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Corrective Measures Proposal

Revitalizing Auto Communities Environmental Response Trust (RACER Trust)

Former Delphi Harrison Thermal Systems, Moraine Plant
Former General Motors Powertrain Group, Moraine Engine Plant
Former General Motors Truck Group, Moraine Assembly Plant

Moraine, Ohio

December 31, 2012

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AMSL	above mean sea level
AOC	Administrative Order on Consent
AOI	Area of Interest
AS/SVE	Air Sparging with Soil Vapor Extraction
ASTM	American Society for Testing and Materials
ASTs	Above Ground Storage Tanks
bls	below land surface
BRA	Baseline Risk Assessment
BTEX	benzene, toluene, ethylbenzene, and xylenes
BUSTR	Ohio Bureau of Underground Storage Tank Regulations
C Tech	C Tech Development Corporation
cis-1,2-DCE	cis-1,2-dichloroethene
cm^3/g	cubic centimeters per gram
CMOs	corrective measures objectives
CMP	Corrective Measures Proposal
CMS	Corrective Measures Study
COPCs	constituents of potential concern
CSDSs	crawlspace depressurization systems
CVOCs	chlorinated VOCs
DMAX	DMAX Engine Plant
DNAPL	dense nonaqueous phase liquid
DOCC	Description of Current Conditions
DVD	digital versatile disc
EDWLs	equivalent drinking water levels
EI	Environmental Indicator
ERD	enhanced reductive dechlorination
EVO	emulsified vegetable oil

FEMA	Federal Emergency Management Agency
ft.	feet
ft./day	feet per day
ft./ft.	feet per foot
g/cm^3	grams per cubic centimeter
GSI	groundwater-surface water interaction
GM Corporation	General Motors Corporation
gpm	gallons per minute
HHRA	Human Health Risk Assessment
HI	hazard index
IMs	interim measures
IM/CM	Interim Measures/Corrective Measures
in.	inches.
IRZ	in-situ reactive zone
ISCO	in-situ chemical oxidation
ISST	in-situ stabilization and treatment
ISTT	In-situ thermal treatment
LNAPL	light nonaqueous phase liquid
LWB	Liquid Waste Burner
MCD	Miami Conservancy District
MCLs	maximum contaminant levels
MGD	million gallons per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MLC	Motors Liquidation Company
MNA	monitored natural attenuation
MVS	Mining Visualization System

NAPL	non-aqueous phase liquid
NFA	no further action
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
ODNR	Ohio Department of Natural Resources
O&M	operation and maintenance
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PDI	Pre-Design Investigation
ppm	parts per million
RACER Trust	Revitalizing Auto Communities Environmental Response Trust
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RME	reasonable maximum exposures
RSLs	Regional Screening Levels
RZs	reactive zones
SVOCs	semi-volatile organic compounds
SSDSs	sub-slab depressurization systems
SMDSs	sub-membrane depressurization systems
SVE	soil-vapor extraction
SWMUs	solid waste management units
SWRBs	storm water retention basin
TCE	trichloroethene
TCL	Target Compound List
TOC	top-of-casing
trans-1,2-DCE	trans-1,2-dichloroethene
U.S. EPA	United States Environmental Protection Agency

USGS	United States Geological Survey
UST	underground storage tank
VISLs	Vapor Intrusion Screening Levels
VOCs	volatile organic compounds
w.c.	water column
WLA	waste load allocation
WPSA	Waste Pile/Staging Area
WWTP	wastewater treatment plant
µg/L	microgram per liter
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,1,1-TCA	1,1,1-trichloroethane

1. Introduction

A multi-phased Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) was completed for the following Revitalizing Auto Communities Environmental Response Trust (RACER Trust) (formerly General Motors Corporation [GM Corporation]) Moraine facilities located in Moraine, Ohio (Site) (Figure 1): former Delphi Harrison Thermal Systems Moraine Plant (former Delphi Thermal Moraine [leased to Delphi Corporation between January 1999 and September 2003]), former General Motors Powertrain Group, Moraine Engine Plant (former Moraine Engine), and General Motors Truck Group, Moraine Assembly Plant (Moraine Assembly) and approved by the United States Environmental Protection Agency (U.S. EPA) in June 2000 (ARCADIS Geraghty & Miller, Inc. 2000a and b, ENVIRON 2000a and b). The RFI, conducted from 1992 to 1998, identified that the primary source area of volatile organic compounds (VOCs) in shallow groundwater at the three facilities is located at Area of Interest (AOI) 7 - Former Oil House Area, in the northern portion of the former Moraine Engine facility (Figure 2). The focus of the *Interim Measures/Corrective Measures Report* (IM/CM Report; ARCADIS Geraghty & Miller, Inc. 2001) was development of a site-wide remedy that addressed the source of the VOCs in groundwater and the downgradient plume based on the site conceptual model at that time.

The IM/CM Report, which was submitted to the U.S. EPA on March 2, 2001, served as the site-wide corrective measures report for the three facilities. Subsequent to submittal of the IM/CM Report, implementation of the corrective measures proposed in the IM/CM Report have been conducted on an ongoing basis by former GM Corporation and subsequently Motors Liquidation Company (MLC) and RACER Trust. These corrective measures include: the Former Oil House Area corrective measures (in-situ remediation of groundwater in the Former Oil House Area and downgradient of the Former Oil House Area, see Figure 2); the capture zone corrective measures (hydraulic control with a pump and treat system for the upper aquifer and hydraulic control for the lower aquifer, see Figure 2); and a site-wide groundwater monitoring program. In addition, former GM Corporation identified the need to conduct the following additional work to refine the final corrective measures for the Site:

- Updated characterization and implementation of interim measures (IMs) at the Waste Pile/Staging Area (WPSA) at the former Delphi Thermal Moraine facility.

- Investigation of the Box Sewer system located at the former Moraine Engine facility.

- Investigation under the former Delphi Thermal Moraine Building 14.

- Focused investigations of groundwater chemistry and hydrogeology in certain areas within and downgradient of the existing area of groundwater contamination.

The supplemental soil and groundwater investigation and targeted soil excavation IMs were completed for the WPSA located south of the former Delphi Thermal Moraine Building 14 (ARCADIS, Inc. 2006) from 2000 to 2006. The soil investigation was completed for the Box Sewer located east of the former Moraine Engine in 2001 and 2002 (ARCADIS, Inc. 2002a). The soil and groundwater investigation was completed for the former Delphi Thermal Moraine Building 14 in 2004 and 2005 (ARCADIS, Inc. 2005a). These investigations were discussed in the Site Summary submitted to the U.S. EPA in June 2005 (ARCADIS, Inc. 2005b). A *Revised Draft Corrective Measures Proposal* (Revised Draft CMP) which served as an addendum to the IM/CM Report was also submitted to the U.S. EPA in June 2005 (BOW Environmental Solutions, Inc. [BOW] 2005a). The Revised Draft CMP included revised corrective measures goals and updates to the final recommended site-wide remedy previously presented in the IM/CM Report. Since submittal of the Revised Draft CMP, former GM Corporation implemented a supplemental groundwater investigation from 2005 to 2008 to further refine the understanding of groundwater chemistry and hydrogeology for the final corrective measures implementation. The groundwater investigation completed in 2006 was presented in the *Corrective Measures Supplemental Groundwater Investigation Report* (ARCADIS, Inc. 2007), along with recommendations for further focused study of groundwater chemistry and hydrogeology. This focused groundwater investigation was completed in 2007 and 2008. The results of these investigations were presented in the 2008 CMP submitted by former GM Corporation to the U.S. EPA on August 25, 2008 (ARCADIS, Inc. 2008). An addendum to the 2008 CMP was submitted to the U.S. EPA by BOW on November 7, 2008 (BOW 2008b). The 2008 CMP Addendum presented the cost estimate for the proposed final corrective measures described in the 2008 CMP. An addendum to the 2008 CMP was submitted by MLC to the U.S. EPA on March 22, 2010 (ARCADIS, Inc. 2010a). The 2010 CMP Addendum proposed additional corrective measures complementary to those proposed in the 2008 CMP to provide more direct treatment of contaminant source, improve control over contaminant migration, and provide supplemental information to 2008 CMP (ARCADIS, Inc. 2008). Additionally, the 2010 CMP Addendum provided estimated costs for all proposed corrective measures superseding costs presented previously in the 2008 CMP Addendum.

This 2012 CMP is a comprehensive document that serves as an updated conceptual site model and includes a summary of all RFI, Supplemental RFI, and additional supplemental investigations that have been completed since approval of the RFI and Supplemental RFI Reports. This 2012 CMP supersedes all previous CMPs and CMP Addendums.

The remainder of this CMP is organized into the following sections:

- Section 2, Facility Background provides a Site description and history, summarizes the regulatory history for the Site, the various investigation activities, the IMs completed to date, and the updated conceptual site model.

- Section 3, Risk Assessment Summary presents the risk screening criteria and identified facility risks as well as the corrective measures objectives (CMOs) for the Site.

- Section 4, Summary of Corrective Measures Options identifies and comparatively evaluates appropriate remedial technologies, taking the current IMs into consideration, to select technology(s) best suited to achieve the CMOs for the Site.

- Section 5, Remedy Recommendation identifies the recommended site-wide remedy and estimated costs.

- Section 6, References lists documents used in preparation of this CMP.

Tables and figures are also included to provide further detail, as appropriate, and a series of appendices have been compiled to supplement the discussions included in the main text. The appendices are as follows:

- Appendix A contains excerpts of pertinent information from the RFI/Supplemental RFI Reports.

- Appendices B through F contain supporting information from several phases of investigations completed since the RFI and Supplemental RFI:

  - Appendix B - Previous Site Investigation Supporting Information - Box Sewer/WPSA/Building 14.

  - Appendix C - Supplemental Groundwater Investigation Supporting Information.

  - Appendix D - Vapor Intrusion Investigation Supporting Information.
  - Appendix E - Landfill L1 Investigation Supporting Information.
  - Appendix F - Pre-Design Investigation Supporting Information.

- Appendix G presents an updated Human Health Risk Assessment (HHRA) to address recently collected data in 2011 and 2012.
- Appendix H contains boring logs and well construction details.
- Appendix I presents a summary of the off-site private well survey conducted in 2007.
- Appendix J includes a refined three-dimensional data analysis of the Site, including hydrostratigraphy models and site-specific VOC plume maps.
- Appendix K presents an evaluation of groundwater-surface water interaction (GSI).

2. Facility Background

This section provides a Site description and history, regulatory history, a summary of the RFI/Supplemental RFI activities and findings, a summary of the additional investigations completed subsequent to the RFI/Supplemental RFI, a summary of the IMs completed to date, a summary of the vapor intrusion and mitigation activities, a summary of the additional Landfill L1 investigation, a summary of the pre-design investigation (northern perimeter, secondary source areas, and Process Sump Area) and a discussion of the revised conceptual site model. The conceptual site model includes Site characteristics, physical setting, refinements made to the geology, hydrogeology, and groundwater chemistry, and results of the off-site well search results.

2.1 Site Description and History

The Site has been used for industrial purposes since the property was acquired in the mid-1920's. The former Moraine Engine and Moraine Assembly facilities occupy approximately 239 acres, while the adjacent former Delphi Thermal Moraine facility occupies approximately 124 acres. The facilities are located in the City of Moraine in Montgomery County in southwestern Ohio. A small portion of the Moraine Assembly facility is located in the City of Kettering. Figure 1 shows the location of each facility, property boundaries, and Site features.

Frigidaire (a former division of former GM Corporation) produced appliances at the Site from the late 1920's until former GM Corporation announced the shutdown of all Frigidaire operations in January 1979. During 1980 and 1981, the majority of the former Frigidaire Plant 2 was converted to the former Moraine Engine facility, and the former Frigidaire Plant 3 and the northeast corner of former Frigidaire Plant 2 were converted to the Moraine Assembly facility. Since 1981, former Moraine Engine operations have included the machining, painting (this operation was discontinued in September 1995), and assembly of diesel truck engines. Operations at the former Moraine Engine facility ceased in the fall of 2000. The plant building was decommissioned and demolished, and the majority of this site has been covered with a parking surface. Former GM Corporation operated a regional haulaway at the location of the former Moraine Engine Plant, which was referred to as the Vehicle Distribution Center until December 2008 when operations ceased.

Since 1981, Moraine Assembly operations included the manufacture, assembly, and painting of small trucks and later sport utility vehicles. Operations at the former Moraine Assembly ceased in December 2008.

Former Delphi Thermal Moraine's major operations, which began in 1941, included the machining and assembly of automotive air conditioning compressors, accumulator dehydrators, and miscellaneous air conditioning valves. Operations at the former Delphi Thermal Moraine Building 14 ceased in September 2003 and the building was decommissioned. Demolition of Building 14 was completed in 2005.

On June 1, 2009, former GM Corporation and certain subsidiaries filed voluntary petitions for relief under Chapter 11 of the Bankruptcy Code. An order was entered approving the sale of substantially all of former GM Corporation's assets to a new and independent company (now known as General Motors Company, LLC) under Section 363 of the Bankruptcy Code on June 5, 2009. The sale closed on July 10, 2009. At that time, former GM Corporation changed its name to Motors Liquidation Company (MLC). RACER Trust was established on March 31, 2011 by a federal bankruptcy court to own, manage, remediate and revitalize the properties from the 2009 former GM Corporation bankruptcy.

Prior to the formation of RACER Trust, the northern portion of the former Moraine Assembly Plant property located at 3100 Dryden Road and referred to as the DMAX Engine Plant (DMAX) (City Lot #5416/Tax Parcel Number J44 04103 0006) was transferred to General Motors Company, LLC. On March 4, 2010, BOW provided the U.S. EPA a letter "RE: Motors Liquidation Company - Moraine, Ohio Former West Haulaway/Current DMAX Facility Documentation" (BOW 2010) providing documentation of the former West Haulaway underground storage tank (UST) investigations and closure reports. No further action has been approved for all Ohio Bureau of Underground Storage Tank Regulations (BUSTR) incident numbers associated with DMAX and no further action has been approved for RCRA Corrective Action by the U.S. EPA. As outlined in the 2011 Administrative Order on Consent (AOC), the DMAX property is not a respondent to the current AOC (U.S. EPA 2011).

On June 30, 2011, RACER Trust sold former Delphi Thermal Moraine, former Moraine Engine Plant, and former Moraine Assembly Plant to IRG Moraine, LLC. As part of the property transfer, RACER Trust retained environmental liability for these properties.

The closed South Settling Lagoon was not included in this property transaction. The closed South Settling Lagoon was retained by RACER Properties LLC.

2.2 Regulatory History

This section provides a chronological RCRA regulatory history for the Moraine Facilities.

The former Delphi Thermal Moraine contains North and South Settling Lagoons shown on Figure 1. The North Settling Lagoon received industrial wastewater from 1972 to 1979, and received non-contact cooling water and storm water runoff from 1980 to 1984. The South Settling Lagoon received industrial wastewater from 1965 to 1979; received dilute acid and alkali rinses from small cleaning and non-cyanodic electroplating processes, water softening sludges, non-contact cooling water, storm water runoff, and fly ash dewatering filtrate from 1980 to 1985; and in 1985 process wastewaters were diverted to the on-site wastewater treatment plant (WWTP). Both lagoons were taken out of service in 1989, and process wastewaters were diverted to the WWTP.

The WWTP was constructed in the early 1980’s to treat process waters generated at the Site and the adjacent facilities and consisted of two separate treatment systems. The Permit-to-Install was issued by the Ohio EPA on October 21, 1980 to the former GM Corporation.

The wastewater generated by the three former plants was pretreated at the WWTP before being treated by the Montgomery County Sanitary System. The WWTP processed wastewaters generated at the Site prior to discharge under a National Pollutant Discharge Elimination System (NPDES) Permit. The WWTP has not discharged any wastewaters since July 2009. The tanks and processes at the WWTP were emptied, cleaned, and decommissioned in 2009.

Former GM Corporation filed a RCRA Part A-Application with Ohio EPA for interim status in November 1980 and began detection monitoring at the North and South Settling Lagoons in February 1981. In 1984, assessment monitoring began for the North Settling Lagoon, while the South Settling Lagoon remained in the detection monitoring program. By October 1988, former GM Corporation expanded the groundwater monitoring assessment plan network for the North Settling Lagoon and expanded the groundwater detection network in the South Settling Lagoon in accordance with an agreed consent order with the State of Ohio. The assessment and detection monitoring programs continued until the lagoon closure activities were completed, as discussed below. Monitoring is now performed as part of the RCRA corrective action site-wide groundwater monitoring program.

Delphi Thermal Moraine submitted closure plans for the North and South Settling Lagoons to U.S. EPA and Ohio EPA in November 1985 and November 1989. Closure discussions between former GM Corporation and Ohio EPA were deferred by mutual agreement to coordinate ultimate closure requirements with the corrective action requirements from the U.S. EPA Region V (the North and South Settling Lagoons were evaluated as solid waste management units (SWMUs) in the RFI at Delphi Thermal Moraine). During the summer of 1999, former GM Corporation met with the Ohio EPA to present and discuss a revised approach for closure of the lagoons. This approach was presented to the Ohio EPA in the *Lagoon Closure Plan* (Closure Plan), dated June 2000 (Conestoga-Rovers & Associates 2000), and approved by the Ohio EPA in a letter to former GM Corporation dated August 24, 2000. Closure activities were initiated in September 2000 and completed in June 2001, as described in Section 2.6.1. Former GM Corporation submitted the *Closure Certification Report* to the Ohio EPA on August 10, 2001 (Conestoga-Rovers & Associates 2001) and was approved by the Ohio EPA in a letter to former GM Corporation dated June 27, 2002. The *Lagoon Post-Closure Plan* (Post-Closure Plan; Conestoga-Rovers & Associates 2002) was submitted to the Ohio EPA on December 13, 2002 and was approved by the Ohio EPA in a letter to former GM Corporation dated December 24, 2003.

