P&T System, Monitored Natural Attenuation with Institutional and Engineering Controls	$16,999,000	$11,604,000	$28,603,000

6. RECOMMENDED CORRECTIVE MEASURE ALTERNATIVE AND RATIONALE

To provide long-lasting protection to human health and the environment, three corrective measure alternatives were developed and evaluated in this CMS for the GE Aviation facility. This CMS Report documents the development of CMOs for the protection of human health and the environment to address COPCs in soil and groundwater at the Facility. Consistent with the Facility RCRA Permit (ID No. OHD 000817312), the RCRA Corrective Action program (USEPA, 1996; 2004), and the USEPA-approved *CMS Work Plan* (OBG 2014), the three corrective measure alternatives developed to addresses media-specific CMOs were evaluated based on the required threshold and decision/balancing factors such that a corrective measure may be recommended for the Facility.

Based on extensive soil and groundwater data generated during Facility investigation and groundwater IRM evaluation and O&M activities and the corrective measure evaluations presented in this CMS Report, the recommended corrective measure for the Facility, presented as Alternative 2, includes continued O&M of the P&T system and MNA with implementation of institutional and engineering controls. Operation of the P&T system would continue under Alternative 2. Since operation of the groundwater IRM was initiated in 2011, effective hydraulic control and reduction of offsite migration of constituents exceeding groundwater CMOs is demonstrated by a stable or decreasing plume mass and orders-of-magnitude decrease in CVOC concentrations in groundwater (**Appendix C**). This alternative also includes implementation of institutional and engineering controls at the Facility, including activity/use restrictions and/or environmental covenant, I&EC Plan and periodic reviews. Under implementation of the I&EC Plan, existing covers (*i.e.,* buildings, vegetation and pavement) would be inspected and maintained, preventing human exposure of impacted surface soil.

As identified in the soil exposure pathway evaluation and reflected in the development of soil CMOs (see **Appendix B**), construction and utility workers (and adult/adolescent trespassers) have the greatest potential for exposure to impacted Facility soils via incidental ingestion, dermal contact, and inhalation of soil dust and ambient vapors. Implementation of institutional and engineering controls, as outlined in the I&EC Plan (**Appendix E**), would implement procedures and controls for the handling and management of impacted soils during intrusive activities at the Facility. The I&EC Plan also includes provisions for health and safety requirements while allowing for continued operation, maintenance and development at the Facility.

With respect to the threshold criteria, Alternative 2 provides for overall protection of human health and the environment, attains applicable CMOs for soil and groundwater, and controls significant sources of releases to the environment. Implementation of an I&EC Plan under Alternative 2 would provide for equal protection of construction and utility works as Alternative 3 and would more cost-effectively achieve corrective measure objectives.

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Tables

Table 1
Screening Evaluation Summary for SWMUs/AOCs
GE Aviation - Evendale, Ohio

SWMU Number	Unit Name	RFI		Recommended Further Action[3]
		Results Above Resident Soil RSLs[1]	Retained Metals Above Background[2]	
8/12	Temporary Drum Storage Area (Former Bldg. 509)/Drum Crusher Unit	TCE, VC, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, indeno[1,2,3-cd]pyrene, TPH, PCBs, As, Co	Co	CMS
14	Battery Storage Area	As, Cd, CN, Co	Cd, Co	CMS
16	Weigh Station Sump	TPH, As	As	CMS
17	Reading Road Landfill	TPH, As, Co	As, Co	CMS
18	Sludge Basin Landfill	Naphthalene, TPH, As	As	CMS
19	East Landfarm	As, Mn	Mn	CMS
20	Former North Landfarm	Benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, indeno[1,2,3-cd]pyrene, As, Mn, TPH	Mn	CMS
21/22	Former 508 Sludge Basin	TCE, VC, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene, TPH, PCBs, As, Cd, Co, Cu, Ni, Sb, CN	Ni[4], Sb[4], Cd, Co, Cu	CMS
27/28	Former Lime Precipitate Basins 1 and 2	As	As	CMS
29	Lime Precipitate Basin 3	TPH, As, Mn, V	Mn, V	CMS
31	Lime Precipitate Basin 5	TPH, As	None	CMS
42	Former Chip Loading Area	--	NA	NFA
61/67	Underground Waste Oil/Fuel Storage Tank 304-7	--	NA	NFA
79	Former Bldg. 800 Wastewater Pretreatment System	As, Cd, Co	Cd, Co	CMS
86	Oil/Water Separator 301-2	As	None	NFA
87/88	Oil/Water Separators 303-1 and 303-3	TPH, PCBs, As	None	CMS
93/94	Oil/Water Separator 500-1E and 500-1W	TPH, As	None	CMS
95	Oil/Water Separator 500-2	As	None	NFA
98/99	Oil/Water Separators 703-1E and 703-1W	TPH, As	None	CMS
100	Oil/Water Separator 707-1	As	None	NFA
118	Process Sewer System - Sanitary Sewer	PCBs	NA	NFA
122	Stormwater Pumphouse 422	As	None	NFA
123	Stormwater Pumphouse 423	As	None	NFA
124	Stormwater Pumphouse 506	TPH, As	As	CMS
141	Gravel Media Coalescing Separator	TPH	NA	CMS
142	Bldg. 800 Machine Sump (Added 1/16/91)	TPH, As, Co	Co	CMS
AOC A	Bldg. P Fuel Spill	TPH	NA	CMS
AOCs D and I	Bldg. B Fuel Spills No. 1 and No. 2	TPH	NA	CMS
AOC L	Bldg. 304 Fuel Spill	Naphthalene, TPH	NA	CMS
AOC W2/SWMUs 62/63	Inactive Underground Product Storage Tanks 417-E M-1; Underground Waste Oil/Fuel Storage Tanks 417-2 and 417-3	TPH	NA	CMS
AOC W3/SWMUs 64/68	Inactive Underground Product Storage Tanks 515-1 to 27; Underground Waste Oil/Fuel Storage Tank 505-28	TPH	NA	CMS
AOC W4/SWMU 65	Inactive Underground Product Storage Tanks 507-5,6,13,14; Underground Waste Oil/Fuel Storage Tank 507-4	TPH	NA	CMS
AOC W10/SWMU 72	Inactive Underground Product Storage Tanks D-1 to 5; Waste Fuel Collection Tank D-1	TPH	NA	CMS
AOC LD	Bldg. 700 South Loading Dock	TCE	NA	CMS
AOC PST	TCE/TCA Product Storage Tanks	TCE	NA	CMS

Notes:
RSL - Regional Screening Level
(1) Analytical results were compared to USEPA Resident Soil RSLs (May 2016). SWMUs/AOCs shaded in green contain chemicals whose maximum concentrations are below Resident Soil RSLs or have concentrations that are consistent with background levels. See text discussion regarding SWMU 118.
(2) None = Concentrations are below background
(3) CMS - Indicates SWMU/AOC will be evaluated further in Corrective Measures Study; NFA - indicates no further action
(4) This metal was detected above its Resident Soil RSL and background level, but only at depths beyond those typically available for direct contact by human receptors.

NA - Not Applicable

Table 2

Summary of SWMUs/AOCs Identified for Management Controls and Soil CMOs

GE Aviation - Evendale, Ohio

SWMU Number	Unit Name	RFI Results		Action Levels		CMS
		COPCs with Results Above Resident Soil RSLs[1]	Maximum Concentration	USEPA Resident Soil RSL[1]	Soil Background Concentration[2]	Soil Corrective Measure Objectives (CMOs)
8/12	Temporary Drum Storage Area (Former Bldg. 509) / Drum Crusher Unit	TCE	22.0	0.91	--	44.9
		Vinyl chloride	0.59	0.059	--	35.9
		Benzo[a]anthracene	2.9	0.16	--	32.3
		Benzo[a]pyrene	2.1	0.016	--	3.23
		Benzo[b]fluoranthene	4.1	0.16	--	32.3
		Indeno[1,2,3-cd]pyrene	1.1	0.16	--	32.3
		PCBs	390	0.23	--	11.5
		TPH	18000	see note 3	--	1255
		As	18.1*	0.68	12.9	21.5
		Co	25.9	23	6.4	220
14	Battery Storage Area	Cd	92	71	0.51	727
		Co	130	23	6.4	220
		CN	80.0	23	--	442
16	Weigh Station Sump	TPH	4600	see note 3	--	1255
		As	23.5	0.68	12.9	21.5
17	Reading Road Landfill	As	18.0	0.68	12.9	21.5
		Co	32.0	23	6.4	220
		TPH	220	see note 3	--	1255
18	Sludge Basin Landfill	TPH	2700	see note 3	--	1255
		Naphthalene	4.7	3.8	--	1280
		As	17.0	0.68	12.9	21.5
19	East Landfarm	Mn	2800.0	1800	459	16604
20	Former North Landfarm	Benzo[a]anthracene	2.9	0.16	--	32.2
		Benzo[a]pyrene	2.5	0.016	--	3.23
		Benzo[b]fluoranthene	4.6	0.16	--	32.3
		Indeno[1,2,3-cd]pyrene	1.6	0.16	--	32.3
		TPH	170*	see note 3	--	1255
		Mn	2900	1800	12.9	16604
21/22	Former 508 Sludge Basin[4]	TCE	20*	0.91	--	44.9
		Vinyl chloride	0.14*	0.059	--	35.9
		Benzo[a]anthracene	1.8	0.16	--	32.3
		Benzo[a]pyrene	0.97	0.016	--	3.23
		Benzo[b]fluoranthene	3.4	0.16	--	32.3
		Dibenz[a,h]anthracene	0.37	0.016	--	3.23
		Indeno[1,2,3-cd]pyrene	1.5	0.16	--	32.3
		PCBs	9.0	0.23	--	11.5
		TPH	7700	see note 3	--	1255
		CN	1500*	23	--	442
		Cd	210*	71	0.51	727
		Co	95*	23	6.4	220
		Cu	5100*	3100	11.8	29495
27/28	Former Lime Precipitate Basins 1 and 2	As	20.0	0.068	12.9	21.5
29	Lime Precipitate Basin 3	TPH	170	see note 3	--	1255
		Mn	2500	1800	459	16604
		V	1570	390	17.4	3662
31	Lime Precipitate Basin 5	TPH	780*	see note 3	--	1255
79	Former Bldg. 800 Wastewater Treatment Pre-System	Cd	320	71	0.51	727
		Co	38	23	6.4	220
87/88	Oil/Water Separators 303-1 and 303-3	TPH	120	see note 3	--	1255
		PCBs	1.53	0.23	--	11.5
93/94	Oil/Water Separators 500-1E and 500-1W	TPH	480	see note 3	--	1255
98/99	Oil/Water Separators 703-1E and 703-1W	TPH	130	see note 3	--	1255
124	Stormwater Pumphouse 506	TPH	220	see note 3	--	1255
		As	18.2*	0.68	12.9	21.5
141	Gravel Media Coalescing Separator	TPH	11796	see note 3	--	1255
142	Bldg. 800 Machine Sump (Added 1/16/91)	TPH	23000	see note 3	--	1255
		Co	87.4	23	6.4	220
AOC A	Bldg. P Fuel Spill	TPH	83	see note 3	--	1255
AOCs D and I	Bldg. B Fuel Spills No. 1 and 2	TPH	4327	see note 3	--	1255
AOC L	Bldg. 304 Fuel Spill	Naphthalene	4.7	3.8		1280
		TPH	3700	see note 3	--	1255
AOC W2 / SWMUs 62/63	Inactive Underground Product Storage Tanks 417 E M-1	TPH	290	see note 3	--	1255
AOC W3 / SWMUs 64/68	Inactive Underground Product Storage Tanks 515-1 to 27	TPH	9100	see note 3	--	1255

SWMU Number	Unit Name	RFI Results		Action Levels		CMS
		COPCs with Results Above Resident Soil RSLs[1]	Maximum Concentration	USEPA Resident Soil RSL[1]	Soil Background Concentration[2]	Soil Corrective Measure Objectives (CMOs)
AOC W4 / SWMU 65	Inactive Underground Product Storage Tanks 507-5,6,13,14	TPH	8000*	see note 3	--	1255
AOC W10 / SWMU 72	Inactive Underground Product Storage Tanks D-1 to 5	TPH	306	see note 3	--	1255
AOC LD	Bldg. 700 South Loading Dock	TCE	9.6*	0.91	--	44.9
AOC PST	TCE/TCA Product Storage Tanks	TCE	14	0.91	--	44.9

Notes:

RSL - Regional Screening Level

Concentrations in mg/kg

(1) Analytical results were compared to USEPA Resident Soil RSLs (May 2016).