Delphi Thermal Moraine received an Administrative Order (1991 Administrative Order) (Docket No. V-W-91R-2) from the U.S. EPA Region V, which became effective on January 30, 1991. The Administrative Order, issued under Section 3008(h) of RCRA, as amended, 42 U.S.C. 6928(h), required Delphi Thermal Moraine to implement a RCRA Corrective Action program at the Moraine facility. Former GM Corporation met the requirements of the 1991 Administrative Order through the completion of a two-phased RFI at the Delphi Thermal Moraine facility and by implementing capture zone IMs. The scope of the IMs was presented in the *Preliminary Interim Measures Work Plan* (Geraghty & Miller, Inc. 1994a). The initial IM was implemented per the *Final Interim Measures Design Plans* (Geraghty & Miller, Inc. 1995) approved by the U.S. EPA on July 31, 1995. The initial, on-going IM consist of controlling migration of VOCs in the upper and lower aquifers at the southern property boundary through groundwater extraction at TW-2 and DN-13, respectively (Figure 2). The groundwater recovered by the upper aquifer recovery well TW-2 was treated using an air stripper tower and discharged through former GM Corporation's NPDES permitted outfall to the Great Miami River. Groundwater was pumped from TW-2 at an average flow rate of approximately 120 gallons per minute (gpm) until the system was shut down in July 2012. DN-13 is a lower aquifer well that Montgomery County has been using in a "Pump-to-Waste" Program since March 1990. The IM consists of continued pumping of DN-13 at an approximate rate of 1,000 gpm.

The results of the first phase of the RFI, completed in late 1992 and early 1993, at Delphi Thermal Moraine, were submitted to the U.S. EPA in July 1993 (Geraghty & Miller, Inc. 1993a). A second phase of the RFI was completed in 1994. The findings of both phases of the RFI for Delphi Thermal Moraine, including a Baseline Risk Assessment (BRA), were reported to the U.S. EPA in a 1996 draft *RCRA Facility Investigation Final Report* (RFI Report; final issue date was April 2000 [ARCADIS Geraghty & Miller, Inc. 2000a and ENVIRON 2000a]). The draft RFI Report stated that there were no unacceptable risks associated with soil/waste present in SWMUs investigated, and concluded that a Corrective Measures Study (CMS) was not necessary for the SWMUs investigated during the RFI at Delphi Thermal Moraine. The U.S. EPA issued comments to former GM Corporation on the draft RFI Report dated June 11, 1996 and former GM Corporation responded to these comments on September 11, 1996. The U.S. EPA provided a reply to the comment responses in correspondence to former GM Corporation dated October 1, 1996. To address the U.S. EPA's issues identified in this correspondence, former GM Corporation agreed to add the Moraine Engine and Moraine Assembly facilities to the Corrective Action program. In response to the findings of the *Preliminary Assessment/Visual Site Inspection* reports (PRC Environmental Management, Inc. 1991a and b) for the former Moraine Engine and Moraine Assembly facilities, on-going RFI activities at the adjacent former Delphi Thermal Moraine, and the extensive discussions between the U.S. EPA and former GM Corporation, the U.S. EPA issued an Amendment to the 1991 Administrative Order (Docket No. VW-R-002-91 [1997 Administrative Order]), effective on April 24, 1997, which included the former Moraine Engine and Moraine Assembly facilities in the Corrective Action program. This Amendment required former GM Corporation to conduct a Supplemental RFI at the two additional facilities.

A multi-phased investigation was completed during the Supplemental RFI, which focused on the Former Oil House Area. The findings of the Supplemental RFI for the former Moraine Engine and Moraine Assembly facilities, including a Supplemental BRA, were reported in a draft *Supplemental RFI Report* submitted to the U.S. EPA and Ohio EPA in June 1999 (ARCADIS Geraghty & Miller, Inc. 2000b and ENVIRON 2000b [these reports were finalized and approved by the U.S. EPA in April 2000]). The *Supplemental RFI Report* determined that constituent concentrations in soils at the AOIs at the former Moraine Engine and Moraine Assembly facilities do not pose an unacceptable risk. However, former GM Corporation recommended and implemented additional IMs to address VOCs in groundwater associated with the Former Oil House Area (AOI 7). A *Primary Groundwater Source Area (AOI 7) Interim Measures Work Plan* (Work Plan) was submitted to the U.S. EPA and Ohio EPA in June 1999 and was approved by the U.S. EPA in July 1999 (ARCADIS Geraghty & Miller, Inc. 1999). The

Work Plan recommended a combination of in-situ technologies to address chlorinated VOCs (CVOCs) in shallow groundwater that were implemented between September 1999 and May 2000. The results of these IMs were presented in the IM/CM Report submitted to the U.S. EPA and Ohio EPA in March 2001 (ARCADIS Geraghty & Miller, Inc. 2001).

To provide a basis for evaluating the performance of these IMs, the Work Plan proposed that a comprehensive site-wide groundwater sampling event for VOCs be conducted to establish a baseline data set. This baseline sampling for VOCs was completed in September 1999. A second site-wide groundwater sampling event was completed between September and October 2000. During this second site-wide event, at the request of the U.S. EPA, groundwater samples were analyzed for Appendix IX VOCs by Method 8260 and cis-1,2-dichloroethene (cis-1,2-DCE), semi-volatile organic compounds (SVOCs) and metals to verify that current groundwater conditions were consistent with previous Site conditions. The results of the 2000 sampling event confirmed that VOCs were the only constituents of potential concern in groundwater at the Site.

Environmental Indicator (EI) forms were prepared for the three former GM Corporation Moraine facilities. Form CA 750 Migration of Contaminated Groundwater Under Control was approved by the U.S. EPA in March 2001 for the three facilities. The positive determination on this form indicates that the migration of contaminated groundwater has stabilized and that monitoring will be conducted to confirm that contaminated groundwater remains within the original area of contaminated groundwater. Form CA 725 Current Human Exposures Under Control was approved for the Moraine Engine and Moraine Assembly facilities in December 2000 and for Delphi Thermal Moraine in September 2002. The positive determination on these forms indicates that there are no unacceptable human exposures to contamination that can be reasonably expected under current land- and groundwater-use conditions. RACER Trust continues to monitor conditions at and near the Site as part of the site-wide monitoring program to confirm that the conclusions of these EI forms remain valid. Revised forms will be submitted to the U.S. EPA per the AOC, as amended, on June 1, 2013.

In March 2000, former GM Corporation submitted to the U.S. EPA a draft *Site-Wide Groundwater Monitoring Plan* (Monitoring Plan) to monitor the effectiveness of the IMs and monitor groundwater quality upgradient and downgradient of the land-based units, including the closed North and South Settling Lagoons (ARCADIS, Inc. 2002b). Former GM Corporation received approval with comments on the Monitoring Plan from the U.S. EPA, dated June 16, 2000 and June 28, 2000. Former GM Corporation submitted responses to the U.S. EPA's comments on July 28, 2000. The U.S. EPA submitted an additional set of comments to former GM Corporation on September 15, 2000 and former GM Corporation submitted responses to the U.S. EPA's comments on November 17, 2000. Former GM Corporation received approval on the Monitoring Plan (Appendix A to the Post-Closure Plan [Conestoga-Rovers & Associates, 2002]) from the Ohio EPA in a letter dated December 24, 2003. RACER Trust continues to implement this site-wide groundwater monitoring program and submits annual reports to the U.S. EPA and Ohio EPA by March 1st of each year. On February 14, 2012, RACER Trust submitted a letter to the Ohio EPA requesting a modification of the Post Closure Plan for the closed South Settling Lagoon. In the letter, RACER Trust provided the *Human Health Risk Assessment Report* for the closed South Settling Lagoon supporting a change of the future land use for the closed South Settling Lagoon from industrial to recreational. On September 10, 2012, the Ohio EPA approved the designation change.

On September 29, 2011, the AOC for the Moraine Site was fully executed proceeding under Section 3008(h) of RCRA, as amended, 42 U.S. C. Section 6928(h), U.S. EPA Docket No: RCRA-05-2011-0016. The performance–based AOC covers corrective action for past releases of hazardous contaminants at or from the Site.

2.3 Evaluation of SWMUs/AOIs

SWMUs identified at the former Delphi Thermal and AOIs identified at the former Moraine Engine and Moraine Assembly were reviewed and evaluated in the *Description of Current Conditions* (DOCC; Geraghty & Miller, Inc. 1991) and Supplemental DOCC (Geraghty & Miller, Inc. 1997) reports, respectively. Two additional SWMUs were identified in the *Interim RFI Report* for the former Delphi Thermal (Geraghty & Miller, Inc. 1993a). SWMUs/AOIs were evaluated to determine if the unit constituted a potentially significant source and if further investigation would be warranted. Supporting information on the SWMU/AOI evaluation is presented in Appendix A.

2.3.1 Former Delphi Thermal SWMUs

The following SWMUs were reviewed and those SWMUs retained for further investigation are highlighted with an asterisk (*):

- Landfill L1*

- Landfill L2*
- Landfill L3*
- North Settling Lagoon (retained for further evaluation)
- South Settling Lagoon (retained for further evaluation)
- Waste Pile/Staging Area*
- Underground Storage Tanks T1, T2, T3, T4*, T5/T6*, T7, T8, T9, T10, T11*,T12* West Tank Farm*, South Tank Farm*
- Incinerator I-1
- Drum Storage Area C-1
- Liquid Waste Burner (LWB)*
- Fill Area*

After approval of the RFI, the former Delphi Thermal Moraine Building 14 and Building 21 were identified for investigation.

2.3.2 Former Moraine Engine and Moraine Assembly AOIs

The following AOIs were reviewed and those AOIs retained for further investigation are highlighted with an asterisk (*):

- AOI 1 - Former Acid-Alkali Tank for #2 and #4 Anozide Systems
- AOI 2 - Former Acid-Alkali Tank for #5 Anozide System
- AOI 3 - Former Acid-Alkali Tank for #6 Anozide System
- AOI 4 - Former Acid-Alkali Tank for Hand Anodize Process
- AOI 5 - Former Acid-Alkali Tank for #4 Pickle Process

- AOI 6 - Former Acid-Alkali Tank for Udylite Etch System
- AOI 7 - Former Oil House Area*
- AOI 8 - Former Acid-Alkali Tanks for Plating/Pickling Processes
- AOI 9 - Former Cyanide Processing Tank
- AOI 10 - Oil Separator Area
- AOI 11 - Former Porcelain Manufacturing Area
- AOI 12 - Former Frigidaire Plant 3 USTs
- AOI 13 - Buildings 4, 6, and 13*
- AOI 14 - Former Hazardous Waste Storage Pad
- AOI 15 - Former Frigidaire Plant 2 Tanks - Three Oil Tanks
- AOI 16 - Former Frigidaire Plant 2 Tanks - Gasoline Tank
- AOI 17 - Building 15*
- AOI 18 - Former Moraine Engine Fuel USTs
- AOI 19 - Chip Salvage Area
- AOI 20 - Moraine Engine Tank Farm
- AOI 21 - High Bay Area Storage Pad
- AOI 22 - Satellite Accumulation Areas

- AOI 23 - Wastewater Collection System
- AOI 24 - Non-Hazardous Waste Storage Pad
- AOI 25 - Former Paint Shop Sludge Pits
- AOI 26 - Moraine Assembly Process Waste Collection Systems
- AOI 27 - Former Hazardous Waste Container Storage Area
- AOI 28 - Moraine Assembly Tank Farm
- AOI 29 - Mix Room Storage Tank
- AOI 30 - Moraine Assembly Flammable Collection/Storage Containment Area
- AOI 31 - Moraine Assembly West Haulaway Storage Tanks
- AOI 32 - Moraine Assembly East Haulaway Storage Tank
- AOI 33 - Moraine Assembly Former Paint Shop Storage Tanks
- AOI 34 - Excavation Area 1*
- AOI 35 - Excavation Area 2*
- AOI 36 - Former Southwest Above Ground Storage Tanks (ASTs)*

After approval of the Supplemental RFI, the Moraine Facilities Box Sewer, the former Moraine Engine Historic Fill Area, and the former Moraine Assembly Process Sump Area were identified for investigation.

2.4 Summary of RFI/Supplemental RFI Activities

The RFI/Supplemental RFI activities included the characterization of soils, groundwater, and ditch sediments at specific SWMUs and AOIs identified at the three facilities. The RFI also included completion of a background soil investigation and development of a groundwater flow model to support the BRA. These RFI activities are discussed in this section. A summary of the SWMUs/AOIs that were investigated during the RFI at all three facilities are presented below, along with an overview of the sampling programs completed during the multi-phased investigations. Supporting information for the RFI/Supplemental RFI is presented in Appendix A.

2.4.1 RFI Background Soil Investigation

A background soil investigation was conducted in 1992 to evaluate potential releases of inorganic hazardous constituents from SWMUs/AOIs. To obtain background soil concentrations, 12 soil borings were drilled to a total depth of 16 feet (ft.) in an area not known to be associated with current or former manufacturing operations or affected by waste management activities at the Delphi Thermal Moraine facility. Both shallow and deep samples were collected from these soil borings. Additional information on the background soil investigation is presented in the *Soil Background Analytical Results Report* (Geraghty & Miller, Inc. 1993b) and the *Delphi Thermal Moraine RFI Report* (ARCADIS Geraghty & Miller, Inc. 2000a).

2.4.2 Groundwater Flow Model

A three-dimensional steady-state groundwater flow model was developed to support the characterization and assessment of hydrogeologic conditions, the RFI investigations, the BRA, the capture zone corrective measures, and the Corrective Action completion strategy. The model construction and calibration was documented in the 1994 *Revised Three-Dimensional Steady-State Flow Model Construction and Calibration Report* (Geraghty & Miller, Inc. 1994b).

2.4.3 RFI Summary

During the Delphi Thermal Moraine RFI, three landfills (Landfills L1, L2, and L3), five underground storage tanks (USTs T4, T5/T6, T11, and T12), the WPSA, the LWB, and the Fill Area were investigated. The two surface impoundments (North and South Settling Lagoons) were further evaluated during the RFI using data previously collected for the RCRA closure program. Additional areas were also investigated during the RFI including surface water/sediment and groundwater quality south of Landfill L1. Locations of the SWMUs and additional areas of investigation are shown on Figure 3. Descriptions of the SWMUs and additional areas investigated during the RFI are excerpted from the RFI Report and presented below. Two rounds of groundwater sampling were also conducted during the Delphi Thermal Moraine RFI. The RFI groundwater, soil, surface water/sediment and waste sampling programs were completed between 1992 and 1994 (Appendix A).

2.4.3.1 Landfills

Three landfills (Landfills L1, L2, and L3) on the former Delphi Thermal Moraine facility were investigated during the RFI; these landfills are pre-RCRA, unlined disposal areas. Landfill L1 is located at the southern end of the facility and covers an area of approximately 7.8 acres (Figure 3); it was used for the collection and disposal of wastes generated by the previous plant operator, Frigidaire, for more than 20 years (i.e., prior to 1950 to approximately 1973). Landfill L2 is located north of former Building 14 and east of the WWTP, and covers an area of approximately 3.7 acres (Figure 3); it was used for the collection and disposal of waste generated by Frigidaire from 1950 to 1975. Landfill L3 is located immediately northeast of the North Settling Lagoon and northwest of Landfill L2, and covers an area of approximately 1.6 acres (Figure 3); it was used for the collection and disposal of sludge from the adjacent North Settling Lagoon System. An estimated 25,000 cubic yards of sludge were placed in Landfill L3 from 1972 to 1979. During the RFI geophysical surveys were conducted at the landfills to delineate the waste boundary. Surficial soil samples were collected for waste characterization and groundwater samples were collected from monitoring wells in the vicinity of the landfills to characterize groundwater quality.

The summary of recent investigations completed within Landfill L1 in 2011 and 2012 and the results from this investigation are provided in Section 2.5.6 and Appendix E.

2.4.3.2 Surface Impoundments

Two surface impoundment SWMUs, the North and South Settling Lagoon systems, were evaluated during the RFI. These SWMUs were subsequently closed as required by the Ohio EPA under RCRA closure. The North Settling Lagoon is located east of Dryden Road, west of the WWTP, north of Building 14, and south of Northlawn Avenue (Figure 3). The North Settling Lagoon covers approximately 4.6 acres. The South Settling Lagoon is located east of Interstate 75, west of Dryden Road, north of Main Street, and south of East River Road (Figure 3). This lagoon covers an estimated area of 7.9 acres. Details of the operating history for these two SWMUs are provided in the DOCC (Geraghty & Miller, Inc. 1991). Sludge and subsoil samples collected in support of RCRA closure were used for the RFI evaluation. Groundwater samples were collected from monitoring wells in the vicinity of the lagoons to characterize groundwater quality.

The North and South Settling Lagoons were closed under Ohio EPA regulations. The approved Post-Closure Plan (Conestoga-Rovers & Associates 2002) includes the post-closure care requirements.

2.4.3.3 Underground Storage Tanks

The 1991 Administrative Order listed 19 USTs to be investigated under the RFI; 15 of the 19 USTs were removed before the RFI. Three of the four remaining USTs (T1 [10,000-gallon tank], T4 [10,000 gallon tank], and T12 [50,000-gallon tank]) were removed during the RFI. UST T11 was used as part of the oily waste collection system associated with the WPSA. USTs T1, T4, and T12 were used to hold a similar waste fluid consisting of wash water or spent detergent solution from a process that used polyester resins or potting compounds. RFI investigative activities were performed at the West Tank Farm, at the South Tank Farm, and at USTs T4, T5/T6, T11, and T12 (Figure 3). Soil samples were collected for release determination and characterization at T4, T5, and T6 and groundwater samples were collected for characterization purposes at the West Tank Farm, South Tank Farm, T11, and T12.

More information regarding UST closure is presented in Section 2.6.2.

2.4.3.4 Waste Pile/Staging Area

The WPSA is located just north of Landfill L1 and east of Building 21 (Figure 3). This SWMU consists of a three-sided sludge bunker (90 ft. by 30 ft. by 5 ft. high), a concrete staging area, and a drainage system associated with this area. The sludge bunker and staging area were originally constructed in 1976 and the entire WPSA covered approximately 2 acres. This SWMU was used to manage grinding sludge from aluminum, steel, and cast iron machinery operations, steel and aluminum turnings, and empty drums. Soil samples were collected for release determination and characterization and groundwater samples were collected for characterization purposes at the WPSA.

The WPSA is further discussed in Sections 2.5.2 and 2.6.5.

2.4.3.5 Liquid Waste Burner

The LWB was in operation from approximately 1957 to 1970 to incinerate spent solvents and oils. The liquids were transferred from on-site locations to the LWB in 55-gallon drums and emptied into two adjacent underground holding tanks for temporary storage. The liquids were then fed to the LWB and incinerated. Surface and subsurface soil samples were collected from the LWB for release determination and characterization.

2.4.3.6 Fill Area

Before the south parking lot was constructed, fill material was used to bring the area up to grade level. The fill material consisted of approximately 75 percent bottom ash (clinkers) from two solid waste incinerators (burned combustible solid waste, such as wood, paper, and cardboard) and approximately 25 percent porcelain sludge from an on-site manufacturing process. Figure 3 shows the location and approximate aerial extent of the fill area (approximately 2.9 acres). Soil samples were collected for waste delineation, release determination and characterization and groundwater samples were collected for characterization purposes at the Fill Area.