(2) Soil background concentrations reported for the Cincinnati area (Ohio EPA, 2015)

(3) The USEPA Resident Soil RSLs for TPH ranges are: 82 mg/kg for TPH (Aromatic-Low), 96 mg/kg for TPH (Aliphatic-Medium), and 2,500 mg/kg for TPH (Aromatic-High).

(4) Antimony and nickel detected above Resident Soil RSLs and background concentrations in this SWMU, but detections above RSLs only occurred at depths greater than those available for human exposure.

*Sample concentration at depth > 12 feet (assumed to be inaccessible for human exposures)

Table 3
Groundwater CMOs for Key CVOCs in Perched Zone, USG and LSG
GE Aviation - Evendale, Ohio

Constituent of Potential Concern	Regulatory Criteria		Perched Zone GW CMOs	USG GW CMOs	LSG GW CMOs
	USEPA MCL[1]	Mill Creek Water Quality Criteria[2]			
1,1-Dichloroethene	NA	32	39	NA	NA
cis-1,2-Dichloroethene	70	NA	NA	155	155
Trichloroethene	5	810	920	260	260
Vinyl Chloride	2	5300	25	50	50

Notes:

Units are in µg/L

1 - USEPA Maximum Contaminant Level (MCL) as identified on the November 2015 RSL Summary Table (USEPA 2015)

2 - OEPA (3745-1-34) Non-Drinking Water Quality Criteria for the Ohio River drainage basin

NA = Not Applicable

		Screening Value/Action Level[1]			CMS				Impacted Area Dimensions/Volumes				
SWMUs (subareas if noted)	Consituents Detected Above Screening Levels	USEPA Resident Soil RSLs	Hamilton Co. Background (95% UCL)	Hamilton Co. Background (as High as)	Soil Corrective Measures Objectives (CMOs)	Maximum Concentration (mg/kg)	Minimum Apparent Depth of Impact	Maximum Apparent Depth of Impact	Depth (ft.)	Area (sq.ft)	Volume (cu.ft)	Volume (cu.yds)	Total SWMU Volume (cu.yds)
SWMU-8													
A	TCE	0.910			44.90	22	0	14	6.0	1,360	8,160	302.2	**1,049**
	Vinyl chloride	0.059			35.90	0.59	16	18					
	Benzo[a]anthracene	0.16			32.3	2.9	2	4					
	Benzo[a]pyrene	0.016			3.23	2.1	2	4					
	Benzo[b]fluoranthene	0.16			32.3	4.1	2	4					
	Indeno(1,2,3-cd)pyrene	0.16			32.3	1.1	2	4					
	TPH (Total)[3,4]	see note 2			1,255	18,000	2	4					
	PCBs (Total)[5]	0.23			11.5	62	2	6					
B	TPH (Total)[3,4]	see note 2			1,213	4800	0	18	18	1,120	20,160	746.7	
	PCBs (Total)[5]	0.23			11.5	390	0	18					
	Arsenic	0.68	12.9	14.3		18.1	16	18					
SWMU-12													
	TPH (Total)[3,4]	see note 2			1,255	12,000	0	6	14	720	10,080	373	**373**
	PCBs (Total)[5]	0.23			11.5	85	0	14					
	Cobalt	23.00			220.0	25.9	0	6					
SWMU-16													
	TPH (Total)[3,4]	see note 2			1,255	4,600	0	6	10	700	7,000	259	**259**
	Arsenic	0.68	12.9	14.3	21.5	23.5	8	10					
SWMU-18													
	TPH (Total)[3,4]	see note 2			1,255	2,700	0	16	16	3,400	54,400	2,015	**2,015**
	Naphthalene	3.8			1,280	4.7	8	10					
	Arsenic	0.68	12.9	14.3	21.5	17	4	6					
SWMU-21/22													
	Trichloroethene	0.91			44.9	20	16	20	20	13,097	261,940	9,701	**9,701**
	Vinyl chloride	0.059			35.90	0.14	2	14					
	Benzo[a]anthracene	0.160			32.3	1.8	2	4					
	Benzo[a]pyrene	0.016			3.23	3	2	14					
	Benzo[b]fluoranthene	0.16			32.3	3.4	2	4					
	Dibenz[a,h]anthracene	0.016			3.2	0.37	2	4					
	Indeno(1,2,3-cd)pyrene	0.16			32.3	1.5	2	4					
	TPH (Total)[3,4]	see note 2			1,255	7,700	2	20					
	PCBs (Total)[5]	0.23			11.5	9	2	20					
	Arsenic	0.68	12.9	14.3	21.5	9.6	8	14					
	Cadmium	71	0.51		727	210	18	20					
	Cobalt	23	6.4		220	95	18	20					
	Copper	3,100	11.8		29,495	5,100	18	20					
	Cyanide	23			442	1,500	16	20					
	Nickel	22,000	14.8	17.2	14,286	38,000	18	20					

SWMUs (subareas if noted)	Consituents Detected Above Screening Levels	Screening Value/Action Level[1]			CMS				Impacted Area Dimensions/Volumes				
		USEPA Resident Soil RSLs	Hamilton Co. Background (95% UCL)	Hamilton Co. Background (as High as)	Soil Corrective Measures Objectives (CMOs)	Maximum Concentration (mg/kg)	Minimum Apparent Depth of Impact	Maximum Apparent Depth of Impact	Depth (ft.)	Area (sq.ft)	Volume (cu.ft)	Volume (cu.yds)	Total SWMU Volume (cu.yds)
SWMU- 141													
	TPH (Total)[3,4]	see note 2			1,255	11,796	0	0.5	2	100	200	7.4	**7.4**
SWMU-142													
	TPH (Total)[3,4]	see note 2			1,255	23,000	0	0.5	2	2,303	4,606	170.6	**170.6**
	Arsenic	0.68	12.9	14.3	21.5	6.5	0	0.5					
	Cobalt	23.00	6.4		220.0	87.4	0	0.5					
AOC L													
	Naphthalene	3.8			1,280	4.7	8	10					
	TPH (Total)[3,4]	see note 2			1,255	3,700	6	10	10	625	6,250	231.5	**231.5**
AOC W3 and SWMU 64-68													
	TPH (Total)[3,4]	see note 2			1,255	9,100	10	20	10	11,238	112,380	4,162	**4,162**
	Arsenic	0.68	12.9	14.3	21.5	6.1	0	5					
AOC W4 and SWMU 65													
	TPH (Total)[3,4]	see note 2			1,255	8,000	14	20	20	6,480	129,600	4,800	**4,800**
AOC W10, SWMU 72													
	TPH (Total)[3,4]	see note 2			1,255	8,029	12	22	10	13,362	133,620	4,949	**4,949**
AOC D and I													
A	Benzo[a]pyrene	0.016			3.23	1.97	2	4	12	2,700	32,400	1,200	**3,859**
	TPH (Total)[3,4]	see note 2			1,255	4,327	0	10					
	TPH DRO (C_{10}-C_{28})[2,3]	see note 2			1,255	3,473	2	12					
B	TPH (Total)[3,4]	see note 2			1,255	4,327	18	22	22	3,263	71,786	2,659	
	TPH GRO (C_6-C_{12})[2,3]	see note 2			1,255	479	18	20					
	TPH DRO (C_{10}-C_{28})[2,3]	see note 2			1,255	3,473	18	22					

Estimated Area of Soil Exceeding Screening Value/Action Levels	**(sq ft)**	**60,468**
	(acres)	**1.4**
Estimated Volume of Soil Exceeding Screening Value/Action Levels	**(cu ft)**	**852,582**
	(cu yds)	**31,577**

Notes:
1) USEPA Regional Screening Level (RSL) - Resident (USEPA, May 2016).
2) The USEPA Resident RSLs for TPH ranges are: 82 mg/kg for TPH (Aromatic-Low), 96 mg/kg for TPH (Aliphatic-Medium), and 2,500 mg/kg for TPH (Aromatic-High).
3) Resident Soil RSL for PCBs (high risk) applied.
4) Blue highlighted Maximum Concentrations exceed CMOs at depths greater than 12 feet.

Table 5
Estimated Mass of COPCs within Groundwater Plumes Affected by IRM System
GE Aviation - Evendale, Ohio

	Aquifer	Conc_Zone (ug/L)	Zone_Avg (ug/L)	Conc Zone (ug/m^3)	Elev Top (ft)	Elev Bot (ft)	Thickness (ft)	Thickness (m)	Area (m^2)	GW Volume (m^3)	Vertical Differential Modifier	Mass (ug)	Mass (g)	Mass (kg)	Mass (lb)	Volume (gal - TCE)
Areal Differential Accounted For	Perched	10-100 ug/l	55	55,000	547.699	528.399	19.300	5.88	110,448	162,435	1	8,933,934,754	8,933,935	8,934	19,696	
	Perched	100-500 ug/l	300	300,000	547.460	526.372	21.088	6.43	100,057	160,781	1	48,234,170,459	48,234,170	48,234	106,338	
	Perched	500-1000 ug/l	750	750,000	550.540	528.039	22.501	6.86	34,292	58,797	1	44,097,841,583	44,097,842	44,098	97,219	
	Perched	1000+ ug/l	1,250	1,250,000	552.551	527.819	24.732	7.54	6,418	12,096	1	15,120,102,136	15,120,102	15,120	33,334	
										Totals		**116,386,048,932**	**116,386,049**	**116,386**	**256,587**	**21,066**

	Aquifer	Conc_Zone (ug/L)	Zone_Avg (ug/L)	Conc Zone (ug/m^3)	Elev Top (ft)	Elev Bot (ft)	Thickness (ft)	Thickness (m)	Area (m^2)	GW Volume (m^3)	Vertical Differential Modifier	Mass (ug)	Mass (g)	Mass (kg)	Mass (lb)	Volume (gal - TCE)
Areal and Vertical Differential Accounted For	Perched	10-100 ug/l	55	55,000	547.699	528.399	19.300	5.88	110,448	162,435	0.5	4,466,967,377	4,466,967	4,467	9,848	
	Perched	100-500 ug/l	300	300,000	547.460	526.372	21.088	6.43	100,057	160,781	0.5	24,117,085,230	24,117,085	24,117	53,169	
	Perched	500-1000 ug/l	750	750,000	550.540	528.039	22.501	6.86	34,292	58,797	0.5	22,048,920,791	22,048,921	22,049	48,609	
	Perched	1000+ ug/l	1,250	1,250,000	552.551	527.819	24.732	7.54	6,418	12,096	0.5	7,560,051,068	7,560,051	7,560	16,667	
Additional Pore Water and Sorbed Mass															2,145	
										Totals		**58,193,024,466**	**58,193,024**	**58,193**	**130,439**	**10,709**

	Aquifer	Conc_Zone (ug/L)	Zone_Avg (ug/L)	Conc Zone (ug/m^3)	Elev Top (ft)	Elev Bot (ft)	Thickness (ft)	Thickness (m)	Area (m^2)	GW Volume (m^3)	Vertical Differential Modifier	Mass (ug)	Mass (g)	Mass (kg)	Mass (lb)	Volume (gal - TCE)
Areal Differential Accounted For	USG	10-100 ug/l	55	55,000	517.207	493.648	23.559	7.18	334,101	599,764	1	32,986,995,875	32,986,996	32,987	72,724	
	USG	100-500 ug/l	300	300,000	517.505	499.872	17.633	5.37	58,136	78,116	1	23,434,652,162	23,434,652	23,435	51,665	
	USG	500-1000 ug/l	750	750,000	516.477	502.221	14.256	4.35	12,039	13,078	1	9,808,412,233	9,808,412	9,808	21,624	
	USG	1000+ ug/l	1,250	1,250,000	515.966	501.113	14.853	4.53	1,778	2,013	1	2,515,820,632	2,515,821	2,516	5,546	
										Totals		**68,745,880,903**	**68,745,881**	**68,746**	**151,559**	**12,443**

	Aquifer	Conc_Zone (ug/L)	Zone_Avg (ug/L)	Conc Zone (ug/m^3)	Elev Top (ft)	Elev Bot (ft)	Thickness (ft)	Thickness (m)	Area (m^2)	GW Volume (m^3)	Vertical Differential Modifier	Mass (ug)	Mass (g)	Mass (kg)	Mass (lb)	Volume (gal - TCE)
Areal and Vertical Differential Accounted For	USG	10-100 ug/l	55	55,000	517.207	493.648	23.559	7.18	334,101	599,764	0.5	16,493,497,937	16,493,498	16,493	36,362	
	USG	100-500 ug/l	300	300,000	517.505	499.872	17.633	5.37	58,136	78,116	0.5	11,717,326,081	11,717,326	11,717	25,832	
	USG	500-1000 ug/l	750	750,000	516.477	502.221	14.256	4.35	12,039	13,078	0.5	4,904,206,117	4,904,206	4,904	10,812	
	USG	1000+ ug/l	1,250	1,250,000	515.966	501.113	14.853	4.53	1,778	2,013	0.5	1,257,910,316	1,257,910	1,258	2,773	
Additional Pore Water and Sorbed Mass	USG														635	
										Totals		**34,372,940,451**	**34,372,940**	**34,373**	**76,414**	**6,274**

	Aquifer	Conc_Zone (ug/L)	Zone_Avg (ug/L)	Conc Zone (ug/m^3)	Elev Top (ft)	Elev Bot (ft)	Thickness (ft)	Thickness (m)	Area (m^2)	GW Volume (m^3)	Vertical Differential Modifier	Mass (ug)	Mass (g)	Mass (kg)	Mass (lb)	Volume (gal - TCE)
Areal Differential Accounted For	LSG	10-100 ug/l	55	55,000	474.651	380.530	94.121	28.69	205,643	1,474,878	1	81,118,282,128	81,118,282	81,118	178,835	
	LSG	100-500 ug/l	300	300,000	473.714	379.961	93.753	28.58	94,551	675,475	1	202,642,577,030	202,642,577	202,643	446,750	
										Totals		**283,760,859,158**	**283,760,859**	**283,761**	**625,585**	**51,362**

	Aquifer	Conc_Zone (ug/L)	Zone_Avg (ug/L)	Conc Zone (ug/m^3)	Elev Top (ft)	Elev Bot (ft)	Thickness (ft)	Thickness (m)	Area (m^2)	GW Volume (m^3)	Vertical Differential Modifier	Mass (ug)	Mass (g)	Mass (kg)	Mass (lb)	Volume (gal - TCE)
Areal and Vertical Differential Accounted For	LSG	10-100 ug/l	55	55,000	474.651	380.530	94.121	28.69	205,643	1,474,878	0.33	26769033102.20	26,769,033.10	26,769.033	59,016	
	LSG	100-500 ug/l	300	300,000	473.714	379.961	93.753	28.58	94,551	675,475	0.33	66872050420.04	66,872,050.42	66,872.050	147,427	
										Totals		**93,641,083,522**	**93,641,084**	**93,641**	**206,443**	**16,949**

TABLE 6. SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL

General Response Action	Remedial Technology	Process Option	Description	Implementability	Effectiveness	Relative Cost	Screening Comments	Potential for Further Consideration
No Action	No action	No action*	No action.	Readily implementable.	Not effective in mitigating potential for migration of COPCs from soil or contact with COPCs in exposed soil.	No capital No O&M	Provides a baseline for comparison of other corrective measures	Yes
Institutional controls	Proprietary controls	Access/use restriction*	Documentation of access and land use limitations as well as continued industrial property use.	Implementable. Would require property owner agreement/implementation.	Effective means of documenting land use restrictions and zoning. Effective means of controlling site use.	Low capital No O&M	Potentially applicable for SWMUs/AOCs with COPC soil concentrations above Resident RSLs and at or below the corrective measures objectives (CMOs)	Yes
		Environmental covenant*	Implementation of access and land use restrictions that would require activities that would potentially disturb or expose contaminated soil within identified SWMUs/AOCs (and require health and safety precautions) or impair the integrity of corrective measures addressing site soils be performed in accordance with the Institutional and Engineering Controls (I&EC) Plan.	Implementable. Would require property owner agreement/implementation.	Effective means of managing activities that would potentially disturb or expose contaminated soil or impact the integrity of soil corrective measures. Effective means of controlling site use.	Low capital No O&M	Potentially applicable for SWMUs/AOCs with COPC soil concentrations above Resident RSLs and CMOs	Yes
	Site controls	Institutional and Engineering Controls Plan*	Documentation of Facility institutional and engineering and physical components of the selected corrective measure requiring operation, maintenance and monitoring to provide continued effectiveness. The I&EC Plan would also include soil management procedures for handling soil within identified SWMU/AOCs during remedial, maintenance, and Facility development activities. The I&EC Plan would also present provisions for periodic site reviews.	Implementable. Would require property owner implementation.	Effective means of documenting site restrictions and remedy components, including operations, maintenance and monitoring requirements. Effective means of communicating soil management and handling procedures.	Low capital No O&M	Potentially applicable	Yes
	Periodic reviews	Periodic site reviews*	Periodic reviews are required where institutional and engineering controls, monitoring plans, and/or operations and maintenance activities are implemented on a site. The purpose of the reviews is to evaluate the areas in regard to the continuing protection of human health and the environment and to provide documentation of corrective measure effectiveness. Site reviews would be conducted at least every five years.	Readily implementable.	Effective means of evaluating continued protection to human health and the environment. Effective means of documenting status and progress of remedies requiring long-term O&M.	No capital Low O&M	Potentially applicable	Yes
Natural recovery	Natural attenuation	Natural attenuation*	The natural degradation of organic contaminants by *in situ* physical, chemical and/or biological processes. Over time, contaminants' mass, concentration, mobility, and/or volume can be reduced by processes that include biodegradation, sorption, dilution, volatilization, and/or transformation.	Readily implementable.	Potentially effective over the long-term for attenuation constituents. Evaluation of attenuation mechanisms would be required. Generally not effective for metals.	No capital No O&M	Potentially applicable	Yes

TABLE 6. SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL

General Response Action	Remedial Technology	Process Option	Description	Implementability	Effectiveness	Relative Cost	Screening Comments	Potential for Further Consideration
Containment	Capping	Vegetated soil/asphalt/ concrete/ building cover	Cover consisting of a soil layer with vegetation, asphalt or concrete to minimize erosion and prevent direct contact with impacted surface soil. Existing Facility buildings would also prevent direct contact with impacted surface soil. Top restoration cover selected based on site use and restoration requirements within the covered area. Grading and cover installation would be performed such that drainage is promoted, erosion is minimized, and cover integrity is protected. Vegetated/asphalt/concrete/building covers are currently implemented over portions of the site.	Readily implementable. Routine cover maintenance and inspections for integrity would be necessary. A vector control program would be likely be required.	Effective means of minimizing erosion of and direct contact with exposed surface soil.	Medium capital Low O&M	Potentially applicable in areas where surface soils exhibit concentrations above CMOs.	Yes
		Low permeability cover	Use of a low permeability cover to minimize surface water infiltration, encourage runoff and controls erosion, and isolate and contain soil. Low permeability cover components may consist of low permeability clay or a geomembrane liner system. Top restoration cover selected based on site use and restoration requirements within the covered area.	Not implementable due to substantial regrading required to meet grade requirements and incompatibility with current and reasonably anticipated site use (*i.e.,* active industrial facility). Potentially applicable for the eastern portion of the site, outside the active industrial area.	Effective means of minimizing erosion of and contact with exposed surface soil and infiltration of surface water. Limitations to site use would be incurred by the presence of a low permeability cover.	High capital Medium O&M	Not applicable or compatible with current and reasonably anticipated future use of the active industrial area. Potentially applicable for the eastern portion of the site.	Yes
***In situ* treatment**	Physical	Soil-vapor extraction (SVE)	Vacuum is applied through extraction wells within the vadose zone to create a pressure/concentration gradient that induces organics sorbed on the soil, dissolved in soil pore water and/or present as vapor to volatilize. Extracted vapors are removed through extraction wells and treated *ex situ* as needed. Soil vapor extraction was implemented as an interim corrective measures at the site.	Potentially implementable for unsaturated soil. Not implementable for saturated soil without dewatering. Off-gas treatment and management of residuals likely required. Implementation not practicable for small discrete areas of impacted soil within active industrial setting. A pilot/pumping test would be necessary to identify radius of influence and implementability in site soil.	Potentially effective for removing VOCs and TPHs in unsaturated soil. Effectiveness limited for removal of PAHs. Not effective for treatment of PCBs and inorganics. Low permeability soil and subsurface heterogeneity would limit effectiveness. Underground utilities and presence of fill material may provide preferential pathways for vapor migration, potentially causing short circuiting, and reducing treatment effectiveness. A treatability study would likely be required.	Medium capital Medium O&M	Not applicable; limited implementability and effectiveness due to low permeability and heterogeneous soils. Treatment effectiveness reduced by presence of fill materials and underground utilities. Implementation not practicable for discrete areas of impacted soil. Not effective for treatment of PCBs or inorganics.	No
	Chemical	Chemical oxidation	Injection of oxidizing agents such as ozone, hydrogen peroxide, hypochlorites, potassium permanganate, and/or sodium persulfide. Oxidation reactions chemically convert constituents to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert.	Potentially implementable for saturated and unsaturated soil. Low permeability and heterogeneity of subsurface materials would likely require advanced delivery techniques (*i.e.*, *in situ* mixing, tight injection point spacing). Potential for health and safety issues when handling oxidant chemicals and working in the vicinity of potentially aggressive reactions. Not implementable in proximity to the existing IRM groundwater collection system. Multiple	Potentially effective for reducing VOCs, TPHs, PAHs, and PCBs in saturated and unsaturated soil. Not effective for treatment of inorganics. Low permeability soil and subsurface heterogeneity would limit effective oxidant distribution and treatment effectiveness. Underground utilities may provide preferential pathways, reducing effective distribution and contact. A treatability study would likely be required.	Medium capital Low O&M	Not applicable; effectiveness dependent on distribution and contact of oxidant with treatment area, which would be limited due to subsurface heterogeneity. Not effective for treatment of inorganics. Not implementable in proximity to the existing IRM groundwater collection system.	No