2.4.3.7 Additional Areas of Investigation

Soil samples were collected from 12 borings during Phase I in the background area to obtain data concerning background concentrations of metals in soils. Two additional borings were drilled during Phase II of the RFI to collect soil samples for analysis of acetone, which had been detected in the background soil samples collected during Phase I. Surface water/sediment samples were collected to support the risk assessment, to evaluate background conditions for surface water and sediment, and to determine if further sampling was required. The area south of Landfill L1 was investigated to further define the extent of groundwater contamination in that area by collecting groundwater samples from an existing upper aquifer monitoring well, WSU-24, and from a lower aquifer monitoring well, GM-20D, that were installed during Phase II of the RFI. Soil samples were collected during the installation of well GM-20D to determine whether the soil contained hazardous constituents. Figure 3 shows the location of these additional areas of investigation.

2.4.4 Supplemental RFI Summary

During the former Moraine Engine and Moraine Assembly Supplemental RFI, investigations were completed at the following six AOIs: AOI 7 - Former Oil House Area, AOI 13 - Buildings 4, 6, and 13, AOI 17 - Building 15, AOI 34 - Excavation Area 1, AOI 35 - Excavation Area 2, and AOI 36 - Former Southwest ASTs. Locations of the AOIs are shown on Figure 4. Descriptions of the AOIs investigated during the Supplemental RFI are excerpted from the Supplemental RFI Report and are presented below. Groundwater was characterized on a site-wide basis and one round of groundwater sampling was conducted during the former Moraine Engine and Moraine Assembly Supplemental RFI (wells located at former Moraine Engine, Moraine Assembly, and former Delphi Thermal Moraine). Additional groundwater sampling was conducted along with the Former Oil House Area investigation. The Supplemental RFI groundwater and soil sampling programs were completed between 1997 and 1998 (Appendix A).

2.4.4.1 AOI 7 – Former Oil House Area

The former Oil House (Building 7) was located north of the Moraine Engine Plant 3 (former Frigidaire Plant 2), and was built at least as early as 1949 (Figure 4). The former Oil House Area consisted of the Oil House (Building 7) and an outdoor area that contained USTs, ASTs, and a drum storage area. This AOI was removed from service in 1979 when three buildings were demolished and all tanks were removed and either replaced or reused. The Oil House Building 7 and associated outside structures covered a total area of approximately 48,000 square ft.

Virgin paints and chemicals necessary for production at the Frigidaire facilities were stored and mixed in the Oil House, and pumped or transferred to various production areas. Materials were shipped to this area by railroad tank cars and tanker trucks and stored in both drums and tanks. Virgin chemicals including oils, paints, thinners, solvents, acids, toluene diisocyanate, and resins were stored inside the Oil House. Alcohols were reclaimed and solvent blending activities were conducted at the Oil House.

The outdoor area just north of the Oil House had seventeen 8,000 to 15,000-gallon ASTs used to store oil, solvents, acids, and other production materials, and three 15,000-gallon USTs used to store oil. According to the 1976 *Spill Prevention Control and Countermeasure Plan* (General Motors Corporation 1976), these tanks had a gravel floor and concrete containment dikes for spill containment. A drummed waste storage area was also located just north of the Oil House and was used to store drummed waste oils, thinners, alcohols, still bottoms from the Oil House and sludges containing chromium, nickel, and phosphorus.

Additionally, a May 1979 aerial photograph showed an area north of the Oil House was used for temporary storage of equipment, boxes, and drums during the conversion of Frigidaire Plant 2. As stated in the Supplemental DOCC, former GM Corporation announced the shut-down of all Frigidaire operations in January 1979. In 1980 and

1981, the majority of the former Frigidaire Plant 2 was converted to the Moraine Engine facility. A November 1979 aerial photograph showed that Building 7 had been demolished, and did not show evidence of the equipment, boxes, and drums seen in the May 1979 aerial photograph. Copies of both the aerial photographs were included in the October 16, 1998 letter from Delphi Thermal to the U.S. EPA, which was presented in the Supplemental RFI Report.

AOI 7 is currently covered with asphalt. As concluded in the Supplemental DOCC, AOI 7 may be a potentially significant source for soil and groundwater contamination, and further investigation was warranted under the Supplemental RFI. Soil samples were collected for release determination and characterization and groundwater samples were collected for characterization purposes at AOI 7.

2.4.4.2 AOI 13 – Former Buildings 4, 6, and 13

Buildings 4, 6, and 13 of the Frigidaire facilities were located south of the Moraine Engine Plant 3 (Figure 4). Buildings 4 and 6 (also known as Moraine Engine Plant 4) were approximately 300,000 square ft. Buildings 4 and 6 were constructed in 1917 and 1926, respectively, and the buildings had many previous uses including manufacturing of service parts, chemical storage, storage for oil recovery, and offices. Frigidaire discontinued operations in 1979, and by late 1981 these buildings were unoccupied.

In 1983, former GM Corporation removed ten polychlorinated biphenyl (PCB)-contaminated electrical transformers from Buildings 4 and 6 and disposed of them off site at a Toxic Substances Control Act-approved facility. Prior to 1985, former GM Corporation removed asbestos from piping within Buildings 4 and 6 and disposed of this material in an approved off-site facility. In 1990, former GM Corporation conducted a comprehensive study of the wood floor block in these buildings. The results indicated that PCBs were present in the floor block. The wood floor block was removed, the concrete floor beneath the wood floor block was cleaned, and PCB sampling was conducted to confirm removal. Additionally, an area on the south side of Building 4, formerly used for plating, was impacted by metals (primarily cadmium). Decontamination activities began in 1995 and demolition of Buildings 4 and 6 took place in 1996.

Building 13 (also known as Moraine Engine Plant 5) was built in 1916 by the Cleveland and Lake Erie Railroad Company and was used for railroad maintenance. It covered an area of approximately 60,000 square ft. Former GM Corporation acquired the building in 1941, and from 1941 until 1979, the building was used for maintenance purposes and storage. After 1979, part of Building 13 was used as a Hazardous Waste Storage Pad. The concrete storage pad covered an area of 2,400 square ft. and had the capacity to store 250 55-gallon drums. It was used for storage of drummed quantities of waste paint thinner and sludges, chlorinated solvents, and non-hazardous waste oil and process fluids prior to removal from the facility. The former Hazardous Waste Storage Pad was clean closed in 1993, and closure was approved by the Ohio EPA. Cleaning and decontamination activities of the remainder of the building began in 1995, and demolition of Building 13 took place in 1996. During demolition, a portion of a UST was found. The partial tank was approximately 5,000 gallons in volume and was determined to previously have contained fuel oil used for heating purposes. The UST was taken out of service prior to 1970. Soil samples were collected from the cavity wall during demolition activities and the results were below the applicable BUSTR standards. Additional information on BUSTR closure activities is presented in Section 2.6.2.

AOI 13 is currently covered with an asphalt parking lot constructed in 1998. As concluded in the Supplemental DOCC, there was a potential for AOI 13 to have been a potentially significant source for soil and groundwater contamination, and further investigation was warranted under the Supplemental RFI. Soil samples were collected for release determination and characterization purposes.

2.4.4.3 AOI 17 – Former Building 15

AOI 17 includes Building 15 and a former Frigidaire Plant 2 used oil UST (Figure 4). Building 15 covered an area of approximately 17,000 square ft., and based on a review of aerial photographs, it was constructed prior to 1949. The building was used for maintenance purposes and included a truck maintenance repair area, an equipment steam booth area and a maintenance spray booth area located in the center of the building. The 900-gallon steel UST located south of Building 13 and north of Building 15 was used to store used oil from garage operations. It is unknown when this tank began operation. The used oil present in the UST at the time of closure contained VOCs (ethylbenzene, tetrachloroethene [PCE], toluene, and xylenes), but no VOCs were detected in the soil tested during closure activities. The UST was removed and clean closed under the BUSTR in 1994.

AOI 17 is currently covered with an asphalt parking lot constructed in 1998 (Building 15 was demolished and removed as part of the parking lot construction). As concluded in the Supplemental DOCC, there was a potential for AOI 17 to have served as a historical source of CVOCs detected in monitoring well GM-21, and further investigation was warranted under the Supplemental RFI. Soil samples were collected for release determination and characterization purposes.

2.4.4.4 AOI 34 – Excavation Area 1

AOI 34 was located north of the Moraine Engine Plant 3 and west of Springboro Road (Figure 4), and was identified from a 1956 aerial photograph. The excavation area was approximately 300 ft. long by 40 ft. wide, with the southern end containing a depression that was possibly filled with liquid. This area was covered with grass at the time the Supplemental DOCC was completed and during the Supplemental RFI sampling (conducted in August 1997). No information was available regarding the types of materials that may have been handled in this area and their potential for releasing hazardous constituents. As concluded in the Supplemental DOCC, no specific basis existed for further investigation at AOI 34; however, a limited investigation to assess the potential presence of contamination was recommended. AOI 34 is currently covered with an asphalt parking lot constructed in 1998. Soil samples were collected for release determination and characterization purposes.

2.4.4.5 AOI 35 – Excavation Area 2

AOI 35 was located north of the Moraine Assembly Plant 1 and east of Springboro Road (Figure 4), and was identified from a 1956 aerial photograph. The excavation area was approximately 200 ft. long by 150 ft. wide, and was covered by a parking lot at the time the Supplemental DOCC was completed and during the Supplemental RFI sampling (conducted in August 1997). No information was available regarding the types of materials which may have been handled in this area and their potential for releasing hazardous constituents. As concluded in the Supplemental DOCC, no specific basis existed for further investigation at AOI 35; however, a limited investigation to assess the potential presence of contamination was recommended. AOI 35 is currently covered by the parking lot associated with the Moraine Assembly plant. Construction activities began in late 1997 and were completed in 1999. Soil samples were collected for release determination and characterization purposes.

2.4.4.6 AOI 36 – Former Southwest Above Ground Storage Tanks

AOI 36 was located in the southwest corner of the Moraine Engine facility and consisted of four sets of concrete AST saddles (Figure 4). The two southern-most sets of saddles consisted of four larger saddles per tank and were contained in an earthen dike area approximately 50 ft. by 70 ft. The two northern-most sets of saddles consisted of two saddles per tank and were contained in a separate 40 ft. by 55 ft. earthen dike area. These tank saddles and earthen berms were identified during a site walkover in June 1997. A review of aerial photographs indicated that the two southern-most tanks were installed prior to 1949. One tank was installed on the northern-most set of saddles between 1949 and 1956. These three tanks were present in the 1975 aerial photograph, but had been removed prior to the 1990 aerial photograph. There was no evidence that the fourth set of saddles was ever used. Use of these tanks was thought to have ceased prior to the early 1970's; however, the tank saddles and earthen berms were still present during the Supplemental RFI investigation. No information was available regarding the types of materials which may have been handled in this area and their potential for releasing hazardous constituents. AOI 36 is currently covered with an asphalt parking lot constructed in 1998. As concluded in the Supplemental DOCC, no specific basis existed for further investigation at AOI 36; however, given the probable use of the area for storage of liquid materials, a limited investigation to determine if a release had occurred was recommended under the Supplemental RFI. Soil samples were collected for release determination and characterization purposes.

2.4.5 RFI and Supplemental RFI Findings and Facility Risks

Implementation of the RFI and Supplemental RFI accomplished the media-specific objectives listed below.

<u>Soil</u>

1. Determine if a release of hazardous constituents has occurred from the SWMUs/AOIs.

2. Define the nature and extent of any hazardous constituents released from the SWMUs/AOIs required to support the BRA.

<u>Waste</u>

1. Define the areal extent of waste in the landfills.

2. Characterize shallow soil/waste constituents in landfills at the Site for the BRA by sampling and analysis.

3. Characterize deep waste/soil contamination from hazardous constituents at landfills for the BRA by sampling groundwater immediately downgradient from the units.

Sediment/Surface Water

Provide a characterization of on-site sediment/surface water to be used in the BRA.

Groundwater

1. Collect site-wide data to characterize groundwater with respect to flow direction, occurrence, and concentrations of Appendix IX constituents and cis-1,2-DCE.

2. Collect data further downgradient of the Site to characterize groundwater with respect to flow direction, occurrence, and concentrations of Appendix IX VOC constituents and cis-1,2-DCE.

3. Collect data that will support the site-wide BRA.

4. Evaluate site-wide natural attenuation of VOCs (Supplemental RFI).

The sludge present in the closed North and South Settling Lagoons was also evaluated during the RFI. Characterization data collected in support of the preparation of RCRA closure plans for these two SWMUs were utilized in the BRA.

The primary objective of the BRA and Supplemental BRA was to address the following questions.

1. Do constituents in soil/waste at any of the SWMUs at Delphi Thermal Moraine pose an unacceptable risk, which warrants corrective measures?

2. Do constituents in soil at any of the AOIs at Moraine Engine or Moraine Assembly pose an unacceptable risk, which warrants corrective measures?

3. Do constituents in groundwater at any of the SWMUs or AOIs at the three former GM Corporation facilities pose an unacceptable risk, which warrants corrective measures?

Presented below is a discussion of how each of these objectives was achieved during the RFI and conclusions regarding the need for additional investigative activities.

2.4.5.1 Soil

RFI - To accomplish the RFI objectives at the nine SWMUs where soil was considered a medium of potential concern (West Tank Farm, T12, T5/T6, T4, T11, WPSA, South Tank Farm, LWB, and Fill Area), a review of historical data was completed and RFI soil sampling was conducted at Delphi Thermal Moraine. Additionally, an analysis of background soil conditions was completed to provide a basis for evaluating constituent concentrations at SWMUs relative to naturally occurring concentrations of these constituents.

The results obtained from the two rounds of RFI soil sampling at Delphi Thermal Moraine provided the information necessary to complete an evaluation of the presence of any suspected release, as well as sufficient detail on the nature and extent of any release to support an evaluation of risks posed by the SWMUs. Soil analytical results and sampling locations are presented in the RFI Report and Appendix A.

Supplemental RFI - To accomplish the Supplemental RFI objectives at the former Moraine Engine and Moraine Assembly facilities, six AOIs where soil was considered a medium of potential concern (AOIs 7, 13, 17, 34, 35, 36) were investigated, a review of historical data was completed, and RFI soil sampling was conducted. The soil sampling results provided information necessary to complete an evaluation of the presence of any suspected release, as well as sufficient detail on the nature and extent of any release to support an evaluation of risks posed by the AOI in the BRA. Soil analytical results and sampling locations are presented in the Supplemental RFI Report and Appendix A.

2.4.5.2 Waste

RFI - Waste was considered a potential concern at the three inactive landfills at the Delphi Thermal Moraine facility and the sludge present in the North and South Settling Lagoons. To accomplish the RFI objectives at Landfills L1, L2, and L3, a review of historical data was completed, a geophysical survey was completed, where possible, one round of RFI waste sampling was conducted, and two rounds of groundwater sampling were conducted.

The areal extent of the landfills was adequately delineated during the RFI, through a review of aerial photography and topographical and physical land features, and the geophysical assessment completed at L2 and L3. The verified boundaries of the landfills were then used to develop a random shallow sampling grid to provide a representative characterization of waste constituents of potential concern in surface materials at these SWMUs. The deep wastes were also characterized through an evaluation of groundwater quality in monitoring wells located immediately downgradient of the landfills. Waste analytical results and sampling locations, including the closed North and South Settling Lagoons are presented in the RFI Report and Appendix A.

No supplemental characterization of the closed North and South Settling Lagoons was conducted during the RFI. Rather, sludge characterization data collected in support of the preparation of RCRA closure plans for these two SWMUs were sufficient for use in the RFI BRA.

2.4.5.3 Surface Water/Sediment

RFI - Surface water and sediment were considered media of potential concern at Delphi Thermal Moraine due to the presence of the drainage ditch on the north end of the facility. To accomplish the RFI objectives, surface water and sediment samples were collected within the drainage ditch at locations upstream and downstream of the facility.

The results obtained from the RFI sampling provided the information necessary to characterize this media, and no supplemental investigative activity was necessary to support the BRA. Surface water and sediment analytical results and sampling locations are presented in the RFI Report and Appendix A.

A review of the RFI sampling for surface water/sediment indicated that constituents detected in the downstream surface water and sediment samples were at concentrations similar to upstream concentrations. Additionally, an evaluation of topographical and land-use features between the drainage ditch and the SWMUs at the north end of the facility, and a comparison with constituents detected in these SWMUs, indicated that the concentration of constituents detected in the downstream surface water and sediment samples were likely attributable to either natural background or off-site sources. Based on this evaluation, no further action was proposed for surface water/sediment.

2.4.5.4 Groundwater

RFI - To accomplish the RFI objectives for groundwater, two rounds of groundwater sampling were conducted from a well network which consisted of 36 monitoring wells during Phase I and 42 monitoring wells during Phase II at the former Delphi Thermal Moraine facility. Additionally, an analysis of background groundwater conditions was completed to provide a basis for evaluating the presence of both naturally and non-naturally occurring constituents coming onto the Delphi Thermal Moraine facility from upgradient sources.

The investigative strategies for characterizing site-wide groundwater quality included evaluating groundwater results upgradient and downgradient of each SWMU, evaluating groundwater results upgradient and downgradient of the Site, and using the site-specific groundwater flow model to support the BRA by estimating concentrations of constituents which may migrate from the former Delphi Thermal Moraine facility. This level of groundwater data and evaluation provided an understanding of the presence of constituents of potential concern beneath and downgradient of the former Delphi Thermal Moraine. Groundwater analytical results and sampling locations are presented in the RFI Report and Appendix A.

Supplemental RFI - To accomplish the Supplemental RFI objectives for groundwater at the former Moraine Engine and Moraine Assembly facilities, site-wide sampling for VOCs, AOI-specific sampling, and bioattenuation indicator parameter sampling were conducted. In addition, water level measurements were collected and three shallow monitoring wells were installed. The RFI concluded that the groundwater objectives had been met and no additional groundwater investigative activities were required to support development of the BRA. Groundwater analytical results and sampling locations are presented in the Supplemental RFI Report and Appendix A.

2.4.5.5 Baseline Risk Assessment and Supplemental Baseline Risk Assessment Results

RFI - A BRA was completed in support of the RFI Report for the former Delphi Thermal Moraine facility (ENVIRON 2000a) in 1996 and approved by the U.S. EPA in 2000. The purpose of the BRA was to evaluate potential risk to human health and the environment posed by releases of hazardous waste and constituents from the 14 SWMUs investigated during the RFI). The key conclusions of the BRA were (ENVIRON 2000a):

- For all soil- and air-related pathways, potential cumulative cancer risk and noncancer effects were estimated to be well below the levels the U.S. EPA considers protective of human health.