TABLE 6. SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL

General Response Action	Remedial Technology	Process Option	Description	Implementability	Effectiveness	Relative Cost	Screening Comments	Potential for Further Consideration
				rounds of oxidant injections may be required to achieve soil cleanup goals.				
***In situ* treatment (continued)**	Chemical (continued)	Flushing	Water, aqueous solution, surfactants, or cosolvents are injected into the subsurface. The extraction fluid is utilized to enhance contaminant solubility. Contaminants are leached into the groundwater and subsequently removed through a collection system and treated *ex situ.*	Potentially implementable for saturated and unsaturated soil. Low permeability and heterogeneity of subsurface materials would likely require advanced tight injection point spacing to improve distribution. Extraction fluid would require recovery and *ex situ* treatment. Implementation not practicable for small discrete areas of impacted soil within active industrial setting.	Potentially effective for enhancing the removal of VOCs, TPHs, PAHs, PCBs, and metals in saturated and unsaturated soil. Low permeability soil and subsurface heterogeneity would limit effective flushing solution distribution and treatment effectiveness. Underground utilities may provide preferential pathways, reducing effective distribution and contact. Potential for uncontrolled mobilization of contaminants. A treatability study would likely be required.	Medium capital Medium O&M	Not applicable; limited implementability and effectiveness due to low permeability and heterogeneous soils. Implementation not practicable for discrete areas of impacted soil within active industrial setting.	No
	Biological	Enhanced Bioremediation	Injection of microbial populations, nutrient sources, or electron donors into the subsurface to enhance biological degradation of organic constituents.	Potentially implementable for saturated soil. Low permeability and heterogeneity of subsurface materials would likely require advanced delivery techniques (*i.e.*, *in situ* mixing, tight injection point spacing). Injection of enhancement bioremediation nutrients may foul injection wells. Not implementable in proximity to the existing IRM groundwater collection system. Multiple rounds of enhanced bioremediation injections may be required to achieve soil cleanup goals.	Potentially effective for reducing VOC and TPH concentrations in saturated soil. Limited effectiveness for treatment of PAHs. Not effective for treatment of PCBs or inorganics. Enhanced bioremediation would augment existing anaerobic degradation occurring in site soil and groundwater. Low permeability soil and subsurface heterogeneity would limit effective flushing solution distribution and treatment effectiveness. Underground utilities may provide preferential pathways, reducing effective distribution and contact. Potential for uncontrolled mobilization of contaminants. A treatability study would likely be required.	Medium capital Low O&M	Not applicable; effectiveness dependent on distribution and contact of enhanced bioremediation nutrients with treatment area, which would be limited due to subsurface heterogeneity. Limited effectiveness for treatment of PAHs. Not effective for treatment of PCBs or inorganics. Not implementable in proximity to the existing IRM groundwater collection system.	No
		Bioventing	Induction of low air flow rates in the subsurface to provide enough oxygen to sustain microbial activity, thereby stimulating the natural *in situ* biodegradation of aerobically degradable compounds in shallow soil. *In situ* bioventing was implemented as interim corrective measures at the site.	Potentially implementable for shallow unsaturated soil. Not implementable for saturated soil without dewatering. Implementation not practicable for small discrete areas of impacted soil. Implementation of bioventing within active industrial setting may be limited. A pilot/pumping test would be necessary to identify radius of influence and implementability in site soil.	Potentially effective for reducing VOC, TPH, and PAH concentrations. Not effective for treatment of PCBs or inorganics. Low permeability soil and subsurface heterogeneity would limit effectiveness. Underground utilities may provide preferential pathways for air flow, potentially causing short circuiting, and reducing treatment effectiveness. A treatability study would likely be required.	Medium capital Low O&M	Not applicable; limited implementability and effectiveness due to low permeability and heterogeneous soils. Implementation not practicable for discrete areas of impacted soil. Not effective for treatment of PCBs or inorganics.	No
	Thermal	Soil heating	Heating of soil using various techniques, including heating wells, thermal blankets, injection points, electrodes, or electromagnetic energy to heat and volatilize organic contaminants. Volatilized contaminants are removed by vapor extraction and treated *ex situ* as needed.	Potentially implementable for saturated and unsaturated soil in conjunction with a hydraulic control and SVE system. Installation and operation of a hydraulic control system may be required to maintain treatment area hydraulics and temperature. High energy requirements	Potentially effective for enhancing the removal of VOC, TPHs, and PCBs in saturated and unsaturated soil. Effectiveness limited for enhancing the removal of PAHs. Not effective for treatment of inorganics. Potential for uncontrolled mobilization of contaminants away from recovery system and release of	High capital Low O&M	Not applicable; implementation not practicable due to risk of producing uncontrolled migration of vapors. Effectiveness of hydraulic control and SVE systems	No

TABLE 6. SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL

General Response Action	Remedial Technology	Process Option	Description	Implementability	Effectiveness	Relative Cost	Screening Comments	Potential for Further Consideration
				anticipated. Subsurface utilities in the vicinity of the treatment area may not be compatible with subsurface temperature increases (*e.g.,* PVC, HDPE). Management of hazards associated with high voltage required.	vapors to the atmosphere. Effectiveness of hydraulic control and SVE systems potentially limited due to low permeability and heterogeneous nature of site soils. A treatability study would likely be required.		potentially limited due to low permeability and heterogeneous nature of site soils. Not effective for treatment of PCBs or inorganics.	
***In situ* treatment (continued)**	Thermal (continued)	Hot air or steam injection	Injection of hot air or steam through injection wells to enhance the recovery of organic contaminants. The injected steam heats the surrounding subsurface, volatilizing organic contaminants, with subsequent collection and treatment through a series of extraction wells.	Potentially implementable for saturated and unsaturated soil in conjunction with a hydraulic control and SVE system. A treatability study would be necessary to evaluate implementability. Subsurface utilities in the vicinity of the treatment area may not be compatible with subsurface temperature increases (*e.g.,* PVC, HDPE). Management of hazardous vapors associated with steam generation required.	Potentially effective for enhancing the removal of VOCs, TPHs and PAHs in saturated and unsaturated soil. Not effective for treatment of PCBs or inorganics. Effective distribution of hot air/steam throughout the treatment area and subsequent vapor collection potentially limited due to low permeability and heterogeneous nature of site soil. A treatability study would likely be required.	High capital Low O&M	Not effective for treatment of PCBs or inorganics.	No
Removal	Excavation	Mechanical excavation*	Use of construction equipment to remove soil. Excavated areas would be backfilled, graded and restored based on Facility area and restoration requirements.	Potentially implementable for removal of impacted soil (*i.e.,* soil concentrations exceeding CMOs). Shoring or side sloping required for deep excavations. Not implementable for inaccessible soil (*i.e.,* soil covered by buildings). Dewatering and/or stabilization may be required to render excavated soil sufficiently dry for management and transportation.	Effective for removal of impacted soil. Effective for small volumes of soil within accessible areas.	High capital No O&M	Potentially applicable.	Yes
Disposal	Off-site treatment/disposal	Disposal at a commercial facility*	Excavated soil would be transported to a permitted commercial landfill, if it meets land disposal restrictions. Excavated soil may require treatment prior to landfill to disposal to meet land disposal restrictions.	Implementability for excavated soil that meets lands disposal restrictions.	Effective for soil suitable for land disposal.	High capital No O&M	Potentially applicable.	Yes

Notes:
* Representative Process Option
AOC – Area of Concern
COPCs - Constituents of Potential Concern
HDPE – High-Density Polyethylene
IRM - Interim remedial measure
O&M - Operation and Maintenance
PAH – Polycyclic Aromatic Hydrocarbon
PCB – Polychlorinated Biphenyl
PVC – Polyvinyl Chloride
RSL – Regional Screening Levels
SWMU – Solid Waste Management Unit
TPH – Total Petroleum Hydrocarbon
VOC - Volatile organic compound

TABLE 7. SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

General Response Action	Remedial Technology	Process Option	Description	Implementability	Effectiveness	Relative Cost	Screening Comments	Potential for Further Consideration
No action	No action	No action*	No action	Readily implementable	Not an effective means of evaluating groundwater or controlling groundwater use.	No capital No O&M	No action assumes that operation of the groundwater IRM components (P&T and MNA) will cease.	Yes
Institutional controls/ Limited actions	Monitoring	Groundwater monitoring*	Periodic sampling and analyses of groundwater as a means of detecting changes in constituent concentrations in groundwater. Groundwater monitoring would be conducted in accordance with the approach and methods outlined in the IRM Performance Monitoring Plan.	Implementable	Effective means for evaluating groundwater conditions. Effective method for monitoring changes in constituent concentrations over time.	Low capital Low O&M	Potentially applicable. Part of the IRM	Yes
	Proprietary controls	Access/use restriction*	Documentation of access and land use limitations as well as restricted groundwater use.	Implementable. Would require property owner agreement/implementation.	Effective means of documenting land use restrictions. Effective means of restricting groundwater use.	Low capital No O&M	Potentially applicable.	Yes
		Environmental covenant*	Implementation and documentation of groundwater use restrictions, access, and land use restrictions that would require activities that would potentially result in exposure to contaminated groundwater (and require health and safety precautions) be conducted in accordance with the Institutional and Engineering Controls (I&EC) Plan.	Implementable. Would require property owner agreement/implementation.	Effective means of precluding use of groundwater and controlling site use.	Low capital No O&M	Potentially applicable	Yes
	Site controls	Institutional and Engineering Controls Plan*	Documentation of Facility institutional and engineering controls and physical components of the selected corrective measure requiring operation, maintenance, and monitoring to provide continued effectiveness. Presents requirements for groundwater monitoring, and includes a provision for periodic site reviews.	Implementable	Effective means of documenting site use restrictions and remedy components, including operation, maintenance and monitoring requirements.	Low capital No O&M	Potentially applicable	Yes
	Periodic reviews	Periodic site reviews*	Periodic reviews where institutional and engineering controls, monitoring plans, and/or operations and maintenance activities are implemented on a site. The purpose of the reviews is to evaluate the areas in regard to the continuing protection of human health and the environment and to provide documentation of remedy effectiveness.	Readily implementable.	Effective means of evaluating continued protection to human health and the environment.	No capital Low O&M	Potentially applicable	Yes

TABLE 7. SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

General Response Action	Remedial Technology	Process Option	Description	Implementability	Effectiveness	Relative Cost	Screening Comments	Potential for Further Consideration
Natural recovery	Natural attenuation	Natural attenuation*	The natural degradation of contaminants by *in situ* physical, chemical and/or biological processes. Over time, contaminants' mass, concentration, mobility, and/or volume can be reduced by processes that include biodegradation, sorption, dilution, volatilization, and/or transformation.	Implementable	Potentially effective for reduction of contaminant concentrations over the long-term. May not be as effective in Perched zone due to marginal aerobic conditions.	No capital No O&M	Potentially applicable. Part of the IRM	Yes
Hydraulic control	Physical barrier wall	Slurry wall	Soil- or cement-bentonite slurry wall placed along the perimeter of the area of contamination to contain groundwater. Containment wall should extend into a confining layer.	Not implementable at depths anticipated necessary to contain groundwater. The Upper and Lower Confining units are not continuous which could allow VOCs to migrate pass the physical containment barrier. Ground water mounding may result, which would require groundwater extraction to manage.	Potentially effective at hydraulically containing groundwater if used in conjunction with a groundwater extraction system.	High capital Low O&M	Not implementable due to depth of groundwater zone and non-continuous confining units	No
		Sheet piles	Sheet piles installed along the area of contamination to contain groundwater. Sheet pile materials include HDPE, fiberglass, vinyl and steel. Sheet piles should extend into a confining layer.	Not implementable at depths anticipated necessary to contain groundwater. The Upper and Lower Confining units are not continuous which could allow VOCs to migrate pass the physical containment barrier. Ground water mounding may result, which would require groundwater extraction to manage.	Potentially effective at hydraulically containing groundwater if used in conjunction with a groundwater extraction system.	Medium to High capital Low O&M	Not implementable due to depth of groundwater zone and non-continuous confining units	No
	Groundwater extraction	Extraction wells (vertical or horizontal) *	Removal of groundwater by pumping from recovery wells for hydraulic control.	Implementable	Effective for collecting groundwater from all three water-bearing units at the site. Effective at hydraulically controlling groundwater flow	Medium to high capital High O&M	Potentially applicable. Seven vertical extraction wells in three water-bearing units are part of the IRM groundwater P&T system	Yes
		Collection trench	Collection trench installed to provide hydraulic control of groundwater that intercepts collection trench.	Not readily implementable at depths anticipated necessary to capture groundwater.	Effective for collecting groundwater. Effective at hydraulically controlling groundwater flow.	High capital High O&M	Not implementable due to depth of the groundwater zone	No
***Ex situ* treatment**	On-site treatment	GE Aviation Facility Groundwater Treatment Plant (GWTP)*	Treatment of collected groundwater at the existing GE Aviation Facility GWTP with subsequent discharge to Mill Creek. The Facility GWTP provides treatment of groundwater through filtration, sequestration, air stripping and pH adjustment.	Implementable. Discharge of treated water from the existing GWTP to Mill Creek will comply with pretreatment requirements identified in the NPDES permit.	Effective for treating site VOCs	Medium capital Low O&M	Potentially applicable. Part of the IRM.	Yes

TABLE 7. SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

General Response Action	Remedial Technology	Process Option	Description	Implementability	Effectiveness	Relative Cost	Screening Comments	Potential for Further Consideration
***In situ* treatment**	Biological	Enhanced bioremediation	Injection of microbial populations, nutrient sources, or electron donors into groundwater to enhance biological degradation of organic constituents.	Availability of microbes that can survive and function in the extreme and variable geochemical conditions is not completely known. The complex hydrogeology, high ground water flow velocities, and volume of groundwater to be treated present significant challenges.	Effective for treatment of VOCs. A treatability study would be necessary to evaluate effectiveness. Factors that may limit the effectiveness of the process include: cleanup goals may not be attained if the soil matrix prohibits contaminant-microorganism contact; the circulation of water-based solutions through the soil may increase contaminant mobility and necessitate treatment of underlying ground water; preferential colonization by microbes may occur causing clogging of nutrient and water injection wells, and preferential flow paths may severely decrease contact between injected fluids and contaminants throughout the contaminated zones. The system is not effective for clay, highly layered, or heterogeneous subsurface environments due to oxygen (or other electron acceptor) transfer limitations. High concentrations of heavy metals, highly chlorinated organics, long chain hydrocarbons, or inorganic salts are likely to be toxic to microorganisms. Bioremediation slows at low temperatures.	High capital Low O&M	The site conditions present concern with effectiveness and continued off site migration of VOCs.	No
	Chemical	Chemical oxidation: potassium permanganate	*In situ* treatment of groundwater using potassium permanganate. Potassium permanganate supplies the permanganate ion to initiate the dechlorination reaction with VOCs. Oxidation reactions chemically convert constituents to non-hazardous or less toxic compounds that are more stable, less, mobile, and/or inert.	Implementable. However, requires delivery and distribution of oxidant to heterogeneous groundwater unit and in communication areas.	May be difficult to maintain oxidant levels based on high groundwater flow rates. Petroleum LNAPL may reduce effectiveness. Post oxidation manganese content of groundwater may be high.	High capital High O&M	The site conditions present concern with effectiveness and continued off site migration of VOCs.	No
		Chemical oxidation: ozone	*In situ* treatment of groundwater using ozone. Oxidation reactions occur between ozone and VOCs upon contact. Oxidation reactions chemically convert constituents to non-hazardous or less toxic compounds that are more stable, less, mobile, and/or inert.	Ozone only implementable in Perched zone (due to need to control potential gas generation).	May be difficult to maintain oxidant levels based on high ground water flow rates. Due to instability of ozone, treatment is limited to impacted areas near the injection points. Less permeable zones may adversely influence ozone distribution. Petroleum LNAPL may reduce effectiveness.	High capital High O&M	The site conditions present concern with effectiveness and continued off site migration of VOCs. Targeting the three water-bearing units with chemical oxidation via ozone injection is not a viable alternative for site groundwater given the presence of VOC sources and large groundwater volume.	No

TABLE 7. SCREENING AND EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER

General Response Action	Remedial Technology	Process Option	Description	Implementability	Effectiveness	Relative Cost	Screening Comments	Potential for Further Consideration
***In situ* treatment (continued)**	Physical	In-well air stripping	Injection of air into the water column within a well to volatilize constituents. Groundwater circulation is performed *in situ*, with groundwater entering the well at one screen interval, and being discharged through a second screen interval. Air is collected and treated as necessary.	Not implementable due to excessive depth in areas and low radius of influence (about 60 feet).	Effective for volatilizing VOCs in saturated zone. Communication areas between the Perched/USG and the USG/LSG could short circuit the flow system around the circulation wells, resulting in ineffective treatment. Circulation wells do not function properly in areas of vertical ground water flow.	High capital Medium O&M	Given the radius of influence, an excessive number of wells would be required associated with the area located downgradient of residual sources in the three water bearing units. Not implementable, and not effective due to non-continuous confining units.	No
		Air sparging	Injection of air into the saturated zone to volatilize constituents within groundwater. Emissions are then collected in the unsaturated zone using a soil vapor extraction system.	Not implementable due to excessive depth in areas and low radius of influence (about 60 feet).	Effective for volatilizing VOCs in saturated zone. Communication areas between the Perched/USG and the USG/LSG could short circuit the flow system around the circulation wells, resulting in ineffective treatment.	High capital Medium O&M	Given the radius of influence, an excessive number of wells would be required associated with the area located downgradient of residual sources in the three water-bearing units. Not implementable, and not effective due to non-continuous confining units.	No
		Circulation wells	Groundwater is pumped to the surface and aerated, removing the majority of the volatile vapors, and the aerated groundwater is then used as recharge to the groundwater table within an area of contaminated soil. The combined process of biological treatment and physical extraction reduces contaminant concentrations.	Not implementable due to excessive depth in areas and low radius of influence (about 60 feet).	Effective for volatilizing VOCs in saturated zone. Communication areas between the Perched/USG and the USG/LSG could short circuit the flow system around the circulation wells, resulting in ineffective treatment. Circulation wells do not function properly in areas of vertical ground water flow.	High capital Medium O&M	Given the radius of influence, an excessive number of wells would be required associated with the area located downgradient of residual sources in the three water-bearing units. Not implementable, and not effective due to non-continuous confining units.	No
		Permeable Reactive Barrier (PRB) - iron treatment wall	Construction of a reactive material wall to treat groundwater as it flows through the treatment zone.	The Upper and Lower Confining units are not continuous which could allow VOCs to migrate past the PRB. Injection is the only method of installation that could be used at the depths encountered at the site. The depth and thickness of the LSG exceeds the current capabilities of PRB installation.	Generally effective for treating VOCs. High groundwater flow velocities require significant volumes of iron for the PRB.	High capital High O&M	Not implementable due to depth of groundwater zone, non-continuous confining units, and the depth and thickness of the LSG	No

Notes:

This table includes technologies and process options to address the Perched, USG and LSG groundwater units (combined) at the Site.
* Representative Process Option
HDPE – High Density Polyethylene
IRM – Interim Remedial Measure
LSG – Lower Sand and Gravel Aquifer
MNA – Monitored Natural Attenuation
NPDES - National Pollutant Discharge Elimination System
OEPA – Ohio Environmental Protection Agency
O&M – Operation, Maintenance and Monitoring
P&T – Pump and Treat
USG – Upper Sand and Gravel Aquifer
VOCs- Volatile Organic Compounds
USG – Upper Sand and Gravel Aquifer
VOCs- Volatile Organic Compounds

TABLE 8. DETAILED EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES

Criterion	Alternative 1 – No Action • No Action • Discontinued O&M of Groundwater Pump and Treat (P&T) System and Monitored Natural Attenuation (MNA)	Alternative 2 – Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls • Continued O&M of Groundwater P&T System • MNA • Institutional and Engineering Controls, including the following: - Access/use restriction and/or environmental covenant - Institutional and Engineering Controls (I&EC) Plan - Periodic site reviews - Groundwater monitoring	Alternative 3 – Soil Excavation/Disposal, Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls • Excavation of soil with offsite treatment/disposal • Continued O&M of Groundwater P&T System • MNA • Institutional Controls, including the following: - Access/use restriction and/or environmental covenant - I&EC Plan - Periodic site reviews - Groundwater monitoring
Overall protection of human health	Partially protective of human health over the long-term. Potential offsite exposures to impacted groundwater addressed through access to public water supply. Existing pavement, buildings and perimeter fence minimize exposure to impacted surface soils; however, Alternative 1 does not provide a means for maintenance and monitoring to ensure protection of human health over time. Alternative would not provide for long-term mitigation of potentially unacceptable risks to human health associated with exposure to contaminated groundwater (through groundwater use restrictions) or subsurface soil (through implementation of an I&EC Plan).	Protection of human health would be provided. Potential offsite exposures to impacted groundwater addressed through access to public water supply. Access restrictions, groundwater use restrictions, and periodic reviews would limit Facility and groundwater use and minimize potentially unacceptable risks to human health associated with exposure to soil and groundwater exceeding CMOs. Additional protection of human health relative to exposure to soil would be afforded though implementation of an I&EC Plan, and access/use restrictions and/or an environmental covenant. Continued operation of the IRM components would mitigate offsite migration of impacted groundwater and provide for mitigation of potentially unacceptable effects of contaminated groundwater to human health. Without further offsite migration of COPCs, downgradient COPC concentrations would degrade under MNA to concentrations that would be protective of human health.	Protection of human health would be provided. Potential offsite exposures to impacted groundwater addressed through access to public water supply. Access restrictions, groundwater use restrictions, and periodic reviews would limit Facility and groundwater use and minimize potentially unacceptable risks to human health associated with exposure to soil and groundwater exceeding CMOs. Additional protection of human health relative to exposure to soil would be afforded though implementation of an I&EC Plan, and access/use restrictions and/or an environmental covenant. Continued operation of the IRM components would mitigate offsite migration of impacted groundwater and provide for mitigation of potentially unacceptable effects of contaminated groundwater to human health. Without further offsite migration of COPCs, downgradient COPC concentrations would degrade under MNA to concentrations that would be protective of human health. Targeted excavation of soil exceeding CMOs at selected locations would provide protection of construction or utility workers at the Facility.
Overall protection of the environment	Partially protective of the environment over the long-term. Existing pavement and buildings reduce erosion of impacted surface soils; however, does not provide a means of inspecting and maintaining existing covers. Alternative would not provide for mitigation of potentially unacceptable risks to the environment associated with migration contaminated groundwater exceeding CMOs. Relies solely on natural attenuation (without monitoring and evaluation) to address COPCs in groundwater and soil.	Protection of the environment would be provided. Continued operation of the existing IRM components would mitigate offsite migration of impacted groundwater and provide for mitigation of potentially unacceptable effects of contaminated groundwater to the environment. Continued operation of the groundwater IRM allows for natural attenuation of COPCs in downgradient groundwater over the long-term. Institutional and engineering controls, including inspection and maintenance of existing Facility overs, under Alternative 2 would provide for protection of the environment.	Protection of the environment would be provided. Continued operation of the IRM components would mitigate offsite migration of impacted groundwater and provide for mitigation of potentially unacceptable effects of contaminated groundwater to the environment. Continued operation of the groundwater IRM allows for natural attenuation of COPCs in downgradient groundwater over the long-term. Protection of the environment would be afforded through targeted excavation of soil exceed CMOs at selected locations; however, the extent and depth of secondary sources may preclude significant improvements of site-wide environmental conditions.
Achievement of media-specific CMOs	Alternative 1 would not achieve soil CMOs. Alternative 1 may attain applicable groundwater CMOs over the long-term. Relies solely on natural attenuation (without monitoring and evaluation) to address groundwater and soil exceeding CMOs.	COPC concentrations in groundwater would likely be reduced to CMOs with continued operation of the IRM and MNA within each of the hydrogeologic units at the Facility within the next three to five years (see Appendix C). Implementation of an I&EC Plan would address exposure to soil exceeding CMOs.	COPC concentrations in groundwater would likely be reduced to CMOs with continued operation of the IRM and MNA within each of the hydrogeologic units at the Facility within the next three to five years (see Appendix C). Implementation of an I&EC Plan would address exposure to soil exceeding CMOs. COPC concentrations in soil would be achieved through targeted removal of soil at concentrations above the site cleanup levels, eliminating the need for site controls to be continued in the remediated area. However, the extent and depth of COPCs precludes site-wide attainment of cleanup standards through soil excavation.
Achievement of source control	Alternative 1 would not provide control of source(s) of releases to the environment. Some degree of soil source control is provided through existing Facility pavements and buildings.	Continued operation of the IRM would likely control the highest COPC concentrations in groundwater at or slightly downgradient of the property boundary and MNA is likely to control COPC concentrations further downgradient of the property boundary. Hydraulic control would have short-term and long-term effects on the environment to reduce COPC concentrations to acceptable standards at or slightly downgradient of the property boundary, if properly implemented. Some degree of soil source control is provided through existing Facility pavements and buildings.	Continued operation of the IRM would likely control the highest COPC concentrations in groundwater at or slightly downgradient of the property boundary and MNA is likely to control COPC concentrations further downgradient of the property boundary. Hydraulic control would have short-term and long-term effects on the environment to reduce COPC concentrations to acceptable standards at or slightly downgradient of the property boundary, if properly implemented. Control of soil COPC sources in soil would be achieved by targeted removal of soil with concentrations above the Facility CMOs at selected locations.