- Under current groundwater use conditions, with or without IMs, potential SWMU-related contributions to groundwater were estimated to result in constituent concentrations at points of groundwater use that are lower than maximum contaminant levels (MCLs) or similar risk-based drinking water concentrations for constituents without MCLs (i.e., equivalent drinking water levels [EDWLs]).

- In addition to the human health evaluation, a screening ecological assessment indicated no adverse impact from the SWMUs and no need for a more detailed ecological assessment.

Supplemental RFI - A Supplemental BRA was completed in support of the Supplemental RFI Report for the former Moraine Engine and Moraine Assembly facilities (ENVIRON 2000b) in 1999 and approved by the U.S. EPA in 2000. This BRA supplemented the original BRA completed in 1996 as part of the RFI at the Delphi Thermal facility, which adjoined the former Moraine Engine and Moraine Assembly facilities. Six AOIs were sampled during the Supplemental RFI. The key conclusions of the Supplemental BRA for these six AOIs were (ENVIRON 2000b):

- Constituents in soil at the former Moraine Engine and Moraine Assembly were determined to not pose an unacceptable risk via direct contact or airborne transport to ambient air. Estimates of potential cumulative cancer risk and noncancer hazard index (HI) for potential exposure to constituents in soil at the AOIs via soil- and air-related pathways, assuming reasonable maximum exposures (RME), were determined to be below levels the U.S. EPA considers protective of human health.

- Constituents in soil/waste at the SWMUs and AOIs were also determined to not pose an unacceptable risk via groundwater transport under the 10 groundwater use scenarios evaluated. In particular, under the groundwater use conditions at the time, with and without taking into account the IMs, potential leaching of constituents from soil/waste to groundwater was not predicted to cause concentrations at points of groundwater use to exceed MCLs or EDWLs for constituents without MCLs.

- No unacceptable human exposure were found to have been occurring, however, constituents in groundwater at AOI 7 were determined to have the potential to migrate to the extent that reasonably expected future uses of groundwater in the lower aquifer might be affected. On this basis, former GM Corporation implemented an IM to address contamination at AOI 7.

2.5 Summary of Additional Site Investigations, Findings, and Facility Risks

Several investigations have been completed since the activities associated with the RFI and Supplemental RFI. This section outlines these investigations, findings, and updated facility risks.

2.5.1 Box Sewer

Frigidaire, previously owned by former GM Corporation, conducted operations at the former Moraine Facilities until 1979. The Box Sewer was used by Frigidaire to convey process water before former GM Corporation converted Plants 2 and 3 into the Moraine Engine and Moraine Assembly facilities in 1979 to 1980. Prior to and as part of the conversion, all process waste connections to the Box Sewer were terminated. Subsequently, only storm water runoff from paved areas and roof drains and non-contact cooling water entered the sewer. Flow exiting the Box Sewer entered a 54-inch diameter storm sewer that flowed west to a storm water retention basin at the former Delphi Thermal Moraine facility, which was part of the Storm Water Management System for the Site. The Box Sewer runs parallel to the east wall of the former Plants 2 and 3 and is approximately 2,300 linear ft. in length, 9 ft. in width, and 10 ft. high (Figure 4). The top of the Box Sewer is at grade and the bottom of the Box Sewer is 10 ft. below grade. The Moraine Engine plant ceased operations in the fall of 2000. Plant decommissioning and demolition was completed in early summer of 2001.

In December 2000 and February 2001, prior to sediment removal, the sediment in the Box Sewer was assessed as part of the site decommissioning activities performed by former GM Corporation. The Box Sewer was sectioned into 27 quadrants and a sediment sample was collected from each quadrant. Sediment samples were analyzed for Toxicity Characteristic Leaching Procedure VOCs and PCBs in order to characterize the sediment for disposal purposes. Former GM Corporation conducted the Box Sewer cleaning between June and July 2001. The average depth of sediment in the Box Sewer prior to cleaning was 2 ft. Sediments were removed from the Box Sewer and placed in lined roll-off containers for proper off-site management and disposal. After cleaning, the Box Sewer was inspected on August 9, 2001. As a result of the inspection, several areas were identified as potential locations where historic releases from the Box Sewer may have occurred. Soil samples were collected for release determination and characterization purposes.

The Box Sewer investigation activities were conducted in November 2001 (ARCADIS, Inc. 2002a). The specific objectives of the investigation were to:

- Determine if a significant release of hazardous constituents to soils in the immediate vicinity of the box sewer had occurred.

- Evaluate the nature and extent of any release identified to support an evaluation of potential risks to current and reasonably expected future receptors using the procedures detailed in the Supplemental BRA (ENVIRON 2000b).

The risk-based assessment of the Box Sewer investigation data indicated that the presence of hazardous constituents in soils do not present a significant risk via the pathways identified under current and reasonably expected future land and groundwater use scenarios. As a result, former GM Corporation proposed no further action for the Box Sewer (ARCADIS, Inc. 2002a).

The *Box Sewer Investigation Summary Report* is included in Appendix B, Attachment B-1.

2.5.2 Waste Pile/Staging Area

As discussed in Section 2.4.3.4, the WPSA was investigated as a SWMU during the former Delphi Thermal Moraine RFI. The RFI objective for this unit was release determination and characterization, and groundwater quality characterization. A total of seven borings were installed in 1992 and 1994 to collect subsurface soil samples. Samples were collected and analyzed for Target Compound List (TCL) VOCs, TCL SVOCs, PCBs, pesticides/herbicides, and Target Analyte List metals. Results are presented and discussed in the Delphi Thermal Moraine RFI Report (ARCADIS Geraghty & Miller, Inc. 2000a). The RFI Report concluded that the investigation activities conducted at the WPSA provided sufficient detail to meet the RFI objectives and provide adequate characterization to support the BRA. Based on the data collected during the RFI, it was concluded in the BRA that no further action was warranted for soil at the WPSA (ENVIRON 2000a), although it was identified as a potential source of metals to groundwater (ENVIRON 2000b) and additional evaluation was warranted, as discussed below.

To address the U.S. EPA comments on the Supplemental RFI dated April 2000 (ARCADIS Geraghty & Miller, Inc. 2000b) and the draft Site-Wide Groundwater Monitoring Plan dated March 2000, and to allow continued use of the unit after 1994 until it was taken out of service in 2003, former GM Corporation agreed to conduct additional investigations at the WPSA. Former GM Corporation submitted a work plan for this additional investigation dated November 30, 2000 (ARCADIS Geraghty & Miller, Inc. 2000c). The U.S. EPA approved this work plan in correspondence dated January 3, 2001, and the additional soil and groundwater investigation was conducted in April 2001. The evaluation of soil was completed through the installation of 13 soil borings. The evaluation of groundwater was completed through the installation of six new monitoring wells upgradient and downgradient of the WPSA, screened in the upper or lower portions of the upper aquifer, and the collection of groundwater samples from 12 temporary well points from the borings installed within the WPSA. The April 2001 investigation was summarized and presented to the U.S. EPA in the *Waste Pile/Staging Area Investigation Interim Report* (ARCADIS, Inc. 2002c). As presented in this report, it was concluded that additional characterization of constituents in soil was needed along the western, southern, and eastern portions of the WPSA. The report also concluded that an additional groundwater sampling event was needed to further characterize the nature and extent of constituents detected in the April 2001 investigation.

The additional recommended characterization was completed in 2002 and 2003 through the installation of 14 soil borings in August 2002, November 2002, and March 2003. Soil samples from these borings were collected from targeted depths and analyzed for targeted constituents. Re-sampling of groundwater from monitoring wells GM-33 through GM-38 was also completed in August 2002. Based on former GM Corporation's review and evaluation of the soil sampling conducted in August 2002, November 2002, and March 2003, and the groundwater sampling conducted in August 2002, an additional investigation of the WPSA to complete the characterization necessary to evaluate the nature and extent of constituents in soil (correspondence from former GM Corporation to the U.S. EPA, dated October 3, 2003) was proposed. These data were needed to support an evaluation of risk under current and reasonably expected future conditions, and to support an evaluation of interim or corrective measures alternatives for this SWMU. In October 2003, three additional borings were installed and soil samples collected for targeted constituents.

Additional investigation of conditions at the WPSA was conducted to address the U.S. EPA comments on the Supplemental RFI (ARCADIS Geraghty & Miller, Inc. 2000b) and the draft Site-Wide Groundwater Monitoring Plan (ARCADIS, Inc. 2002b), and to address continued use of the WPSA after completion of the RFI. The specific objectives of the WPSA investigation for soil and groundwater were:

- Determine if a release of hazardous constituents to soils had occurred from the WPSA since the RFI was completed and, if so, evaluate the nature and extent of the release(s) to support an evaluation of the potential risks using procedures detailed in the Supplemental RFI BRA (ENVIRON 2000b).

- Collect groundwater quality data upgradient and downgradient of the WPSA to characterize groundwater with respect to flow direction and quality to support an evaluation of potential risks using the procedures detailed in the Supplemental RFI BRA (ENVIRON 2000b).

The risk-based assessment of the WPSA investigation data determined that the presence of hazardous constituents in soils may pose a potentially significant risk via the certain conditions (ARCADIS, Inc. 2004a):

- No significant current human exposure to constituents in soil at the WPSA was identified as the WPSA was inactive at the time.

- Potentially significant human exposure via direct contact with constituents in soil at some parts of the WPSA may occur in the future if pavement were to be removed and the area were to be redeveloped for commercial/industrial use.

- With the removal of oil-impacted soil and soil identified as containing significant constituent concentrations, soil at the WPSA would not be expected to pose a significant risk via direct contact if the area were to be redeveloped for commercial/industrial use.

- Constituents in the WPSA did not appear to have significantly affected groundwater underlying the WPSA. With the removal of soil to address potential future worker exposure risks via soil direct contact, constituents in soil remaining at the WPSA were not expected to significantly affect future groundwater quality. Existing impacts to groundwater observed at the WPSA, attributable to other sources at the Site (e.g., former Oil House Area), were being addressed as part of site-wide corrective action.

The *Waste Pile/Staging Area Investigation Summary Report* is included in Appendix B, Attachment B-2.

Based on these findings, former GM Corporation performed a limited soil removal at the WPSA between September 26 and October 4, 2005 (further discussed in Section 2.6.5) and the key conclusions presented in the *WPSA Interim Measures Report* (ARCADIS, Inc. 2006) were as follows:

- Soil excavation has resulted in post-IM routine worker and maintenance worker risks that meet the U.S. EPA's acceptable risk levels.

- Nonetheless, the existing pavement that covers the WPSA was to be maintained by former GM Corporation and institutional controls put in place such that any subsurface activities would be governed by the Site's health and safety requirements, which provide for worker protection during such activities.

2.5.3 Former Building 14

The former Delphi Thermal Moraine conducted their main manufacturing activities in the former Building 14, which was constructed in stages starting with the first structure in 1941 and the last addition completed in 1976 resulting in a total floor space of approximately two million square ft. The former Delphi Thermal Moraine's major operations, which began in 1941, included the machining and assembly of automotive air conditioning compressors, accumulator dehydrators, and miscellaneous air conditioning valves. Operations at the former Delphi Thermal Moraine Building 14 ceased in September 2003 and the building was decommissioned. Demolition of Building 14 was completed in 2005.

As proposed in former GM Corporation's July 14, 2004 submittal to the U.S. EPA, a supplemental soil and groundwater investigation was conducted at the former Delphi Thermal Moraine Building 14 (former Building 14) in August 2004. The investigation results were presented in the *Former Building 14 Investigation Summary Report* (ARCADIS, Inc. 2005a).

As part of the Building 14 demolition, former GM Corporation implemented an investigation of conditions beneath the Building 14 area in August 2004. Soil and groundwater data collected as part of this investigation were assessed in comparison with risk-based screening values. Based on the risk-based data screening, no soil or groundwater concentrations were identified which would present a significant risk to the receptors and pathways identified under current and reasonably expected future land and groundwater use scenarios (ARCADIS, Inc. 2005a).

The *Former Building 14 Investigation Summary Report* is included in Appendix B, Attachment B-3.

2.5.4 Supplemental Groundwater Investigation

Based on the results of the site-wide groundwater monitoring program, former GM Corporation proposed to collect supplemental groundwater data to provide additional information for evaluating the performance and refinement of the ongoing corrective measures.

The scope of these supplemental field data collection activities were presented in several work plans that were submitted to the U.S. EPA between 2005 and 2008 (BOW 2005b, 2006a, 2006b. 2007a, 2007b, 2007c, 2007d, and 2008a). A summary of the supplemental investigations completed in 2006 has been presented in the *Corrective Measures Supplemental Groundwater Investigation Report* (ARCADIS, Inc. 2007).

A total of 46 borings and 47 monitoring wells were installed on- and off-site between 2005 and 2008. During installation of the borings associated with this investigation, vertical aquifer profile groundwater samples were collected approximately every 10 to 15 ft. within the upper aquifer and in some cases extending to the lower aquifer. Analytical data for all the supplemental investigation work are presented in Appendix C. The boring and well construction logs for all of the borings/wells completed as part of the supplemental investigation are included in Appendix C.

As part of the supplemental groundwater investigation, a detailed water level study was completed for pumping well DN-13 in March and April 2007. Pressure transducer data were obtained in upper and lower aquifers in the area of lower aquifer pumping well DN-13 for refinement of the understanding of groundwater flow downgradient of the Site and documentation of responses to specific stresses on the two aquifers. The results and findings from this study are presented in Appendix C.

Following completion of the supplemental groundwater investigation conducted in 2006, 2007, and early 2008, the data were evaluated using risk-based data screening criteria to assess the potential significance of concentrations detected in the new monitoring wells. Former GM Corporation submitted the results of this assessment with the supplemental risk assessment in Appendix G to the 2008 CMP (ENVIRON 2008).

2.5.5 Summary of Vapor Intrusion Assessment Activities

In a February 11, 2010 meeting between the U.S. EPA and MLC, a field investigation was proposed to provide site-specific data to evaluate the vapor intrusion pathway in the Riverview Plat neighborhood, located to the southwest of the Site, and the eastern Site boundary. The general objectives of the vapor intrusion assessment activities at the Site were as follows:

- Determine if the presence of VOC-containing soil-gas in the Riverview Plat neighborhood and along the eastern boundary of the Site is considered a potential pathway for vapor intrusion.

- Determine the source of VOC-containing soil-gas in the Riverview Plat neighborhood, and determine if Landfill L1 and the closed South Settling Lagoon are a contributing source of site-specific VOCs in soil-gas.

- Complete sub-slab and indoor air sampling to determine if the vapor intrusion pathway is complete at the properties in the Riverview Plat neighborhood.

- Engage the local community to provide updates on the status of the vapor intrusion assessment activities and to provide an opportunity for the local residents to express concerns.

The following is a summary of the vapor intrusion assessment activities completed between February 2010 and December 2012. A detailed *Summary of Vapor Intrusion Assessment and Mitigation Activities* is included in Appendix D.

As outlined in the revised *Vapor Intrusion Verification Work Plan* (ARCADIS, Inc. 2010b) dated September 16, 2010 and approved by the U.S. EPA on September 29, 2010, an investigation was completed in October and November 2010 and March 2011 to evaluate the potential for a complete vapor intrusion pathway in the Riverview Plat neighborhood and along the eastern boundary of the Site. Groundwater and soil-gas data were used as part of the overall weight of evidence for evaluating the vapor intrusion pathway. Based on the results of the Vapor Intrusion Verification Investigation, the following conclusions were made:

- PCE and trichloroethene (TCE) were the primary chemicals of concern identified in soil-gas.

- Concentrations of PCE and TCE in soil-gas increased with depth which indicated that groundwater was the primary source of the PCE and TCE detected in soil-gas.

- Based on the concentrations of PCE and TCE in soil-gas, indoor air and sub-slab sampling at properties in the Riverview Plat neighborhood was completed.

- Based on the lack of a site-specific VOC source in soil or groundwater and confirmation that VOCs were not detected above the May 2012 U.S. EPA Regional Screening Levels (RSLs) for soil-gas (Action Levels) in the samples collected, a future phase of investigation to the east of the Site was not warranted.

As outlined in the *Vapor Intrusion Verification Work Plan Addendum* (RACER Trust 2011a) dated November 14, 2011 and approved by the U.S. EPA on January 10, 2012, a field investigation was completed from January 30, 2012 to February 6, 2012 to further evaluate the potential for a complete vapor intrusion pathway along the southern and eastern perimeter of the closed South Settling Lagoon. Soil-gas and groundwater table samples were collected in association with this investigation.

The groundwater table and soil-gas sampling results indicated that groundwater is the most significant contributor of site-specific VOCs, primarily of PCE and TCE, to soil-gas along the perimeter of the closed South Settling Lagoon. Soil-gas concentrations correlated with groundwater data results and increased in concentration with depth. Concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) and 1,1,1-trichloroethane (1,1,1-TCA) were not detected in groundwater but were detected in low concentrations in soil-gas. The BTEX and 1,1,1-TCA concentrations in soil-gas were several orders of magnitude below their respective May 2012 U.S. EPA RSLs for soil-gas (Action Levels). Based on the review of the soil-gas data, these compounds were not risk-based drivers. Further investigation as to the source of these low concentrations was not warranted.

As outlined in the *Landfill L1 Investigation Work Plan* dated October 27, 2011 (ARCADIS, Inc. 2011a) (approved by the U.S. EPA with conditions on November 1, 2011) and the Landfill L1 Work Plan Addendums dated November 29, 2011 (RACER Trust 2011b) and July 17, 2012 (RACER Trust 2012a) (approved by the U.S. EPA on July 18, 2012), a field investigation was completed at Landfill L1 from November through December 2011, September 2012, and December 2012. The specific objectives of the investigation were to: 1) determine the site-specific VOC concentrations of soil-gas along the western, eastern, and southern boundaries and within the landfill; 2) determine if the landfill is a potential contributing source for site-specific VOCs in the soil-gas beneath the Riverview Plat neighborhood and the City of Moraine Municipal Building property; 3) characterize the waste within the landfill; 4) determine the relative contribution of waste containing site-specific VOCs to groundwater; 5) confirm the vertical and horizontal extent of the waste; 6) determine the influence the soil-gas present within the landfill has on the ambient air; and 7) assess the potential for site-specific VOC-containing soil-gas to migrate laterally from the landfill and collect within the storm sewer dry wells.