TABLE 8. DETAILED EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES

Criterion	Alternative 1 – No Action • No Action • Discontinued O&M of Groundwater Pump and Treat (P&T) System and Monitored Natural Attenuation (MNA)	Alternative 2 – Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls • Continued O&M of Groundwater P&T System • MNA • Institutional and Engineering Controls, including the following: - Access/use restriction and/or environmental covenant - Institutional and Engineering Controls (I&EC) Plan - Periodic site reviews - Groundwater monitoring	Alternative 3 – Soil Excavation/Disposal, Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls • Excavation of soil with offsite treatment/disposal • Continued O&M of Groundwater P&T System • MNA • Institutional Controls, including the following: - Access/use restriction and/or environmental covenant - I&EC Plan - Periodic site reviews - Groundwater monitoring
Short-term effectiveness	No active components are related to this alternative. Existing pavement, buildings, and fencing provide effective means of reducing exposure to impacted surface soil; however, Alternative 1 does not provide a means of maintenance and monitoring to ensure effectiveness. Offsite groundwater exposure is addressed through access to public water supply.	The short-term effectiveness is supported through continuation of the groundwater P&T IRM and institutional and engineering controls. There is no construction associated with continued operation of the IRM, therefore there would be no impacts to the community. Compliance with OSHA regulations and a HASP during operation of the groundwater P&T system will be required. Short-term risks to personnel operating the P&T system, waste transporters, and disposal facility personnel would be present due to handling, transport, and disposal of treatment residuals. The IRM is likely an effective alternative to mitigate groundwater contaminant exposure to human health and the environment at and downgradient of the property boundary. Operation of the IRM and MNA are estimated to meet the CMOs for groundwater within the next three to five years (see Appendix C). I&EC Plan, access/use restrictions and/or an environmental covenant, and periodic reviews would be effective at controlling Facility use, groundwater use, and reducing exposure to impacted soil upon implementation of measures at the Facility.	The short-term effectiveness is supported through continuation of the groundwater P&T IRM, institutional and engineering controls, and targeted excavation. There is no construction associated with continued operation of the IRM, therefore there would be no impacts to the community. Limited impacts to the community and workers at the Facility are anticipated as a result of soil excavation. Dust and volatile emissions, if any, would be monitored and controlled during removal of soil. Compliance with OSHA regulations and a HASP during operation of the groundwater P&T system and during excavation activities will be required. Short-term risks to personnel operating the P&T system, waste transporters, and disposal facility personnel would be present due to handling, transport, and disposal of treatment residuals. The IRM is likely an effective alternative to mitigate groundwater contaminant exposure to human health and the environment at and downgradient of the property boundary. Operation of the IRM and MNA are estimated to meet the CMOs for groundwater within the next three to five years. Institutional controls including an environmental covenant, I&EC Plan, access/use restrictions and/or an environmental covenant and periodic reviews would be effective at controlling Facility use, groundwater use, and reducing exposure to impacted soil upon implementation of measures at the Facility. Targeted excavation of soil exceeding CMOs at selected locations would be effective in the short-term at reducing potential exposure to COPCs, but may not significantly contribute to near-term goals at the facility level. Limited soil removal, backfill and surface restoration of select SWMUs/AOCs is assumed to be completed in approximately one year.
Long-term effectiveness	No active components are related to this alternative. Existing pavement, buildings, and fencing provide effective means of reducing exposure to impacted surface soil; Alternative 1 does not provide for maintenance and monitoring to ensure long-term effectiveness. Offsite groundwater exposure is addressed through access to public water supply; however, Alternative 1 does not provide for maintenance and monitoring to evaluate long-term effectiveness.	The long-term effectiveness is supported through continuation of the IRM and institutional and engineering controls. Compliance with OSHA regulations and a HASP during operation of the groundwater P&T system will be required. Long-term risks to personnel operating the P&T system, waste transporters, and disposal facility personnel would require management, particularly during handling, transport, and disposal of treatment residuals. The IRM is likely an effective alternative to mitigate groundwater contaminant exposure to human health and the environment at and downgradient of the property boundary. Operation of the IRM and MNA are estimated to meet the CMOs for groundwater within the next three to five years, followed by MNA only. Institutional controls including an environmental covenant, I&EC Plan, access/use restrictions and/or an environmental covenant, and periodic reviews would provide long-term effectiveness for controlling Facility use, groundwater use, and reducing exposure to impacted soil.	The long-term effectiveness is supported through continuation of the IRM, institutional and engineering controls, and limited removal of soil. Compliance with OSHA regulations and a HASP during operation of the groundwater P&T system and during excavation activities will be required. Long-term risks to personnel operating the P&T system, waste transporters, and disposal facility personnel would require management, particularly during handling, transport, and disposal of treatment residuals. The IRM is likely an effective alternative to mitigate groundwater contaminant exposure to human health and the environment at and downgradient of the property boundary. Operation of the IRM and MNA are estimated to meet the CMOs for groundwater within the next three to five years, followed by MNA only. Institutional controls including an environmental covenant, I&EC Plan, access/use restrictions and/or an environmental covenant, and periodic reviews would provide long-term effectiveness for controlling Facility use, groundwater use, and reducing exposure to impacted soil. Targeted excavation of soil exceeding CMOs at selected locations would provide for long-term reduction of CPOCs and potential exposures in soil, but would not significantly improve conditions site-wide.

TABLE 8. DETAILED EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES

Criterion	Alternative 1 – No Action • No Action • Discontinued O&M of Groundwater Pump and Treat (P&T) System and Monitored Natural Attenuation (MNA)	Alternative 2 – Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls • Continued O&M of Groundwater P&T System • MNA • Institutional and Engineering Controls, including the following: - Access/use restriction and/or environmental covenant - Institutional and Engineering Controls (I&EC) Plan - Periodic site reviews - Groundwater monitoring	Alternative 3 – Soil Excavation/Disposal, Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls • Excavation of soil with offsite treatment/disposal • Continued O&M of Groundwater P&T System • MNA • Institutional Controls, including the following: - Access/use restriction and/or environmental covenant - I&EC Plan - Periodic site reviews - Groundwater monitoring
Reduction of toxicity, mobility, and/or volume through treatment	No treatment components are related to this alternative, therefore no reduction of toxicity, mobility, and/or volume through treatment. Reduction of COPC toxicity, mobility, and/or volumes relies solely on natural attenuation (without monitoring and evaluation). Mobility of COPCs in surface soils would be reduced by existing pavement and buildings.	Mobility of groundwater containing COPCs is mitigated by operating the existing IRM. Groundwater containing chlorinated VOCs is extracted and treated *ex situ* at a rate of approximately 280 gallons per minute, thereby reducing toxicity, volume and mobility of dissolved and adsorbed phase VOCs. Since the groundwater IRM was initiated in 2011, over 500 million gallons of groundwater has been extracted for treatment. Chlorinated VOC concentration in groundwater have been reduced by orders of magnitude. There is risk to human health due to exposure to groundwater P&T system residuals during handling, transport, and disposal. Mobility of COPCs in surface soil would be reduced through maintenance of existing pavement and building covers. Reduction of toxicity and volume of COPCs in soil through treatment is not included in Alternative 2. Mobility of COPCs in surface soils would be reduced by existing pavement and buildings.	Mobility of groundwater containing COPCs is mitigated by operating the existing IRM. Groundwater containing chlorinated VOCs is extracted and treated *ex* situ at a rate of approximately 280 gallons per minute, thereby reducing toxicity, volume and mobility of dissolved and adsorbed phase VOCs. Since the groundwater IRM was initiated in 2011, over 500 million gallons of groundwater has been extracted for treatment. Chlorinated VOC concentration in groundwater have been reduced by orders of magnitude. There is risk to human health due to exposure to groundwater P&T system residuals during handling, transport, and disposal. Targeted excavation of soil would reduce the toxicity and volume of soil exceeding cleanup criteria through the removal and offsite disposal of 36,100 cubic yards of soil.
Long-term reliability	No active components are related to this alternative. Existing pavement, buildings, and fencing provide effective means of reducing exposure to impacted surface soil; however, Alternative 1 does not provide for maintenance and monitoring to ensure long-term reliability.	Institutional and engineering controls are an adequate and reliable means of controlling Facility use and direct contact with Facility soil and groundwater. Continued operation and maintenance of the IRM would be an adequate and reliable control to support the effectiveness of the groundwater corrective measure.	Institutional and engineering controls are an adequate and reliable means of controlling Facility use and direct contact with Facility soil and groundwater. Continued operation and maintenance of the IRM would be an adequate and reliable control to support the effectiveness of the groundwater corrective measure. Excavation and proper offsite management is an adequate and reliable means for addressing COPCs in soil and reducing potential exposures to impacted soil at selected locations where excavation is feasible.
Implementability	There are no technologies to be constructed in this alternative.	The IRM, consisting of strategic groundwater pumping and MNA, is currently being implemented. Institutional controls including an environmental covenant, I&EC Plan, access/use restrictions and/or an environmental covenant, and periodic reviews are readily implementable. Monitoring, inspection and maintenance of IRM components and implementation of a MNA program are implementable.	The IRM, consisting of strategic groundwater pumping and MNA, is currently being implemented. Institutional controls including an environmental covenant, I&EC Plan, access/use restrictions and/or an environmental covenant, and periodic reviews are readily implementable. Monitoring, inspection and maintenance of IRM components and implementation of a MNA program are implementable. Excavation and offsite disposal of 36,100 cubic yards of material is implementable. Landfill capacity and construction water management needs would be considered during the design phase. Implementability challenges would exist during excavation activities due to nearby active operations and proximity of utilities and other structures.
Cost:			
Total estimated capital cost	$0	$134,000	$16,999,000
Present worth of operation and maintenance cost (30 years, 7% discount factor)	$0	$11,629,000	$11,604,000
Total estimated net present worth cost	$0	$11,763,000	$28,603,000

Notes:
CMO – Corrective Measure Objective
COPC – Constituent of Potential Concern
HASP – Health and Safety Plan
I&EC – Institutional and Engineering Controls
IRM – Interim Remedial Measure
MNA – Monitored Natural Attenuation
Ohio EPA –Ohio Environmental Protection Agency
O&M – Operation and Maintenance
OSHA – Occupational Safety and Health Administration

Table 9
GE Aviation - Evendale, Ohio
Alternative 2 Cost Estimate

Alternative 2 - Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls

COST ESTIMATE SUMMARY

Site: GE Aviation Facility
Location: Evendale, Ohio
Phase: Corrective Measures Study
Base Year: 2017

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
DIRECT CAPITAL COSTS						
Institutional Controls						
Access/Use Restriction/Environmental Covenant	LS	1	$20,000	$20,000		
Institutional and Engineering Controls Plan	LS	1	$80,000	$80,000		
				Item Subtotal:	**$100,000**	
				TOTAL DIRECT CAPITAL COST (rounded):	**$100,000**	
				ENGINEERING/MANAGEMENT, CONSTRUCTION OVERSIGHT, OH&P	**$19,000**	6%, 8%, and 5% respectively
				CONTINGENCY (15%)	**$15,000**	Scope Contingency
				TOTAL CAPITAL COST (rounded)	**$134,000**	

Table 9
GE Aviation - Evendale, Ohio
Alternative 2 Cost Estimate

Alternative 2 - Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls

COST ESTIMATE SUMMARY

Site: GE Aviation Facility
Location: Evendale, Ohio
Phase: Corrective Measures Study
Base Year: 2017

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
OPERATION AND MAINTENANCE COSTS - Years 1 through 30						
Inspections, Reporting and Maintenance						
Engineering Controls Inspection and Reporting	LS	1	$10,000	$10,000		Semi-annual inspection of covers and fencing, reporting
Existing SWMU/AOC Cover Repairs	LS	1	$5,000	$5,000		Incidental vegetation/asphalt/concrete cover repairs; impacted SWMUs/AOCs
				Item Subtotal:	*$15,000*	
Groundwater IRM System Operation and Maintenance						
Routine RW and GWTP O&M	LS	1	$183,000	$183,000		Licensed operator, PM, materials, equipment and tools, H&S and PPE
Scheduled Maintenance	LS	1	$75,000	$75,000		Includes monthly air stripper tray cleaning; technician, electrician, controls & mechanical support, PM, materials, PPE
Preventative Maintenance	LS	1	$20,000	$20,000		Air stripper clean-in-place event, performed annually
Engineering Support/System Testing/Support Services	LS	1	$28,500	$28,500		H&S, legal, technical, clerical, engineering, laboratory support services; compliance sampling labor & analytical
Chemicals	LS	1	$156,000	$156,000		Sequesterant usage, approximately 10 gallons per day
Alarm Response	LS	1	$5,000	$5,000		Operator response to GWTP emergency/alarm conditions
Electrical power	kwh	78,000	$0.046	$3,588		
Handling, T&D of solids from cleaning	LS	1	$10,000	$10,000		On-site staging, analytical, T&D
				Item Subtotal:	*$481,088*	
Groundwater Monitoring						
Minor monitoring well repairs	LS	1	$15,300	$15,300		
Annual groundwater gauging	LS	1	$8,000	$8,000		
Semi-annual groundwater sampling	LS	1	$38,300	$38,300		
IRM PMP sampling + EW laboratory	LS	1	$86,000	$86,000		
PMP GW hydraulic monitoring	LS	1	$43,700	$43,700		
MNA sampling and lab analysis/data validation	LS	1	$44,300	$44,300		
				Item Subtotal:	*$235,600*	
Meetings/Reporting						
Regulatory Reports	LS	1	$5,000	$5,000		DMR and air reporting
Quarterly/Annual Groundwater IRM Reports	LS	1	$51,000	$51,000		
USAF Meetings, Coordination Years	LS	1	$28,000	$28,000		Technical review, invoicing and meetings
Team Meetings, Progress Rpts, Budgets	LS	1	$74,000	$74,000		Qtrly progress reports, meetings, coordination, budget support
Regulatory Assistance and USEPA Meetings	LS	1	$44,000	$44,000		Meetings, communication
				Item Subtotal:	*$202,000*	
OPERATION AND MAINTENANCE COSTS - Years 5, 10, 15, 20, 25, 30						
Periodic Site Reviews	EA	1	$20,000	$20,000		
				Item Subtotal:	*$20,000*	