During the investigation, waste, soil, groundwater, soil-gas, ambient air, and storm sewer dry well air samples were collected. The following is a summary of the vapor intrusion related conclusions of the Landfill L1 Investigation:

- The soil-gas VOC concentrations along the western, eastern, and southern boundaries of the landfill were determined. Based on the results of the waste samples, the soil-gas samples, and the groundwater samples, the primary source of VOCs in landfill soil-gas appears to be the waste within the landfill. Since the soil-gas concentrations in the landfill are associated with the waste and not groundwater, off-site vapor intrusion issues associated with landfill soil-gas are not anticipated to be an issue.

- Methane was detected in landfill soil-gas at concentrations exceeding 5% (100% of the lower explosive limit). The methane concentrations detected in the landfill soil-gas are not uncommon in landfill settings. To determine if methane was migrating off-site, the dry wells near the western and southern landfill perimeter and the soil-gas points on the eastern portion of the Riverview Plat neighborhood were sampled for methane. Based on the results of the methane sampling activities, soil-gas containing methane is not migrating to the Riverview Plat neighborhood or the nearby storm sewer dry wells.

- Current dissolved methane groundwater concentrations in the landfill are comparable to the dissolved methane concentrations detected prior to initiation of IMs. The dissolved methane concentrations at the landfill may be contributing to the methane concentrations detected in landfill soil-gas. However, as indicated above, soil-gas containing methane is not migrating to the Riverview Plat neighborhood or the nearby storm sewer dry wells.

- Based on a comparison of the chemical signatures of the soil-gas samples from the landfill, the Riverview Plat neighborhood, and the City of Moraine Municipal Building property to the south of the landfill, the landfill is not a significant contributing source of site-specific VOCs to the soil-gas beneath the Riverview Plat neighborhood to the west or the City of Moraine Municipal Building property to the south.

- Based on a comparison of the chemical distribution profiles of the soil-gas samples from the landfill to the ambient air samples collected along the western perimeter of the landfill and the dry well samples collected to the west of the landfill, the impact that the landfill soil-gas has on ambient air and the dry wells, if any, is not significant.

Based on the results of the Vapor Intrusion Verification Investigation and in a letter dated December 3, 2010, the U.S. EPA requested that a Sub-Slab and Indoor Air Sampling Work Plan be prepared. Therefore, the *Sub-Slab and Indoor Air Sampling Work Plan* (ARCADIS, Inc. 2011b) was prepared, and the U.S. EPA conditionally approved the Work Plan on February 8, 2011. The *Sub-Slab and Indoor Air Sampling Work Plan* was revised per the U.S. EPA's conditional approval and finalized on March 4, 2011. Sub-Slab and Indoor Air Sampling Work Plan Addendums, dated February 27, 2012 (RACER Trust 2012b) and March 19, 2012 (RACER Trust 2012c), were prepared and approved by the U.S. EPA on March 2, 2012 and June 1, 2012, respectively. Per the Work Plan and Work Plan Addendums, a Sub-Slab and Indoor Air Investigation was initiated in March 2011 to evaluate whether the vapor intrusion pathway was complete in the residential and commercial structures in the Riverview Plat neighborhood and at the City of Moraine Municipal Building.

Concentrations of PCE, TCE, and/or 1,1-DCA were detected in the sub-slab and indoor air samples collected from the properties in the Riverview Plat neighborhood at concentrations that were greater than or equal to the Action Levels. Therefore, vapor intrusion mitigation was recommended for applicable properties. Details pertaining to the vapor intrusion mitigation activities are included in Section 2.6.7 and in Appendix D.

The following is a summary of the general conclusions of the vapor intrusion assessment activities completed to date at the Site:

- Based on the results of the Vapor Intrusion Verification Investigation, the closed South Settling Lagoon Vapor Intrusion Investigation, and the Landfill L1 Investigation, the primary source of VOC-containing soil-gas in the Riverview Plat neighborhood is PCE and TCE in groundwater. The results of the Vapor Intrusion

Verification Investigation indicated that concentrations of site-specific VOCs in soil-gas within the Riverview Plat neighborhood increase with depth. This attenuation confirms that the source of site-specific VOCs in soil-gas is attributable to concentrations of site-specific VOCs in groundwater. Additionally, the results of the Vapor Intrusion Verification Investigation indicated that there is not a vapor intrusion exposure risk along the eastern boundary of the Site.

- The closed South Settling Lagoon and Landfill L1 are not contributing significant sources of site-specific VOCs to soil-gas within the Riverview Plat neighborhood.
- Sub-slab and indoor air sampling activities have been completed at the properties within the Riverview Plat neighborhood, where access has been provided. Based on the results of these activities, concentrations of site-specific VOCs, specifically PCE and TCE, exceeded the sub-slab and indoor air Action Levels within most of the sampled properties.
- Vapor intrusion mitigation systems were recommended for most of the sampled properties within the Riverview Plat neighborhood.
- Sub-slab and indoor air sampling activities and community outreach efforts are on-going.

2.5.6 Summary of Landfill L1 Investigation

The Landfill L1 Investigation was completed in accordance with the *Landfill L1 Investigation Work Plan* dated October 27, 2011 (ARCADIS, Inc. 2011a). The Work Plan was approved by the U.S. EPA with conditions on November 1, 2011. Landfill L1 Investigation Work Plan Addendums were submitted to the U.S. EPA on November 29, 2011 (RACER Trust 2011b) and July 17, 2012 (RACER Trust 2012a). The Landfill L1 Investigation Summary Report is presented in Appendix E.

The specific objectives of the investigation were to: 1) determine the VOC concentrations of soil-gas along the western, eastern, and southern boundaries and within the landfill; 2) determine if the landfill is a potential contributing source for VOCs in the soil-gas beneath the Riverview Plat neighborhood, located to the west of the landfill, and the City of Moraine Municipal Building property, located to the south of the landfill (previously discussed in Section 2.5.5); 3) characterize the waste within the landfill; 4) determine the relative contribution of waste containing site-specific VOCs to groundwater; and 5) confirm the vertical and horizontal extent of the waste.

The first phase of the field investigation was completed between November 14, 2011 and December 22, 2011. Due to the inability to penetrate relatively hard landfill material, the direct push drilling methodology was limited in the ability to define the vertical extent of the waste. Desired depths were not reached at all locations, and native soil was not encountered at several soil boring locations. Therefore, based on the evaluation of landfill materials from the initial drilling activities and as discussed with the U.S. EPA during a February 1, 2012 meeting, the Landfill L1 Work Plan Addendum, dated July 17, 2012, was prepared to advance two additional borings using sonic drilling methods.

The objectives of field work outlined in the Landfill L1 Work Plan Addendum were to: 1) further refine the vertical extent of the waste; 2) further characterize the waste and underlying native soil for site-specific VOCs; 3) determine the leaching potential of the waste to groundwater; 4) determine the influence the soil-gas present within the landfill has on the ambient air; and 5) assess the potential for VOC-containing soil-gas to migrate laterally from the landfill and collect within the storm sewer dry wells. The field work associated with the Landfill L1 Work Plan Addendum was completed from September 19 to 20, 2012.

The Landfill L1 Investigation findings have been used to refine the conceptual site model and the corrective measures evaluation presented in Sections 2.7 and 4.4, respectively. A summary of the conclusions of the investigation is presented below and a separate assessment of risk for Landfill L1 is presented in Appendix G. The summary of the vapor intrusion related conclusions of the Landfill L1 Investigation was presented in Section 2.5.5 and is not repeated in this subsection.

- The waste within the landfill was characterized. The maximum total CVOC concentration was detected in the waste sample from the 32 to 36-ft. interval of boring LF-21, located in the central portion of the landfill. The maximum total BTEX concentration was detected in the waste sample from the 28 to 32-ft. interval of boring LF-12A, located in the central portion of the landfill.

- Leaching potential calculations were completed and provided rationale as to why the concentrations of the site-specific VOCs are low in the monitoring wells downgradient of Landfill L1 when they are higher in some of the waste or soil samples from within the landfill. Advective flow is hindered by the low-permeability clay and sludge within the landfill. Transport is limited to vapor diffusion, which is too slow to leach BTEX constituents before they can degrade. The CVOCs will take so long to reach the saturated zone that it will take centuries to reach 1.0 micrograms per liter (µg/L) in groundwater given dilution, even if the CVOCs could leach through the low-permeability layer in the upper saturated zone. Detectable VOCs in monitoring wells downgradient of the landfill are more likely to originate from sources upgradient of the landfill.

- The horizontal extent of waste within the landfill was generally delineated; however, due to limitations associated with working outside the landfill perimeter (e.g., property fence and utilities outside the fence), it appears the landfill extends past the fence-line at some locations.

- The full vertical extent of the waste was delineated at several locations; however, the vertical extent of the waste was not delineated at every boring location due to the limitations with the direct push drilling methodology (i.e., refusal) during the first phase of the field investigation. During the second phase of the field investigation, borings were completed using sonic methods and the full vertical extent of the waste at the central portion of the landfill was confirmed.

2.5.7 Summary of Pre-Design Investigation

As discussed during meetings between the U.S. EPA and RACER Trust between 2010 and 2012, a series of focused pre-design investigations were conducted prior to full-scale implementation of the final proposed remedy. The work was completed at three main investigation areas including the Secondary Source Areas (Box Sewer, Historic Fill Area, West Tank Farm, and former Building 21 Area), upgradient Northern Perimeter, and the Process Sump Area from late June to late September 2012 (Figure 2 in Appendix F). Field work associated with the pre-design investigation was completed in accordance with *Pre-Design Investigation Work Plan* (PDI Work Plan) dated April 26, 2012 (ARCADIS, Inc. 2012a) and subsequent *Pre-Design Investigation Work Plan Addendum* (PDI Work Plan Addendum) dated August 22, 2012 (RACER Trust 2012d). The PDI Work Plan and PDI Work Plan Addendum were approved by the U.S. EPA on June 1, 2012 and August 31, 2012, respectively. The *Pre-Design Investigation Summary Report* is included in Appendix F.

The Pre-Design Investigation was completed to meet the following technical approaches and objectives in support of the final remedy:

- A focused soil and groundwater investigation was conducted at the Box Sewer, Historic Fill Area, West Tank Farm, and the former Building 21 Area secondary source areas to determine if the areas are contributing to groundwater contamination in the upper aquifer. In addition, a focused and limited groundwater chemistry and hydrogeology investigation was completed in the lower aquifer at the West Tank Farm and the former Building 21 investigation areas to assess the presence or absence of till unit(s) and determine the nature and extent of contamination in the lower aquifer.

- Groundwater quality and plume boundaries have been extensively studied; however, the upgradient off-site plume located to the north of the Site had not been fully delineated. Upgradient northern perimeter boundary borings were completed to provide further understanding of the geometry (horizontal/vertical) of the upgradient off-site plume near wells HR-9/HR-10.

- A focused soil and groundwater investigation was conducted at the Process Sump Area (AOI 26) to determine the nature and extent of contamination in both the upper and lower aquifers, confirm the presence or absence of till unit(s), and refine the dimensions of the process sump treatment area.

A summary of the conclusions of each investigation is presented below and a separate assessment of risk for the secondary source areas and the Process Sump Area are presented in Appendix G. The pre-design investigation findings have been used to refine the conceptual site model and the corrective measures evaluation presented in Sections 2.7 and 4, respectively.

2.5.7.1 Upgradient Northern Perimeter

The groundwater chemistry and lithology at the upgradient Northern Perimeter were further delineated to provide a better understanding of the upgradient off-site groundwater concentrations. The presence and/or absence of the regional clay till unit was confirmed and a lower aquifer monitoring well (RMW-88) was installed to replace monitoring well HR-10 (Figure 2). Groundwater concentrations in the upper aquifer were below U.S. EPA MCLs and in the lower aquifer were above MCLs (NP-1 for vinyl chloride and NP-2 for cis-1,2-DCE and vinyl chloride). Groundwater concentrations at RMW-88 were below MCLs (Figure 7 in Appendix F).

2.5.7.2 Secondary Source Areas

Focused soil and groundwater investigations were conducted at the Box Sewer, Historic Fill Area, West Tank Farm, and the former Building 21 Area to determine if these areas are contributing to groundwater contamination in the upper aquifer and, in some cases, the lower aquifer.

- The soil concentrations at the Box Sewer, as compared to the previous investigation, are significantly lower. The groundwater profiling data at the Box Sewer indicated that concentrations increased with depth (e.g., BOX-1). The presence of PCE and TCE at elevated concentrations in the deeper portion of the upper aquifer is likely due to the presence of historic releases from the former Oil House Area and the presence of source material near the Process Sump Area.

- Soil at the Historic Fill Area had not been previously characterized. Very little fill material was observed during drilling at the Historic Fill Area and the soil concentrations do not indicate the presence of source material. The groundwater profiling data are consistent with concentrations downgradient of historic releases from the former Oil House Area.

- The soil concentrations at the West Tank Farm, as compared to the previous investigations, are significantly lower. The groundwater profiling data at the West Tank Farm indicated that concentrations are similar with depth. The groundwater data are consistent with previous groundwater concentrations observed in this area and with the current understanding of plume migration.

- Soil at the former Building 21 Area had not been previously characterized and the soil concentrations do not indicate the presence of source material. The groundwater profiling data are consistent with previous groundwater concentrations observed in this area and with the current understanding of plume migration.

- In addition, a focused and limited groundwater chemistry and hydrogeology investigation was completed in the lower aquifer at the West Tank Farm and the former Building 21 Area. The presence of the regional clay till unit was confirmed at these locations and the nature and extent of contamination in the lower aquifer was determined. At both locations, a lower aquifer monitoring well was installed to help refine plume dimensions within the lower aquifer.

2.5.7.3 Process Sump Area

A focused soil and groundwater investigation was conducted at the Process Sump Area to determine if this area is contributing to groundwater contamination in the upper aquifer and lower aquifer (Figure 8 in Appendix F).

- Shallow soil concentrations in the vadose zone at the Process Sump Area investigation did not indicate the presence of source material; however, deeper soil concentrations just above the water table (e.g., PSA-8 [32-34 ft.]) and saturated soil concentrations (e.g., samples collected between 50 and 68 ft. below land surface [bls]) do indicate the presence of source material. The soil concentrations just above the water table (e.g., PSA-8 [32-34 ft.]) have detections of PCE and TCE only (Tables 7 and 8 and Figure 8 in Appendix F). The groundwater concentrations just below the water table (e.g. PSA-8 [31-36 ft.]) have detections of only PCE and TCE (Table 9 and Figure 8 in Appendix F). The lack of source material in the vadose zone above indicates that the source for the unsaturated material above the water table (e.g., capillary fringe) may be due to groundwater by mechanism of soil sorption by water table fluctuation and/or soil-gas (U.S. EPA 2005).

- Groundwater in both the upper and lower aquifers was characterized and determined to be impacted primarily with PCE and TCE. The most significant impacts occurred in the upper aquifer between the deepest clay till unit and the regional clay till unit indicating the source is likely not from the Process Sump Area. The groundwater impacts at the Process Sump Area may be related to other areas of concern (e.g., former Oil House Area).

- Dense non-aqueous phase liquid (DNAPL) globules were visible and the hydrophobic dye test was positive for soil boring PSA-6 (58-60 ft. bls). This confirmed that residual DNAPL is present in the interbedded units at this location of the upper aquifer at the Process Sump Area.

- The geometry of clay till units was characterized in detail (Figures 10 through 13 in Appendix F). Interbedded areas of the upper aquifer is layered into several saturated deposits of low permeability (fine sands and silts) interbedded with dry clay-rich till with varying thicknesses at the Process Sump Area with thickening of the clay till units to the east (e.g., soil borings PSA-1 and PSA-10). At soil boring PSA-3 there is a 21 ft. thick gravel deposit from 35 to 56 ft. bls indicating channelization of the interbedded units (eroded by glacial melt waters) in some areas. PSA-5 also has a gravel deposit from 35 to 45 ft. bls. A similar sand and gravel deposit was observed in the same vicinity at GM-75S.

2.6 Summary of Interim Measures

2.6.1 Lagoon Closures

As indicated in Section 2.2, the former Delphi Thermal Moraine contains North and South Settling Lagoons (Figure 1). Former Delphi Thermal Moraine submitted closure plans for the North and South Settling Lagoons to the U.S. EPA and the Ohio EPA in November 1985 and November 1989. Closure discussions between former GM Corporation and the Ohio EPA were deferred by mutual agreement to coordinate ultimate closure requirements with the corrective action requirements from the U.S. EPA Region V (the North and South Settling Lagoons were evaluated as SWMUs in the RFI at Delphi Thermal Moraine). During the summer of 1999, former GM Corporation met with the Ohio EPA to present and discuss a revised approach for closure of the lagoons. This approach was presented to the Ohio EPA in the Closure Plan, dated June 2000 (Conestoga-Rovers & Associates 2000), and approved by the Ohio EPA in a letter to former GM Corporation dated August 24, 2000. Closure activities were initiated in September 2000 and completed in June 2001.

Closure activities included site preparation, waste solidification, backfilling, and cover installation. During the initial phase of closure activities, site preparation, including mobilization and logistics (access and security) were completed. Preparation also included removal, demolition, and/or abandonment of certain subsurface structures and removing existing vegetation.

The waste solidification activities of the lagoon closure were completed by the in situ physical mixing of the waste, soil, and reagents. Solidification was conducted in place by placing the soil on the sludge surface and the pozzolanic material in trenches excavated into the sludge, and mixing with a track hoe. Sludge solidification was conducted to achieve a minimum physical strength criterion of as outlined in the approved Closure Plan. After solidification, representative samples of the sludge were sampled and tested to verify that the minimum unconfined compressive strength was achieved.

Following solidification of the waste, the lagoons were backfilled with soil material from existing on-property soil stockpiles. As outlined in the approved Closure Plan, a minimum of 10 ft. of soil barrier was placed between the solidified sludge and the cover. To facilitate future use of the North Settling Lagoon as a new vehicle and employee parking lot, a 10-ft. buffer of additional crushed limestone was installed above the subgrade to provide additional bearing. As part of the backfilling procedures, a surface water drainage system was installed in each of the lagoons. Surface water is collected in a network of swales, catch basins, and underground pipes. Collected storm water is discharged to the existing underground 84-inch diameter storm sewer present along the north perimeter of the South Settling Lagoon. Storm water drainage from the North Settling Lagoon is collected in a network of catch basins and underground pipes, and is discharged to the stormwater retention basins located adjacent to the southwest side of the North Settling Lagoon. No modification to the NPDES permit was required because the system discharges to existing drainage points.

As outlined in the approved Closure Plan, the final cover systems were installed after a 90-day settlement period had passed for the subgrade. The North Settling Lagoon cover system consists of a compacted 5-inch thick layer of granular material that was overlain with a 3-inch thick asphalt pavement. The cover system for the South Settling Lagoon consists of a foot of compacted clay, with a 6-inch thick vegetated top soil layer.

Former GM Corporation submitted the Closure Certification Report to the Ohio EPA on August 10, 2001 (Conestoga-Rovers & Associates 2001) and it was approved by the Ohio EPA in a letter to former GM Corporation dated June 27, 2002. The Post-Closure Plan (Conestoga-Rovers & Associates 2002) was submitted to the Ohio EPA on December 13, 2002 and was approved by the Ohio EPA in a letter to former GM Corporation dated December 24, 2003. The plan outlined groundwater sampling, inspection and maintenance activities for the closed lagoons. The Site-Wide Groundwater Monitoring Plan was provided as an attachment to this report as Attachment A. The Post-Closure Plan outlined the frequency of inspections (monthly to quarterly) to be completed at the North and South Settling Lagoons. The Post-Closure Plan outlined inspections for erosion damage, settlement and subsidence, and security and fencing (quarterly) and pest damage mowing and revegetation (South Settling Lagoon) (monthly from April to October). Cover maintenance for the lagoons included maintaining the asphalt cover for the North Settling Lagoon and the vegetated cover for the South Settling Lagoon. Maintenance of the cover consisted of repairing and/or replacing the asphalt and regrading to maintain adequate surface water drainage, as necessary for the North Settling Lagoon, and mowing, revegetation, and regrading to maintain adequate surface water drainage, as necessary for the South Settling Lagoon. As part of post-closure activities, former GM Corporation placed property deed restrictions on the closed North and South Settling Lagoons.

2.6.2 Underground Storage Tank Closures

The following is a summary of the UST farms located at the Site and the current regulatory status of each tank.

2.6.2.1 Former Delphi Thermal Moraine

West Tank Farm

The West Tank Farm contained 14 USTs that were removed between 1986 and 1992. Five of the USTs were regulated by BUSTR [BUSTR Facility Identification (ID) No. 57000002-N00002] and nine of the USTs were investigated during the RFI and referred to as SWMUs. The following table summarizes the tank contents, capacity, removal date, and regulatory status for the USTs in the West Tank Farm:

Tank No.	Tank Contents	Capacity (Gallons)	Removal Date	Current Regulatory Status
BUSTR Tank ID No. 6 (Tank No.1)	Unleaded Gasoline	10,000	August 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 7 (Tank No. 2)	Gasoline (1972-1981) Diesel Fuel (1981-1991)	6,000	August 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 8 (Tank No. 3)	Cindol Coolant (1972-1985 Cutting Oil (1985-1991)	10,000	August 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 9 (Tank No. 7)	Quaker 568 (Coolant)	10,000	June 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 10 (Tank No. 8)	Cimstar Coolant	10,000	June 1992	Tier 1 Site Investigation Required
SWMU T8 (Tank No. 4)	Trichloroethene (prior to 1973) Tetrachloroethene (1973 - ~1978)	10,000	October 1988	RCRA Corrective Action NFA Approved[1]
SWMU T8 (Tank No. 5)	Trichloroethene (prior to 1973) Tetrachloroethene (1973 - ~1978)	10,000	October 1988	RCRA Corrective Action NFA Approved[1]

Tank No.	Tank Contents	Capacity (Gallons)	Removal Date	Current Regulatory Status
SWMU T7 (Tank No. 6)	Oily Waste	10,000	May 1986	RCRA Corrective Action NFA Approved[1]
SWMU T7 (Tank No. 9)	Oily Waste	10,000	May 1986	RCRA Corrective Action NFA Approved[1]
SWMU T7 (Tank No. 10)	Oily Waste	10,000	October 1988	RCRA Corrective Action NFA Approved[1]
SWMU T10 (Tank No. 11)	Stoddard Solvent	10,000	May 1986	RCRA Corrective Action NFA Approved[1]
SWMU T10 (Tank No. 12)	Stoddard Solvent	10,000	May 1986	RCRA Corrective Action NFA Approved[1]
SWMU T9 (Tank No. 13)	Napthalite	10,000	May 1986	RCRA Corrective Action NFA Approved[1]
SWMU T9 (Tank No. 14)	Napthalite	10,000	May 1986	RCRA Corrective Action NFA Approved[1]

Notes:
1 – The U.S. EPA approved the RFI (ARCADIS Geraghty & Miller, Inc. 2000a; Environ 2000a). The RFI concluded that no further action (NFA) was required for SWMUs in the West Tank Farm.

A report summarizing the closure activities, including tank removal, soil sample collection, and backfilling with clean soil was submitted to BUSTR in 1993 for the West Tank Farm.

Upon removal of the tanks that formerly contained PCE (SWMU T8), sheet piling was installed around the perimeter of the West Tank Farm excavation to allow for soil removal to a depth where groundwater was encountered. Approximately 1,000 tons of soil was excavated and soil sampling was conducted during the closure activities in 1988 and 1989. Oversight of the closure activities was performed by the Ohio EPA. The former Still Room, located inside former Building 14, was connected to the West Tank Farm via underground piping and was part of the solvent recovery process. As part of the RCRA closure completed in 1990 under Ohio EPA oversight, one 3,000-gallon PCE product storage tank and one 1,500 gallon waste PCE tank were removed, soil samples were collected, and soil was excavated.

South Tank Farm

The South Tank Farm contained eight USTs that were removed between 1986 and 1992. Five of the USTs were regulated by BUSTR (BUSTR Facility ID No. 57000002-N00004) and three of the USTs were RFI SWMUs. The following table summarizes the tank contents, capacity, removal date, and regulatory status for the USTs in the South Tank Farm.

Tank No.	Tank Contents	Capacity (Gallons)	Removal Date	Current Regulatory Status
BUSTR Tank ID No. 1	Washing Oil	10,000	November 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 2	Lube Gear Oil	10,000	November 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 3	Bruko D-332 Drawing Oil	10,000	November 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 4	215 Sec. Hydraulic Oil	10,000	November 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 5	Cimtech 3900 Coolant	10,000	October 1992	Tier 1 Site Investigation Required
SWMU T1 (Tank No. 27)	Mineral oil (prior to 1974 - ~1978), Styrene (~1978 - ~1982), Empty (~1982 – Date of Removal)	10,000	November 1992	RCRA Corrective Action NFA Approved[1]
SWMU T2 (Tank No. 2)	Dirty Oil	11,000	May 1986	RCRA Corrective Action NFA Approved[1]
SWMU T3 (Tank No. 8)	Dirty Oil (~1978), Empty (~1978 - ~1984), Microlubic 540 (~1984 - ~1986)	11,000	May 1986	RCRA Corrective Action NFA Approved[1]

Notes:
1 – The U.S. EPA approved the RFI (ARCADIS Geraghty & Miller, Inc. 2000a; Environ 2000a). The RFI concluded that NFA was required for the South Tank Farm.

A report summarizing the closure activities, including tank removal, soil sample collection, and backfilling with clean soil was submitted to BUSTR in 1993 for the South Tank Farm.

Northwest Tank Farm

The Northwest Tank Farm contained three BUSTR regulated USTs that were removed in 1992 (BUSTR Facility ID No. 57000002-N00005) and no RFI SWMUs. The following table summarizes the tank contents, capacity, removal date, and regulatory status for the USTs in the Northwest Tank Farm.

Tank No.	Tank Contents	Capacity (Gallons)	Removal Date	Current Regulatory Status
BUSTR Tank ID No. 11	Quaker 540 Microcut Coolant	15,000	November 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 12	Refrigerant Oil	15,000	November 1992	Tier 1 Site Investigation Required
BUSTR Tank ID No. 13	Refrigerant Oil	15,000	November 1992	Tier 1 Site Investigation Required

A report summarizing the closure activities, including tank removal, soil sample collection, and backfilling with clean soil was submitted to BUSTR in 1993 for the Northwest Tank Farm.

Wind Tunnel

One 1,000-gallon gasoline UST was located adjacent to the Wind Tunnel, which was located southwest of former Delphi Thermal Building 14. This UST was removed in 1992 and was regulated by BUSTR (Facility ID No. 57000002-N00008). The following table summarizes the tank contents, capacity, removal date, and regulatory status:

Tank No.	Tank Contents	Capacity (Gallons)	Removal Date	Current Regulatory Status
BUSTR Tank ID No. 14	Gasoline	1,000	November 1992	BUSTR NFA Issued 6/7/2001

A report summarizing the closure activities, including tank removal, soil sample collection, and backfilling with clean soil was submitted to BUSTR in 1993 for the Wind Tunnel.

2.6.2.2 Former Moraine Engine

The former Moraine Engine contained three BUSTR regulated USTs that were removed between 1989 and 1994 (BUSTR Facility ID No. 57000005-N00001 and N00002 – also referred to as Incident #579907). There is some confusion regarding the facility ID number, since BUSTR also lists the site ID as 57010329; however, the old incident numbers are the same (i.e., #579907) for both ID #57000005 and #57010329. The following table summarizes the tank contents, capacity, removal date, and regulatory status for the USTs at the former Moraine Engine:

Tank No.	Tank Contents	Capacity (Gallons)	Removal Date	Current Regulatory Status
BUSTR Tank ID No. 1	Gasoline	6,000	September 1991	BUSTR NFA Issued 12/23/1991
BUSTR Tank ID No. 2	Diesel	6,000	September 1991	BUSTR NFA Issued 12/23/1991
BUSTR Tank ID No. 3	Used Oil	1,000	February 1994	BUSTR NFA Issued 6/20/1994
BUSTR Tank ID Not Available	Leaded Gasoline	10,000	November 1989	BUSTR NFA Issued 4/10/1992

2.6.2.3 Former Moraine Assembly

The former Moraine Assembly West Haulaway contained ten USTs, eight of which were regulated by BUSTR (BUSTR Facility ID No. 57010096-N00001 and N00002 –

also referred to as Incident #5702718). All tanks were removed in 1998. The following table summarizes the tank contents, capacity, removal date, and regulatory status for the USTs:

Tank No.	Tank Contents	Capacity (Gallons)	Removal Date	Current Regulatory Status
BUSTR Tank ID No. 2	Diesel	20,000	April 1998	BUSTR NFA Issued 5/24/1999
BUSTR Tank ID No. 3	Diesel	20,000	April 1998	BUSTR NFA Issued 5/24/1999
BUSTR Tank ID No. 4	Diesel	20,000	April 1998	BUSTR NFA Issued 5/24/1999
BUSTR Tank ID No. 5	Not Used or possibly contained used oil	1,000	April 1998	Not applicable
BUSTR Tank ID No. 6	Motor Oil (associated with wastewater treatment	1,000	April 1998	Not regulated
BUSTR Tank ID No. 7	Engine Oil	10,000	April 1998	BUSTR NFA Issued 5/24/1999
BUSTR Tank ID No. 8	Transmission Fluid	8,000	April 1998	BUSTR NFA Issued 5/24/1999
BUSTR Tank ID No. 9	Engine Oil	8,000	April 1998	BUSTR NFA Issued 5/24/1999
BUSTR Tank ID No. 10	Antifreeze	8,000	April 1998	BUSTR NFA Issued 5/24/1999
BUSTR Tank ID No. 11	Used Oil	1,000	April 1998	BUSTR NFA Issued 5/24/1999

Prior to closure activities in 1998 and 1999 at the former West Haulaway, a stained area believed to be a result of a diesel fuel spill was discovered beneath the containment pad of a diesel fuel dispenser during a 1990 UST upgrade. Soil samples were collected and soil excavation was completed to address the stained area. BUSTR issued an NFA on April 10, 1992 for the stained area.

Former Moraine Assembly also contained one BUSTR regulated UST (tank owner was Allied Automotive Group and BUSTR Facility ID No. 57000790) that was removed in

2007. The following table summarizes the tanks content, capacity, removal date, and regulatory status for this UST:

Tank No.	Tank Contents	Capacity (Gallons)	Removal Date	Current Regulatory Status
BUSTR Tank ID Not Available	Gasoline	1,000	June 2007	BUSTR NFA issued 12/23/2007

2.6.3 Capture Zones

A review of potential technologies which could be applied at the Site to address VOCs in groundwater at the property boundary was conducted in 1994. Hydraulic controls were selected to achieve the IMs objectives. The capture zone IM for the upper aquifer consists of groundwater extraction at the property boundary using well TW-2 (Figure 2); treatment through an air stripper tower; and discharge through former GM Corporation's NPDES permitted outfall to the Great Miami River. The Ohio EPA approved renewal of NPDES Permit 1IC00008*KD for the internal outfall related to TW-2 on September 11, 2012. Additional system design information is presented in the *Preliminary Interim Measures Work Plan* (Geraghty & Miller, Inc. 1994a) and the *Final Interim Measures Design Plans* (Geraghty & Miller, Inc. 1995). Groundwater was pumped from TW-2 at an average flow rate of approximately 120 gpm. On July 20, 2012, RACER Trust sent the U.S. EPA a letter indicating that operation of TW-2 would be discontinued. RACER Trust indicated operation of TW-2 was no longer necessary based on the performance of the upgradient in-situ reactive zone (IRZ) barrier and that hydraulic control of the upper aquifer will be maintained by continued operation of lower aquifer well, DN-13 (Figure 2). Groundwater recovery from TW-2 began on January 31, 1996 and was discontinued on July 31, 2012.

Well DN-13 is a lower aquifer well that Montgomery County has been using in a Pump-to-Waste Program since March 1990. The capture zone IM for the lower aquifer consists of continued pumping of DN-13 at an approximate rate of 1,000 gpm. Discussions began between MLC and the Ohio EPA in 2011 to terminate the Pump-to-Waste designation and permit the outfall under the NPDES program. On March 1, 2012, RACER Trust received an email from the Ohio EPA stating that the modified NPDES permit 1IC00008 was scheduled to become effective on April 1, 2012. On March 30, 2012, the Ohio EPA sent a letter "Re: Ohio EPA Permit No. 1IC00008*JD" providing the final modifications of the NPDES Permit for permitted outfall 003 associated with DN-13 and internal monitoring station 601 associated with the TW-2 treatment system. The modification to the NPDES permit became effective on April 1, 2012. On September 11, 2012, the Ohio EPA approved the final NPDES Permit 1IC00008*KD. A detailed analysis for the DN-13 capture zone is provided in Section 2.7.6

2.6.4 In-Situ Reactive Zones

Based on a review of potential remedial technologies which could be applied at the Site to address VOCs in groundwater at and emanating from the former Oil House Area, two remediation technologies were selected as the most likely to achieve the IM objectives in 1999. One technology was chemical (non-biological) oxidation of the contaminants using hydrogen peroxide and the creation of Fenton's reagent; the other technology was enhanced bioremediation, primarily via the reductive dechlorination process. The system design for these in-situ technologies was presented in the *Primary Groundwater Source Area (AOI 7) Interim Measures Work Plan* (ARCADIS Geraghty & Miller, Inc. 1999).

The chemical oxidation technology was selected for the Former Oil House Area primary source area which contained the highest VOC concentrations because this technology provided the greatest potential for rapidly reducing high VOC concentrations. Chemical oxidation as a remedial alternative is based on the introduction of an oxidant, such as hydrogen peroxide (H_2O_2), into the subsurface. The resulting hydroxyl radicals (OH^-), a strong chemical oxidizer, can create an environment which oxidizes organic compounds such as PCE and TCE (and their degradation daughter products 1,2-DCE and vinyl chloride). The reaction is a nearly instantaneous oxidation of these compounds upon contact with the hydroxyl radicals. Fenton's reagent, a combination of hydrogen peroxide and ferrous salts, can be used to cost-effectively create hydroxyl radicals. The in-situ oxidation testing within the former Oil House Area was conducted in 1999 and 2000. Based on the results of this testing presented in the IM/CM Report, former GM Corporation concluded that in-situ oxidation is a potentially viable technology at this Site and continued implementation should result in the desired reduction of VOC concentrations; however, the radius of influence achieved with this technology was limited and due to the large amounts of chemicals needed, special considerations of safety concerns associated with technology implementation would be required.

The reductive dechlorination of CVOCs in groundwater can be enhanced by the introduction of a carbon source that stimulates activity of indigenous microorganisms. The high carbon loading triggers a succession of microbial species. Initially, aerobic electron acceptors such as oxygen and nitrate are consumed. Then, the microbial succession leads to a consortium of species that survive by sulfate reduction, methanogenesis, and other similar metabolic pathways, supporting the highly reducing conditions necessary for the dechlorination of PCE, TCE, cis-1,2-DCE, and vinyl chloride. This enhanced reductive dechlorination process has been developed at the Site through the use of reactive zones for introduction of a degradable carbon source necessary to develop the desired reducing conditions.

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ERD was implemented in 1999 as a component of the Former Oil House Area corrective measures at three zones: 1) at the southern boundary of the Former Oil House Area (RZ-1); 2) at an intermediate downgradient location south of the Former Oil House Area in the ME well series area (RZ-2 which was operated from 1999 to 2002); and 3) at a downgradient location south of former Delphi Thermal Moraine (RZ-3 West) and the former Moraine Engine plant (RZ-3 East). Using the data obtained from the Supplemental Groundwater Investigation conducted in 2006, RZ-4 was designed and installed to address VOC impacts identified west of RZ-3 West (GM-16). The RZ locations are shown on Figure 2.

- At RZ-1, molasses solution was introduced into the upper aquifer, above the upper clay till. The carbon injection wells are screened across the lower 10 ft. of the upper aquifer, which is 4 ft. to 12 ft. thick. RZ-1 consists of 21 introduction wells, of which 12 wells (RZ-1J through RZ-1U) were added in 2002 to expand RZ-1. Several monthly carbon introductions were completed in existing wells upgradient of GM-23 (OW-1, OW-2, and OW-3) to demonstrate the ability to solubilize and biodegrade the previously adsorbed VOCs in this area.

- Former RZ-2 consisted of four pre-existing monitoring wells (ME-1 [abandoned], ME-2, ME-4, ME-5 [abandoned]), located along the western edge of the former

Moraine Engine Plant 3 building. The RZ-2 wells were screened within the upper 3 ft. of the upper aquifer. RZ-2 was operated from 1999 to 2002.