Present Worth Analysis Years (1-30)		Discount Factor	**Present Worth ($)**
Cost Type	Cost	Df=7	**(rounded)**
Capital Cost - Year 0	$134,000	1.00	**$134,000**
Annual O&M - Years 1-30	$933,688	12.41	**$11,586,000**
Periodic O&M - Years 10, 15, 20, 25, 30	$20,000	2.16	**$43,000**
	TOTAL PRESENT WORTH ESTIMATED ALTERNATIVE COST (rounded):		**$11,763,000**

Table 10
GE Aviation - Evendale, Ohio
Alternative 3 Cost Estimate

Alternative 3 - Soil Excavation/Disposal, Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls

COST ESTIMATE SUMMARY

Site: GE Aviation Facility
Location: Evendale, Ohio
Phase: Corrective Measures Study
Base Year: 2017

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
DIRECT CAPITAL COSTS						
General Conditions	LS	1	$50,000	$50,000		Trailer, signage, construction fencing, PPE
Mobilization/Demobilization	LS	1	$268,000	$268,000		Decontamination pad, staging, , soil stockpile area, temporary construction water management mob/demob
Surveys and Permits	LS	1	$59,000	$59,000		
				Item Subtotal:	*$377,000*	
Institutional Controls						
Access/Use Restriction/Environmental Covenant	LS	1	$20,000	$20,000		
Institutional and Engineering Controls Plan	LS	1	$80,000	$80,000		
				Item Subtotal:	*$100,000*	
Excavation						
Excavation of Soil	CY	36,100	$11	$397,100		Accessible soil exceeing CMOs
Sheeting	SF	49,300	$43	$2,110,040		
Backfill	CY	35,100	$29	$1,019,655		
Transport and Disposal - asphalt	CY	800	$100	$80,000		
Transport and Disposal - non-hazardous soil	CY	23,900	$120	$2,868,000		
Transport and Disposal - hazardous soil	CY	12,200	$300	$3,660,000		
Restoration - Vegetation	SF	28,300	$0.16	$4,528		
Restoration - Asphalt	SY	6,800	$64	$436,560		Allowance for WTP setup/piping/equipment, operator labor
Construction and safety oversight	LS	1	$473,000	$473,000		Superintendent, Safety officer
Construction water management - rental	LS	1	$1,004,000	$1,004,000		Temporary *ex situ* treatment system rental allowance and conveyance
Construction water management - operator	LS	1	$156,000	$156,000		Temporary treatment system operator
				Item Subtotal:	*$12,208,883*	
				TOTAL DIRECT CAPITAL COST (rounded):	**$12,685,883**	
				ENGINEERING/MANAGEMENT, CONSTRUCTION OVERSIGHT, OH&P	**$2,410,318**	6%, 8%, and 5% respectively
				CONTINGENCY (15%)	**$1,902,882**	Scope Contingency
				TOTAL CAPITAL COST (rounded)	**$16,999,000**	

Table 10
GE Aviation - Evendale, Ohio
Alternative 3 Cost Estimate

Alternative 3 - Soil Excavation/Disposal, Continued O&M of Groundwater P&T System, Monitored Natural Attenuation, with Institutional and Engineering Controls

COST ESTIMATE SUMMARY

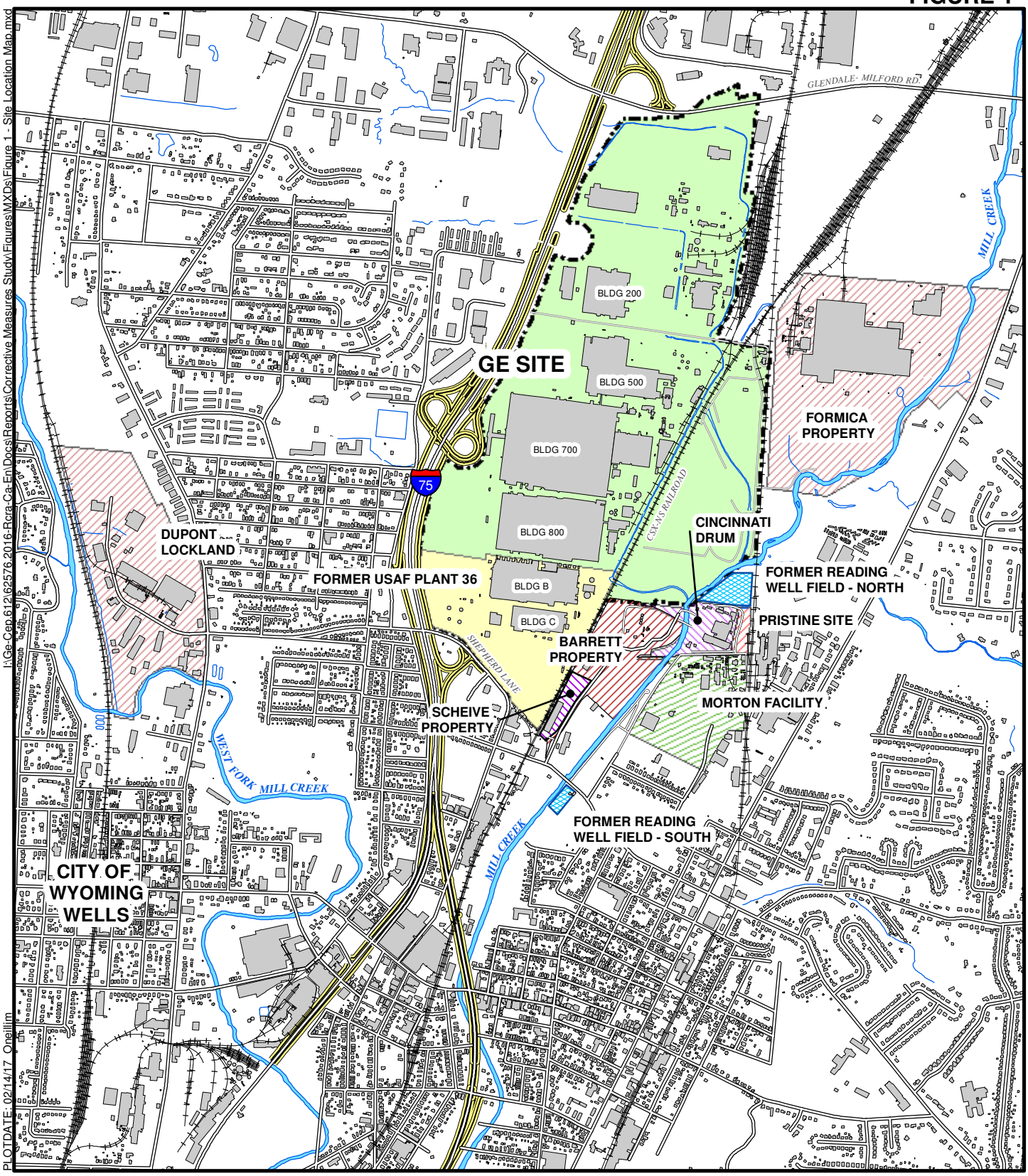
Site: GE Aviation Facility
Location: Evendale, Ohio
Phase: Corrective Measures Study
Base Year: 2017

ITEM	UNIT	ESTIMATED QUANTITY	ESTIMATED UNIT COST	ESTIMATED COST		NOTES
OPERATION AND MAINTENANCE COSTS - Years 1 through 30						
Inspections, Reporting and Maintenance						
Engineering Controls Inspection and Reporting	LS	1	$10,000	$10,000		Semi-annual inspection of covers and fencing, reporting
Existing SWMU/AOC Cover Repairs	LS	1	$3,000	$3,000		Incidental vegetation/asphalt/concrete cover repairs; impacted SWMUs/AOCs
				Item Subtotal:	*$13,000*	
Groundwater IRM System Operation and Maintenance						
Routine RW and GWTP O&M	LS	1	$183,000	$183,000		Licensed operator, PM, materials, equipment and tools, H&S and PPE
Scheduled Maintenance	LS	1	$75,000	$75,000		Includes monthly air stripper tray cleaning; technician, electrician, controls & mechanical support, PM, materials, PPE
Preventative Maintenance	LS	1	$20,000	$20,000		Air stripper clean-in-place event, performed annually
Engineering Support/System Testing/Support Services	LS	1	$28,500	$28,500		H&S, legal, technical, clerical, engineering, laboratory support services; compliance sampling labor & analytical
Chemicals	LS	1	$156,000	$156,000		Sequesterant usage, approximately 10 gallons per day
Alarm Response	LS	1	$5,000	$5,000		Operator response to GWTP emergency/alarm conditions
Electrical power	kwh	78,000	$0.046	$3,588		
Handling, T&D of solids from cleaning	LS	1	$10,000	$10,000		On-site staging, analytical, T&D
				Item Subtotal:	*$481,088*	
Groundwater Monitoring						
Minor monitoring well repairs	LS	1	$15,300	$15,300		
Annual groundwater gauging	LS	1	$8,000	$8,000		
Semi-annual groundwater sampling	LS	1	$38,300	$38,300		
IRM PMP sampling + EW laboratory	LS	1	$86,000	$86,000		
PMP GW hydraulic monitoring	LS	1	$43,700	$43,700		
MNA sampling and lab analysis/data validation	LS	1	$44,300	$44,300		
				Item Subtotal:	*$235,600*	
Meetings/Reporting						
Regulatory Reports	LS	1	$5,000	$5,000		DMR and air reporting
Quarterly/Annual Groundwater IRM Reports	LS	1	$51,000	$51,000		
USAF Meetings, Coordination Years	LS	1	$28,000	$28,000		Technical review, invoicing and meetings
Team Meetings, Progress Rpts, Budgets	LS	1	$74,000	$74,000		Qtrly progress reports, meetings, coordination, budget support
Regulatory Assistance and USEPA Meetings	LS	1	$44,000	$44,000		Meetings, communication
				Item Subtotal:	*$202,000*	
OPERATION AND MAINTENANCE COSTS - Years 5, 10, 15, 20, 25, 30						
Periodic Site Reviews	EA	1	$20,000	$20,000		
				Item Subtotal:	*$20,000*	

Present Worth Analysis Years (1-30)		Discount Factor	**Present Worth ($)**
Cost Type	Cost	Df=7	**(rounded)**
Capital Cost - Year 0	$16,999,000	1.00	**$16,999,000**
Annual O&M - Years 1-30	$931,688	12.41	**$11,561,000**
Periodic O&M - Years 10, 15, 20, 25, 30	$20,000	2.16	**$43,000**
	TOTAL PRESENT WORTH ESTIMATED ALTERNATIVE COST (rounded):		**$28,603,000**

Figures

FIGURE 1



GE AVIATION
EVENDALE, OHIO

SITE LOCATION MAP

0 1,000 2,000 4,000
Feet

N

O'BRIEN & GERE ENGINEERS, INC.