- RZ-3 consists of 46 introduction wells, 30 wells in RZ-3 West (RZ-3A through RZ-3DD), and 16 wells in RZ-3 East (RZ-3FF through RZ-3KK, and RZ-3MM through RZ-3VV). At RZ-3, the carbon injection wells were screened from approximately the aquifer surface to a depth of 46 ft. to 68 ft. bls, allowing carbon introduction through the lower 20 to 30 feet of the upper aquifer. Introduction wells RZ-3RR through RZ-3VV were installed in April 2005 to establish an RZ further down-gradient and closer to the property boundary. The additional introduction wells were screened from 34 ft. to 54 ft. bls. Wells RZ-3MM through RZ-3QQ have not been operated since the installation of RZ-3RR through RZ-3VV in 2005, therefore, of the 16 existing introduction wells in RZ-3 East, only 11 are active.

- RZ-4 consists of 15 introduction wells, 7 wells in RZ-4 West (RZ-4I through RZ-4O), and 8 wells in RZ-4 East (RZ-4A through RZ-4H). These wells were installed in July 2006. The RZ-4 West wells are located in the southeast corner of the closed South Settling Lagoon and the RZ-4 East wells are located north of Landfill L1 and west of the WPSA. At RZ-4, the carbon injection wells were screened from approximately the aquifer surface to a depth of 57 ft. to 62 ft. bls, allowing carbon introduction through the lower 30 ft. of the upper aquifer.

To establish conditions conducive to ERD within RZs RZ-1, RZ-2, and RZ-3, a readily degradable carbon source (a dilute solution of molasses and potable water) was periodically delivered into the RZ introduction wells during a 6-month period from December 1999 to May 2000. The molasses solution consisted of either a 10-to-1 or 20–to-1 ratio of potable water to feed-grade molasses that was pumped into each RZ well. The initial event, conducted in December 1999, consisted of two consecutive rounds of carbon source introductions in each RZ well. After the initial event, the carbon source solution introductions were scheduled twice per month through May 2000. Due to the success during the first six months of implementing this technology, carbon source introduction activities continued in October, November, and December 2000, and subsequently from June 2001 through December 2012.

Introductions in RZ-1 were modified in the fall of 2003 after review of the previous site-wide groundwater analytical results. Due to the success of RZ-1, former GM Corporation implemented a reduced carbon loading frequency of one introduction event every other month, and periodically monitored GM-28 to verify that the necessary reducing conditions were being sustained to promote the dechlorination process. In

May 2005, the introduction routine was changed to two injections every quarter to maintain reducing conditions and sufficient carbon to allow for complete degradation of the VOCs. This injection schedule of two per quarter was followed until July 2008 when former GM Corporation increased the injection frequency at RZ-1 to monthly. Introductions continued from 2008 through 2012 on a monthly introduction schedule in RZ-1. Introductions since the beginning of operation in 2000 (RZ-3 West) and 2005 (RZ-3 East) have continued on a monthly introduction schedule in RZ-3.

Monthly carbon introductions in RZ-4 East began in August 2006. Monitoring well GM-19S serves as the downgradient performance monitoring well for RZ-4 East. A significant reduction in CVOC mass has been observed at monitoring well GM-19S, demonstrating the effectiveness of ERD in this zone. RZ-4 West was in operation from August 2006 through August 2007. Operation of RZ-4 West is currently on hold due to observations of moderate levels of dissolved methane in groundwater at performance monitoring well GM-64 and field observations which indicate the presence of excess gas build-up at RZ-4 West injection well-heads (likely a mixture of methane and carbon dioxide). These observations indicate the need to assess the issues associated with the continued operation of RZ-4 West. This assessment will be completed prior to continuing operation of RZ-4 West.

In November 2005, a more dilute molasses solution (20:1 water to molasses ratio) was used during the introduction event. Previously, a 10:1 water to molasses ratio was used. Adjustments to the introduction procedures were made based on evaluation of monitoring results and the variability in acceptance rates of the more concentrated solution into the formation. ARCADIS has observed at other sites utilizing ERD technology, that a lower solution concentration of molasses in the injectate is sufficient, and in many cases better, to achieve distribution of carbon in the subsurface. A more dilute molasses solution will reduce fermentation by-products, such as carbon dioxide and organic acids that cause reductions in pH, and in some instances may limit distribution of the carbon solution due to gas building up in soil pore space. By lowering the molasses concentration, a reduction in fermentation by-products is achieved, which is shown to improve the delivery of organic carbon to the desired locations. The decreased concentration was coupled with an increase in the volume introduced with the intent of "pushing" the carbon solution further away radially from the introduction wells, where deemed necessary. This modification was made prior to the November 2005 event and as a result, an improvement in the delivery of the carbon solution has been noted.

System operation and performance data are presented in the most recent annual *Site-Wide Groundwater Monitoring Report* for 2011 (ARCADIS, Inc. 2012b). As discussed in Section 4, the ERD RZs with some refinements are evaluated as part of the corrective measures.

2.6.5 Waste Pile/Staging Area

The primary component of the WPSA IMs was removal of the impacted soil identified for excavation to reduce source material for the protection of groundwater. The soil removal and site restoration activities were completed in 2005. The performance objective of the WPSA IMs was to remove a sufficient volume of source material for the protection of groundwater based on a set soil volume limit determined by an evaluation of the existing borings. This objective was met by completing soil removal (approximately 2 cubic yards), off-site disposal, and soil confirmation sampling. In addition, the results of the soil confirmation sampling demonstrated that soil excavation has resulted in post-IM routine worker and maintenance worker direct contact risks that meet the U.S. EPA's acceptable risk levels. Another component of the WPSA IMs is the maintenance of a paved cover over the WPSA in conjunction with institutional controls to reduce the potential for direct contact exposure to soil. The institutional controls for the WPSA will be incorporated as part of the final corrective measures, as discussed in Section 4.7. Additional information is presented in the *Waste Pile/Staging Area Interim Measures Work Plan* (ARCADIS, Inc. 2004b) and *Waste Pile/Staging Area Interim Measures Report* (ARCADIS, Inc. 2006).

2.6.6 Former Hazardous Waste Storage Pad

As outlined in the Supplemental DOCC for the Moraine Engine Plant (Geraghty & Miller, Inc., 1997), in April 1993, the Former Hazardous Storage Pad was clean closed according to an Ohio EPA-approved closure plan (Dames & Moore 1993). The concrete storage pad covered an area of 2,400 square ft. (30 ft. by 80 ft.), had the capacity to store 250 55-gallon drums, and is located on the footprint of former Building 13 at the southern portion of the former Moraine Engine Plant. The pad was used for storage of drummed quantities of waste paint thinner and sludges, chlorinated solvents, and non-hazardous waste oil and process fluids prior to removal from the facility.

During closure, the remaining inventory was removed, a visual inspection of the pad was conducted,12 background soil samples were collected and analyzed for inorganic constituents (chromium, barium, and lead), soil samples from six locations beneath the pad were collected and analyzed for organic and inorganic compounds (chromium, barium, and lead), and the pad was decontaminated (Dames & Moore 1994). The sampling results for subsurface soil and the rinsewater met the criteria specified in the closure plan. Closure was approved by the Ohio EPA in a final letter of closure, dated July 21, 1993.

2.6.7 Vapor Intrusion Mitigation Activities

Since concentrations of PCE, TCE, and 1,1-DCA were detected in the sub-slab and indoor air samples collected from the properties in the Riverview Plat neighborhood at concentrations that were greater than or equal to the Action Levels, the *Vapor Intrusion Mitigation Work Plan* (ARCADIS, Inc. 2011c) dated September 13, 2011 was prepared. The U.S. EPA approved the Work Plan on September 14, 2011. Additionally, Vapor Intrusion Mitigation Work Plan Addendums dated February 23, 2012 (RACER Trust 2012d), May 18, 2012 (RACER Trust 2012e), and August 10, 2012 (RACER Trust 2012f) were submitted to the U.S. EPA. The February 23, 2012 Addendum and the May 18, 2012 Addendum were both approved by the U.S. EPA on June 1, 2012. The August 10, 2012 Addendum is currently pending approval.

Once the sub-slab and indoor air sampling is completed and an Action Level is exceeded, the objective of the vapor intrusion mitigation activities at the Site is to install mitigation systems to reduce the concentrations of site-specific VOCs in indoor air at properties within the Riverview Plat neighborhood to concentrations that are below the Action Levels. Vapor intrusion mitigation systems were, and continue to be, installed in applicable properties, where access has been provided.

Active vapor intrusion mitigation systems are designed to prevent vapors present below the foundation of the structure from entering the indoor air within the structure. The active mitigation systems include a depressurization system that creates a negative pressure (or vacuum) below the foundation of the structure using an electric powered fan. Sub-slab depressurization systems (SSDSs), sub-membrane depressurization systems (SMDSs), crawlspace depressurization systems (CSDSs), or a combination thereof, as applicable based on the foundation type(s), are used to mitigate vapor intrusion in the Riverview Plat neighborhood. The mitigation systems are designed to reverse the pre-existing pressure gradient across the foundation of the structure. The resulting vacuum below the foundation prevents soil vapor from entering the structure.

Accessible crawlspace, inaccessible crawlspace, basement, slab-on-grade, or a combination of these foundations are present in the Riverview Plat neighborhood. The foundations are sealed to the extent possible to minimize the existing pathways for vapors to enter the building and to minimize short-circuiting of the mitigation system. Permanent sub-slab sample points are installed in properties with basement or slab-on-grade foundation types to allow for monitoring of the pressure field extension and to verify sub-slab depressurization that exceeds negative 0.004 inches (in.) of water column (w.c.).

The active mitigation system design is based on SSDS, SMDS, and CSDS design criteria found in American Society for Testing and Materials (ASTM) Standard E2121, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings (ASTM 2003), Vapor Intrusion Guidebook (U.S. EPA 2010), Radon Reduction Techniques for Existing Detached Houses (U.S. EPA 1993), and Indoor Air Vapor Intrusion Mitigation Approaches (U.S. EPA 2008a). A detailed *Summary of Vapor Intrusion Assessment and Mitigation Activities* is included in Appendix D.

The following is a summary of the conclusions of the vapor intrusion mitigation activities completed to date at the Site:

- Vapor intrusion mitigation systems were recommended for most of the sampled properties within the Riverview Plat neighborhood and systems have been installed in the properties where access was provided.

- The vapor intrusion mitigation systems installed to date have effectively reduced site-specific VOCs in indoor air to concentrations that are below the Action Levels.

- Vapor intrusion mitigation system installation activities and community outreach efforts are on-going.

2.7 Conceptual Site Model

This section presents data collected during previous and recent investigations through 2012 presented in this CMP (Sections 2.4 through 2.6). This section includes the site characteristics (historical and current); physical setting, refinements made to the geology, hydrogeology, and improved understanding of nature and extent of site-specific VOCs. The site-specific VOCs are 1,1,1-TCA, 1,1-DCA, 1,1-dichloroethene (1,1-DCE), benzene, cis-1,2-DCE, ethylbenzene, PCE, toluene, trans-1,2-DCE, TCE, vinyl chloride, and xylenes (total) as defined in the IM/CM Report (ARCADIS Geraghty & Miller, Inc. 2001).

The assessment of the significant amount of data collected has improved the understanding of the nature and extent of site-specific VOCs to support the evaluation of facility risks, CMOs, and corrective measures technologies. For detailed information, refer to Appendix E (Landfill L1 Investigation Supporting Information) and Appendix F (Pre-Design Investigation Supporting Information). Also included are results and descriptions of the refinement to the groundwater flow model (Section 2.7.7), groundwater-surface water interaction (Section 2.7.8 and Appendix K), and the off-site well survey results (Section 2.7.9 and Appendix I).

2.7.1 Site Characteristics

2.7.1.1 Local Land Use

Land use surrounding the Site (Figure 1) is almost entirely industrial and commercial with only a few small areas of residential use. The former Delphi Thermal Moraine facility is the western boundary of the Site and is zoned for general industry. The western portion of the former Moraine Assembly facility is located in an area zoned for general industry, while the eastern portion is located in an area zoned for light industry. The former Moraine Engine facility is located in an area zoned for general industry. Areas adjacent to the Site are zoned for general industry, light industry, general business, neighborhood business, and one- and two-family residential uses.

2.7.1.2 Physical Setting

2.7.1.2.1 Topography

The Site is located in the Great Miami River valley. The surrounding topography formed by continental glaciations and melt water outwash streams can be seen on the Dayton South Quadrangle and Miamisburg Quadrangle United States Geological Survey (USGS) topographic maps (USGS 2008). Overlying bedrock and valley fill glacial deposits are bounded by the bedrock valley walls that extend approximately one mile east and west of the Site to the elevations ranging between 900 and 1,000 ft. above mean sea level (AMSL). Topographically, the Site lies in the valley flats. The Site is within floodplain of the Great Miami River and has little relief with elevations ranging from 725 to 740 ft. AMSL. The Site and surrounding area is protected by the Miami Shores Levee that is part of the Miami Conservancy District (MCD) flood protection system (MCD 2008).

2.7.1.2.2 Climate

The climate is continental denoted by geographic location within the interior of a large landmass with hot humid summers and cold winters. The average temperature in Dayton, Ohio was 52.0 degrees Fahrenheit (11.1 degrees Celsius) between 1934 and 2011 (National Oceanic and Atmospheric Administration [NOAA] 2012). Average annual precipitation was 37.68 in. per year from 1919 to 2011 (NOAA 2012).

2.7.1.2.3 Surface Water and Drainage Features

Moraine and the surrounding region are in the Great Miami River drainage basin. The Great Miami River generally flows north to south in the vicinity of the Site and is closest to the Site on the southern end (Figure 1). No major tributaries to the Great Miami River pass through the Site. The Flood Insurance Rate Map for Moraine shows that the area affected by the 100-year flood does not include the Site (Federal Emergency Management Agency [FEMA] 1981).

Storm water management via the North and South storm water retention basins (SWRBs) that discharge to the Great Miami River is under management by the current property owner, IRG Moraine, LLC. The North SWRB is located just southwest of the closed South Settling Lagoon and the South SWRB is located on just west of the southwest corner of former Delphi Thermal Moraine Building 14 (Figure 1).

As part of the IMs as described in Section 2.6.3, the TW-2 Groundwater Recovery and Treatment system was an intermediate discharge to the South SWRB until the system was shut down on July 31, 2012. In addition, well DN-13 that is used for lower aquifer capture is pumped directly to the Great Miami River via a drainage ditch on the south side of Main Street. Discharge is managed through NPDES Permit 1IC00008*KD by RACER Trust effective September 11, 2012.

2.7.2 Regional Geology, Hydrogeology and Groundwater Use/Flow

2.7.2.1 Regional Geology

The Site and surrounding areas lay over the Great Miami River buried valley aquifer, which consists of fluvio-glacial sand and gravel outwash deposits separated by discontinuous deposits of fine-grained sand, silt, and clay-rich till. The glacial deposits are from the most recent Wisconsinan-age glaciation with older Illinoian-age deposits in the deeper parts of the valley (Ohio Department of Natural Resources [ODNR] 2005). The till units formed by the glaciation were deposited as layers, blocks, and lenses. The till units are thin layers that cover the upland areas and also occur thicker and intermittent within the buried valley; however, the extent of some till layers can occur laterally over long distances across the buried valleys. The till in some areas was buried by the sand and gravel outwash deposits and eroded or were completely removed by the fluvio-glacial melt water deposition.

Ordovician shales and limestones of the Richmond Group comprise the dominant bedrock units forming the valleys in the Dayton area (ODNR 2006). The Richmond Group is overlain by the Silurian Brassfield Formation in upland areas. Prior to the Illinoian and Wisconsinan glacial stages, the bedrock valleys were as much as 190 to 225 ft. deep (Norris and Spieker 1966). The top of bedrock beneath the region is approximated to be 200 to 250 ft. bls (Norris and Spieker 1966 and ODNR 1986).

2.7.2.2 Regional Hydrogeology

Beneath the Site and surrounding areas, the bedrock units are not considered important sources of groundwater because they have significantly lower transmissivity values relative to the buried glacial valley aquifers.

The clay-rich till units have low permeability with vertical hydraulic conductivity as low as 1×10^{-2} ft. per day (Dumouchelle 1998). Groundwater flow is restricted in and by these units. Where the tills are laterally continuous across the valley separating the sand and gravel rich glacial deposits; several confined to semi-confined aquifers may be present (Norris and Spieker 1966 and Sheets 2007). The Site consists of two primary upper and lower aquifers separated by a laterally continuous till unit.

The sand and gravel outwash deposits range in thickness from 120 to 250 ft. (Norris and Spieker 1966). These coarse valley deposits provide a vast groundwater supply to the region. Transmissivity of the deposits was reported by Dumouchelle (1998) to range from 3,000 $ft.^2$/day to 70,000 $ft.^2$/day. Single wells in this prolific aquifer system have been reported to yield as much as 4.3 million gallons per day (MGD) (Norris and Spieker 1966). The estimated total porosity was reported by Sheets (2007) to range from 15% to 25%.

Precipitation provides the primary means of recharge to the groundwater system in the region which is estimated at 15 in. per year in the vicinity of the Site (ARCADIS, Inc. 2008). The primary natural discharge of the groundwater system is to surface water streams and heavy anthropogenic discharge by regional pumping. In some cases when area pumping is significant, recharge also occurs through losing surface water bodies to the groundwater system.

2.7.2.3 Regional/Local Groundwater Use and Groundwater Flow

Under natural conditions, the groundwater flow direction in the Great Miami River Valley is generally toward the major streams and further down valley flow is south/southwest. Current groundwater flow follows this trend at the Site with both upper and lower aquifer systems flowing to the south/southwest (Figures 5 and 6).

2.7.2.3.1 Lower Aquifer Historic and Current Groundwater Use

2.7.2.3.1.1 Public Water Supply

Regionally, the lower portions of the groundwater system have historically been and are currently used for public water supply. This Greater Moraine Water System was maintained by the Montgomery County Sanitary Engineering Department and consisted of four well fields (Lamme Road, Dryden North, Dryden South, and Miami Shores) that formerly supplied the cities of Moraine, Kettering, and Centerville (Geraghty & Miller, Inc. 1983). These well fields were used until 1986, when all systems were switched to the City of Dayton well field in conjunction with county storage facilities and pump stations to supply potable water to the region, including the Site. However, the Dryden South well field was used in the summer of 1987 and Miami Shores was used in the summers of 1987 and 1988 to supplement high demand (Geraghty & Miller, Inc. 1994b). Currently, the Lamme Road well field is abandoned, Dryden South is inactive, and Dryden North is inactive except for DN-13 which is maintained by Montgomery County and used by RACER Trust as part of the lower aquifer IM capture well that began operation in 1990 (Section 2.6.3). Miami Shores is inactive, but is maintained by Montgomery County and is the primary backup to the City of Dayton. The closest active well field is approximately two miles to the south, consisting of three wells that supply the City of West Carrollton.