612/62576
FEBRUARY 2017

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FIGURE 2

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LEGEND

- HISTORIC IRM LOCATION
- EXISTING IRM TREATMENT BUILDING
- ODOT PLAN - RIGHT OF WAY
- HISTORIC DRAINAGE DITCH REMEDIATION
- EXISTING IRM PIPING (UNTREATED)
- EXISTING IRM PIPING (TREATED)
- EXISTING IRM EXTRACTION WELLS

GE AVIATION
EVENDALE, OHIO

RCRA INTERIM MEASURES LOCATION MAP

0 200 400 800
Feet

N

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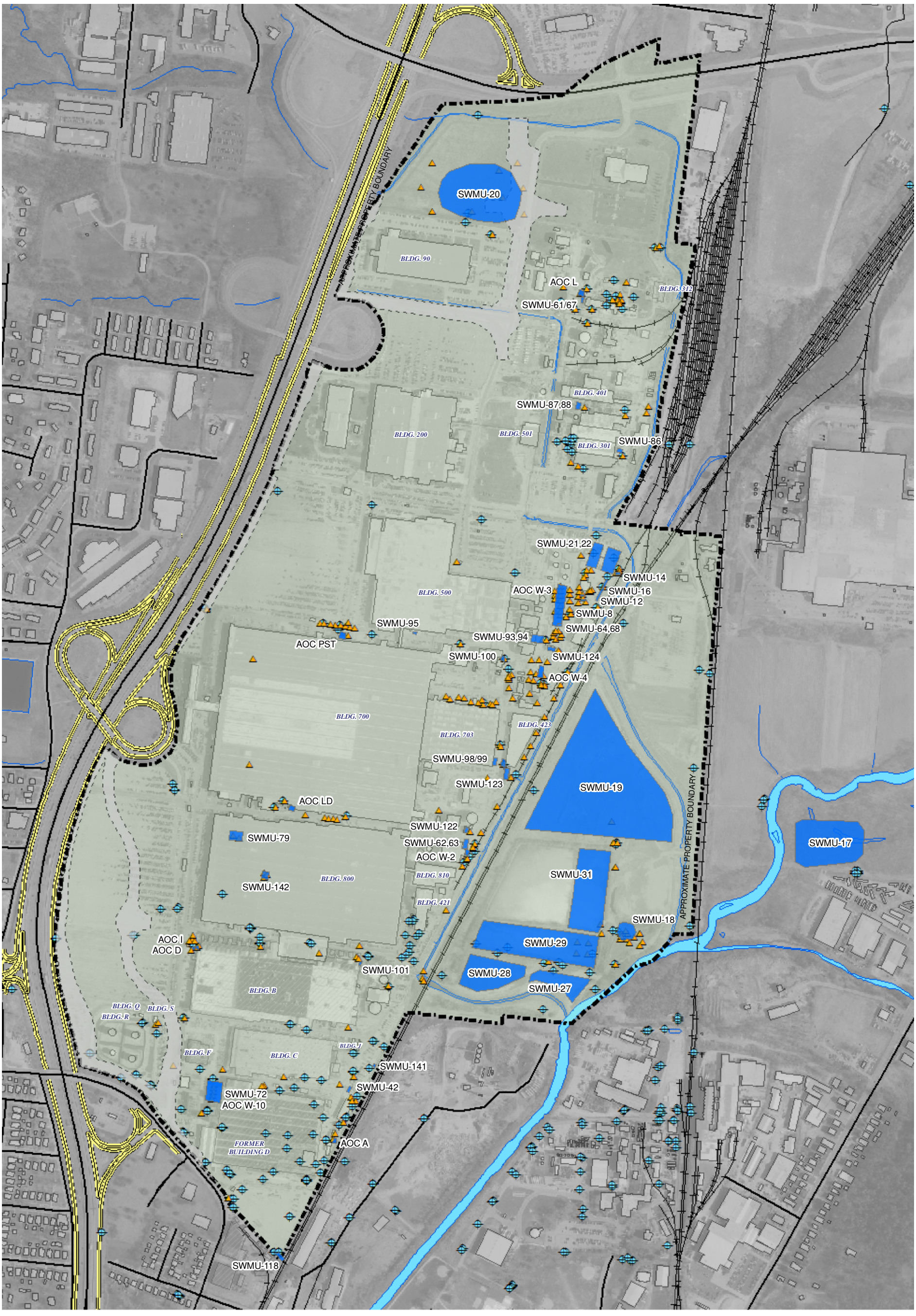
612/62576

FIGURE 3



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LEGEND

- SWMUs/AOCs/IRPs
- ODOR PLAN - RIGHT OF WAY
- SITE PROPERTY BOUNDARY
- SOIL BORING LOCATION
- MONITORING WELL LOCATION

GE AVIATION
EVENDALE, OHIO

SWMUs/AOCs/IRPs

0 200 400 800
Feet

N

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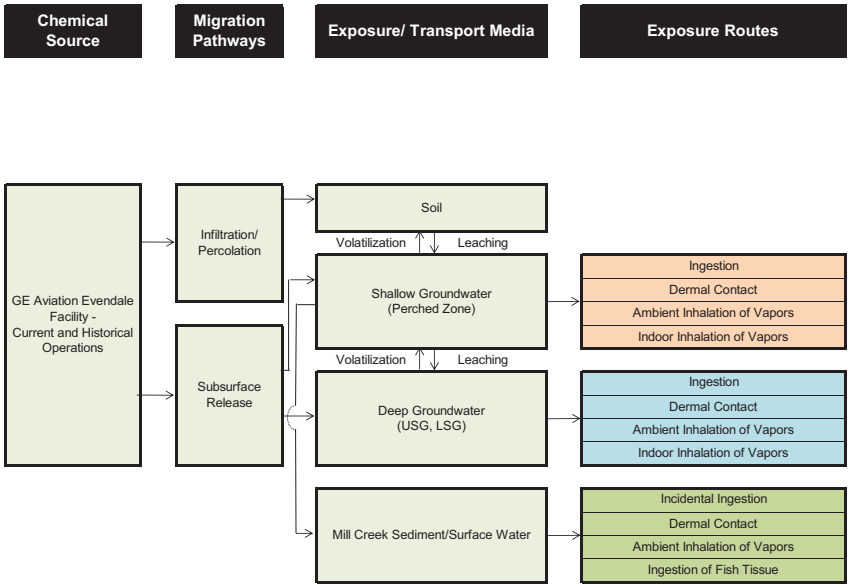
FIGURE 4

Human Health Conceptual Site Model
GE Aviation Evendale Facility
Evendale, Ohio



Exposure Routes	Potential Human Receptors[a]						
	On-Site Receptors				Off-Site Receptors		
	Outdoor Industrial Worker	Utility Worker	Construction Worker	Indoor Industrial Worker	Child Resident	Adult Resident	Creek User
	Current / Future	Current / Future	Current / Future	Current / Future	Current / Future	Current / Future	Current / Future
	>18 years old	>18 years old	>18 years old	>18 years old	0-6 years old	>18 years old	> 6 years old
Ingestion	◊	Δ	◊	◊	●	●	●
Dermal Contact	◊	●	◊	◊	●	●	●
Ambient Inhalation of Vapors	◊	●	◊	◊	Δ	Δ	Δ
Indoor Inhalation of Vapors	◊	◊	◊	●	●	●	●
Ingestion	◊	◊	◊	◊	●	●	●
Dermal Contact	◊	◊	◊	◊	●	●	●
Ambient Inhalation of Vapors	◊	◊	◊	◊	◊	◊	◊
Indoor Inhalation of Vapors	◊	◊	◊	◊	●	●	●
Incidental Ingestion	◊	◊	◊	◊	◊	◊	●
Dermal Contact	◊	◊	◊	◊	◊	◊	Δ
Ambient Inhalation of Vapors	◊	◊	◊	◊	◊	◊	Δ
Ingestion of Fish Tissue	◊	◊	◊	◊	◊	◊	Δ

Notes:
● : Potentially complete exposure pathway.
Δ : Pathway is considered to represent *de minimis* exposure.
◊ : Incomplete exposure pathway.

a: Both current and reasonably anticipated future scenarios considered in pathway analysis.

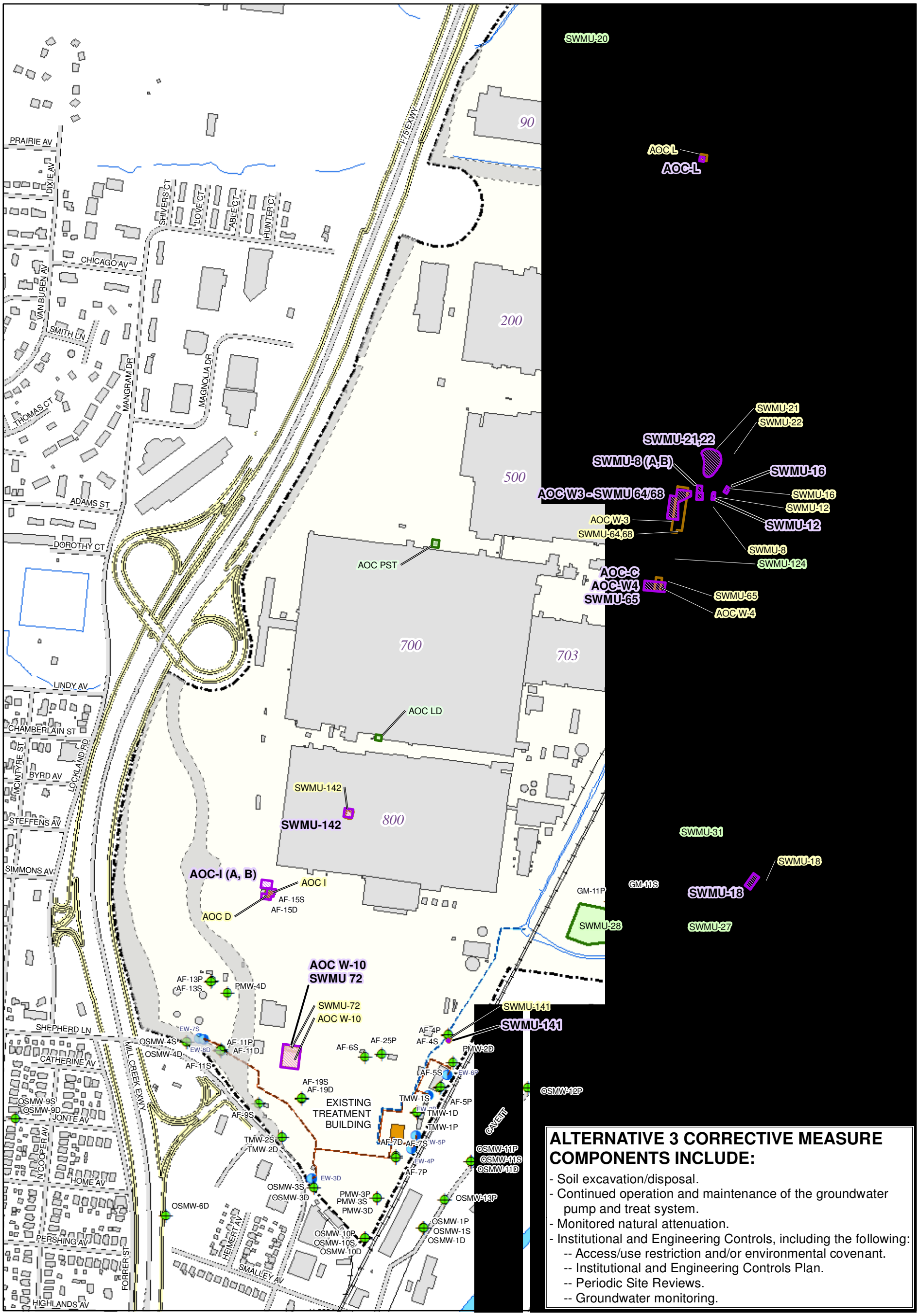
Nonresponsive

Nonresponsive

Nonresponsive

Nonresponsive

FIGURE 9



ALTERNATIVE 3 CORRECTIVE MEASURE COMPONENTS INCLUDE:

- Soil excavation/disposal.
- Continued operation and maintenance of the groundwater pump and treat system.
- Monitored natural attenuation.
- Institutional and Engineering Controls, including the following:
  - -- Access/use restriction and/or environmental covenant.
  - -- Institutional and Engineering Controls Plan.
  - -- Periodic Site Reviews.
  - -- Groundwater monitoring.

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LEGEND

- EXISTING IRM TREATMENT BUILDING
- ODOT PLAN - RIGHT OF WAY
- ASSUMED AREAS OF EXCAVATION
- RSLs < SOIL CONCENTRATIONS ≤ CMOs
- SOIL CONCENTRATIONS >CMOs
- SITE PROPERTY BOUNDARY
- EXISTING IRM PIPING (TREATED)
- EXISTING IRM PIPING (UNTREATED)
- EXISTING IRM EXTRACTION WELLS
- GROUNDWATER MONITORING WELL LOCATIONS

GE AVIATION
EVENDALE, OHIO

CMS ALTERNATIVE 3

0 200 400 800
Feet

N

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