2.7.2.3.1.2 Industrial Water Supply

The lower aquifer portions in the region are currently also used as an industrial water supply. Historically, on-site production wells were used for industrial water supply. Prior to 1978, pumping at the former Delphi Thermal Moraine facility was high relative to pumping at the Dryden North well field (Dryden North). For instance, in 1974 former Delphi Thermal Moraine was withdrawing approximately 12 MGD compared to the Dryden North well field which was pumping approximately 3.7 MGD. It is estimated that Frigidaire was also pumping at withdrawal amounts similar to former Delphi Thermal Moraine. This rate of groundwater use was modeled in 1983 during an investigation of Landfill L1 (Geraghty & Miller, Inc. 1983). This modeling effort determined that under these pumping conditions, groundwater at the southern end of the Site would likely flow north toward the plant pumping centers and a hydraulic divide would develop between Landfill L1 and the Dryden North well field. As a result of the historic plant pumping cone-of-depression, groundwater flow direction beneath areas local to Landfill L1, for example, were south to north, rather than the reverse seen today (current groundwater flow conditions presented in Section 2.7.4.1.2). By 1981, former Delphi Thermal Moraine pumping had decreased to approximately 2 MGD, while Montgomery County pumping remained relatively constant or increased. Under these conditions, the model predicted that groundwater contaminants would likely move towards both pumping centers, with the predominant flow to the southwest (flow divide predicted to be directly beneath Landfill L1). In addition, the response to the termination of pumping by Montgomery County in 1986 and the reduced pumping at the facilities in the late 1980s, water levels have risen approximately 10 ft. in the upper aquifer and 5 ft. in the lower aquifer at the Site (ARCADIS Geraghty & Miller, Inc. 2000b).

In March 1990, Montgomery County with former GM Corporation cooperation, initiated a Pump-to-Waste program using DN-13 in the Dryden North well field (Section 2.6.3). The estimated flow rate for DN-13 is 1,000 gpm. Along with this on-going IM for lower aquifer plume capture, historic pumping in the lower aquifer fluctuated with facility operations and ceased for each entity with the shut-down of operations for former Delphi Thermal Moraine (2005), former Moraine Engine (2000), and former Moraine Assembly (2008). Site-wide lower aquifer groundwater flow since 1990 has been and is generally to the southwest (Figure 6).

Currently there is no on-site restriction for groundwater use of the lower aquifer; however, groundwater use restrictions are contemplated for the final corrective measures (Section 4.7).

2.7.2.3.1.3 Upper Aquifer

The upper portions of the groundwater system in the vicinity of the Site have been used historically for shallow private well use, but are no longer used for potable uses (see off-site well survey results in Section 2.7.9 and Appendix I for exceptions). Future development of the upper aquifer as an industrial or potable water source is not expected due to the low sustainability and storage compared to the lower aquifer of the groundwater system. Furthermore, the development of public water systems using groundwater as a source is governed by Ohio statute (Chapter 6109 of the Ohio Revised Code), and Ohio EPA regulations and guidelines adopted there under (OAC

Chapters 3745-82, Ohio EPA, 1991). Likewise, the installation of private water wells is governed statewide by Ohio Department of Health regulations (OAC Chapter 3701-28).

Historically, groundwater extraction from the upper aquifer occurred on-site at the property boundary from extraction well TW-2; which began pumping in January 1996 with an average flow rate of 120 gpm and operated continuously until shut down in July 2012 (Section 2.6.3).

Currently there is no on-site restriction for groundwater use of the upper aquifer; however, groundwater use restrictions are contemplated for the final corrective measures (Section 4.7).

2.7.2.3.1.4 Current Pumping

Historic records indicate that private water wells in the upper and lower portions of the aquifer system have been installed in the vicinity of the Site. Therefore, off-site well surveys were conducted (including the most current in 2007 – Section 2.7.9 and Appendix I) to identify the presence of existing wells to identify use and purpose.

Current pumping rates in the region within the vicinity of the Site were obtained from the most recent data available (2011) from the ODNR. These wells include active municipal water supply wells and active remediation wells that are/were operating at the Site. Table 1 lists the extraction well entities and pumping rates. For the Site, the pumping rate for lower aquifer pump to waste well DN-13 was estimated at 0.85 MGD based on direct totalizer readings for 2011. The pump was refurbished in April 2007 and flow was measured at approximately 1.6 MGD in June 2008. Recently, the well screen was cleaned and the pump was refurbished in November 2011. Following this work, flow was measured at approximately 1.4 MGD. DN-13 flow fluctuates as fouling and motor degradation occurs periodically between maintenance periods.

2.7.3 Site-Specific Assessment

2.7.3.1 Three-Dimensional Data Analysis

A three-dimensional approach for analyzing data was used for Site groundwater quality and hydrostratigraphy. Due to the large quantity of vertical data collected, traditional two-dimensional figures do not accurately portray Site conditions. To fully understand the relationship of site-specific VOC distribution and hydrostratigraphy, the Site conditions are best represented using three-dimensional data analysis and visualization. The three-dimensional quantitative site model combines:

- Interpreted hydrostratigraphy from numerous borings (Appendix H); note that driller logs and select boring logs accuracy and geologic information was taken into consideration for the interpretation.

- Site-wide annual monitoring well sample results for site-specific VOCs (2012) (Upper and Lower Aquifer Data Box - Figures 7 and 8).

- Landfill L1 and pre-design investigation vertical aquifer profiling sample results for site-specific VOCs (2012) (Appendices E and F, respectively).

- Site survey and base map.

Note that recent groundwater quality data (2006 to 2008) from the Supplemental Groundwater Investigation were used for groundwater plume bounds (Appendix J and Figures 7 and 8) and historical groundwater quality data (pre-1999 baseline conditions before initiating the groundwater interim measure) for the former Oil House Area was used to approximate current potential concentrations (ARCADIS Geraghty & Miller, Inc. 2000b) were used to supplement 2012 data interpretation.

The hydrostratigraphy, the source areas and VOC concentration data can be evaluated in a virtual-reality framework. The Mining Visualization System (MVS) by C Tech Development Corporation (C Tech) was selected as the software environment for modeling. MVS was used for advanced data analysis and visualization because of its features, including a rigorous numerical and geostatistical engine; seamless interface with GIS, databases, and CAD; and advanced rendering of groundwater plume geometry and distributions. The ability to render the groundwater plume distribution and hydrostratigraphy three-dimensionally is a definite advantage over two dimensional or fence-diagram methods, as the analyst can see the information dynamically from virtually any angle or magnification.

All data analysis was in three dimensions, including groundwater plume distribution and hydrostratigraphy mapping. Manual and computer contouring of site-specific VOC concentration data from vertical aquifer profiling and monitoring wells were used to interpolate a continuous three-dimensional representation of site-specific VOCs throughout the subsurface. The three-dimensional representation can then be displayed in a variety of manners that includes iso-volumes of equal concentration or isoconcentration contour lines. Similarly, hydrostratigraphic data were posted in three-dimensions, and equivalent hydrostratigraphic units between boreholes were manually identified and correlated in the model. The site-specific VOC distributions were developed recognizing that the hydrostratigraphy controls groundwater flow and solute transport in the system.

Two-dimensional figures included in Appendix J were generated from the three-dimensional model. Plan-view isoconcentration maps were extracted for PCE, TCE and total site-specific CVOCs at elevations corresponding to the upper and lower aquifers. Profile views of the PCE, TCE, and site-specific total CVOCs in each aquifer were also developed to aid in visualizing the three-dimensional geometry. A more detailed assessment of the data can be obtained by using the virtual reality tool to view the site-specific VOC plumes and hydrostratigraphy models that are included on digital versatile disc (DVD) in Appendix J. A discussion of the upper and lower aquifer plume geometry is presented in Section 2.7.5.

2.7.3.2 Local Geology and Hydrostratigraphy

Generally, the Site is underlain by glacial outwash sand and gravel deposits along with interspersed to semi-continuous glacial till. The Site is distinguished by three main hydrostratigraphic units and two principal aquifers (upper aquifer, regional clay till and lower aquifer). These two aquifers are divided by the relatively continuous clay-rich till (regional clay till). However, in some areas, there is an upper clay till that separates the upper aquifer into upper and lower zones and areas within the upper aquifer have interbedded units. Where the regional clay till is absent, the upper and lower aquifers are in direct communication and identified by depth only. The upper clay till, regional clay till and other discontinuous clay units act as aquitards. The two distinguishable facies are higher permeability zones (upper and lower aquifer sand and gravel), which are dominated by advective transport (groundwater moves readily), to the lower permeability zones (upper aquifer interbedded units, the upper clay till and the regional clay till), which is dominated by chemical diffusion. Hydrostratigraphic cross sections were generated from the three-dimensional model. A main site cross section figure with area enlargements was generated (Figure 9) to depict the hydrostratigraphic units from an oblique view of the Site from off-site downgradient (southwest) following a northwest line through Landfill L1, former Building 14, former Moraine Engine, former Oil House Area, and then east through the Process Sump Area along the southern edge of former Moraine Assembly. Additional cross sections were generated for the Process Sump Area available in Appendix F (Figures 11 to 13 located in Appendix F). The main hydrostratigraphic units, in order of increasing depth, are identified as:

- Upper Aquifer - the upper aquifer is present above the regional clay till and in some areas above and below the upper clay till, if present. In the areas where the upper clay till is not present, the upper aquifer is thicker. In the areas where the regional clay till is not present, the upper aquifer is directly underlain by the lower aquifer. The upper aquifer is heterogeneous related to fluvio-glacial outwash deposition. The encountered, somewhat stratified deposits are poorly sorted sand and gravel with various amounts of silt and fine sand for the higher permeable (sand and gravel) facies to interbedded sequences of fine sand, silt, clay and till for the lower permeable (interbedded) facies (Figure 9). Thickness varies from as much as approximately 51 ft. to as little as 6 ft. Historically, this unit in some areas above the upper clay till may have been completely unsaturated with the widespread groundwater withdrawals (Section 2.7.2.3). The upper aquifer is thickest where the regional clay till is absent further downgradient and off-site just north of and to the south of Holes Creek (Appendix J – Solid View of Upper Clay Till and Regional Clay Till).

  The aquifer as a whole is considered semi-confined. Confined zones occur between the upper clay till and the regional clay till. Unconfined zones occur above the upper clay till or where the upper clay till is not present.

  The interbedded sequences of fine sand, silt, clay, and till was encountered in the vicinity of the Process Sump Area (Appendix F) near the intersection of Springboro Road and Stroop Road in a localized area where the upper clay till is absent. Interbedding was also observed west of Springboro Road at boring BOX-1 (Figure 9 and Appendix J). The interbedded units of the upper aquifer is layered into several saturated deposits of low permeability (fine sands and silts) interbedded with dry clay-rich till with varying thicknesses (detailed cross sections are presented on Figures 11 through 13 of Appendix F and Appendix J). However, at soil boring PSA-3 there is a 21 ft. thick gravel deposit from 35 to 56 ft. bls indicating channelization of the interbedded units (eroded by glacial melt waters) in some areas. PSA-5 also has a gravel deposit from 35 to 45 ft. bls. A similar sand and gravel deposit was observed in the same vicinity at GM-75S. The upper aquifer at this area consists of units with varying permeability over several orders of magnitude (gravel, sand, silty sand, clayey sand, and silt). The channelization of the low permeable interbedded units observed in the upper aquifer is centered on the area of PSA-5, GM-75S, and PSA-3 (Figure 9 and Appendix J).

  In some areas, drilling has encountered boulder-size glacial erratics at the base portion of this unit above the upper clay till and above the regional clay till.

- Upper Clay Till - the upper clay till is estimated to have a continuous distribution extending from the northern end of the Site to as far south as Blanchard Avenue with an exception near the Process Sump Area (intersection of Springboro Road and Stroop Road where a localized area of the upper clay till is not present). Figure 9 and the three-dimensional analysis available in Appendix J (Geologic Cross Sections and Solid View of Upper Clay Till and Regional Clay Till) depicts the distribution of the upper clay till that is present primarily east of the railroad that bisects the Site. The unit is unstratified, poorly sorted, and hard/dry consisting of a clay to silty clay matrix intermixed with small amounts of sand and gravel. The thickness of the upper clay till varies from approximately 1 ft. to 24 ft.

- Regional Clay Till - the regional clay till is laterally continuous across the Site. However, the regional till is absent in off-site areas downgradient near and south of Holes Creek and is thin to the northern end of the Site. As with the upper clay till, the unit is unstratified, poorly sorted, and hard/dry consisting of a clay to silty clay matrix intermixed with small amounts of sand and gravel. The regional clay till thickness is relatively consistent with an average of approximately 11 ft. (Figure 9 and Appendix J).

- Lower Aquifer - the lower aquifer is present below the regional clay till. The areas where the regional clay till is not present, the upper and lower aquifers are in direct communication. The lower aquifer is heterogeneous related to fluvio-glacial outwash deposition. The encountered, somewhat stratified deposits are poorly sorted sand and/or gravel with various amounts of silt and fine sand fall within the higher permeable sand and gravel facies. Deposits in the lower aquifer are coarser than the upper aquifer with mappable gravel channels. Lower permeable units rarely are observed. The lower aquifer is confined with an estimated maximum thickness of approximately 110 ft. in the vicinity of the Site (Figure 9 and Appendix J).

2.7.4 Hydrogeology

The following sections present analysis of hydrogeologic data collected for respective aquifers, including groundwater flow, groundwater gradients, and horizontal groundwater flow velocity.

Recharge to the region is primarily from flow within the aquifers that includes direct infiltration of precipitation and recharge from perennial streams. The perennial Great Miami River flows generally from north to south through the region and locally as a source for groundwater. The perennial Holes Creek, located south of the Site, flows generally southeast to northwest and is a minor source of groundwater recharge.

2.7.4.1 Aquifer Hydraulic Characteristics

2.7.4.1.1 Hydraulic Conductivity

2.7.4.1.1.1 Upper Aquifer

Hydraulic conductivity estimates for the upper aquifer were calculated from steady-state drawdown tests and pneumatic slug test analyses (results presented in Appendix F), pneumatic slug testing (results presented in Appendix E), and prior aquifer testing (ARCADIS Geraghty & Miller, Inc. 2000b and Geraghty & Miller, Inc. 1990). The hydraulic conductivity in the upper aquifer from the geometric means of varying solutions from the pre-design investigation hydraulic testing and pneumatic slug tests from Landfill L1 ranges from approximately 10 ft./day to as much as 3,500 ft./day based on the 2012 investigations. Intervals tested may be biased towards the higher permeability range of the aquifer for vertical aquifer profiling sampling. In some areas (e.g. Process Sump Area) with saturated fine grained sand and silt intervals, low yielding groundwater inhibited the collection of a screening sample and hydraulic testing was not completed or anomalous due to inadequate development of the screened interval.

Historical slug testing at the former Oil House Area in the upper aquifer above the upper clay till, recorded an hydraulic conductivity range from 4 to 80 ft./day (ARCADIS Geraghty & Miller, Inc. 2000b). Historical testing from large scale pumping tests at the western portion of the Site in the area of minimal to no upper clay till occurrence recorded hydraulic conductivity values that ranged from 1,500 to 2,000 ft./day (Geraghty & Miller, Inc. 1990).

The 2012 results indicate a range of permeability for the saturated units in the upper aquifer that are lower than historical large scale pumping test results for the Site due to the resolution of sampling and interbedded upper aquifer areas encountered (e.g., Process Sump Area/former Oil House Area). However, the higher end results for the sand and gravel upper aquifer unit at the western side of the Site (e.g., former Building 21 Area) are comparable to historic data obtained from large volumetric pumping tests conducted at the western area of the Site (Geraghty & Miller, Inc 1990). Appendix F contains the pre-design investigation hydraulic testing results and Appendix E contains pneumatic slug testing at Landfill L1.

From the results of the hydraulic testing of the upper aquifer, three categories were determined for the upper aquifer: sand and gravel units (e.g., western area of the Site), interbedded units, and sand and gravel channels in the interbedded units. From the various areas tested, the upper aquifer has a range of hydraulic conductivity that spans three orders of magnitude that is consistent with the high degree of variability of the hydrostratigraphic units. Areas with interbedded sequences, which include fine-grained zones with coarse sand and gravel channelization has the highest range of hydraulic conductivities spanning two to three orders of magnitude (e.g., Process Sump Area). The areas with sand and/or sand and gravel (e.g., former Building 21 Area - Appendix F) span one order of magnitude.

2.7.4.1.1.2 Lower Aquifer

Hydraulic conductivity estimates for the lower aquifer were calculated from steady-state drawdown tests and prior aquifer testing. The hydraulic conductivity in the lower aquifer was determined to be 270 ft./day in the Process Sump Area (Appendix F). Historical testing from large scale pumping tests recorded values that ranged from 260 to 440 ft./day at the western area of the Site (Geraghty & Miller, Inc. 1990).

The ranges in hydraulic conductivities are consistent with the hydrostratigraphy of the lower aquifer as lower permeable units rarely are observed. These hydraulic conductivity values are also consistent with regional estimates (Sheets 2007). The lower aquifer hydraulic conductivity has an exhibited median value of 350 ft./day.

2.7.4.1.2 Groundwater Flow

2.7.4.1.2.1 Upper Aquifer

Depth-to-water data from upper aquifer wells were collected on September 24 and 25, 2012 and surveyed top-of-casing (TOC) elevations were used to convert the measured data to potentiometric elevations using surveyed TOC elevations (Tables 2 and 3). Groundwater elevations ranged from 700.54 ft. AMSL (MW-4 - southwest of the Site and west of the Great Miami River) to 709.56 ft. AMSL (GM-24 - northeast end of Site). A contour map of the potentiometric surface was manually drawn for the upper aquifer (Figure 5). Groundwater flow for the upper aquifer is generally from northeast to southwest. In historical reports, TW-2 pumping was observed by slight deflections of potentiometric surface contour lines. A comparison of the September 2012 general groundwater flow conditions to the historical groundwater flow conditions documented in the annual groundwater monitoring reports for the upper aquifer post-2001, indicates a similar flow direction across the Site.

A more southerly groundwater flow trend is also observed for the upper aquifer when the river stage is relatively high (approximately 4 ft. above median) during periods of high precipitation as shown in upper aquifer potentiometric surface map in March 2008 (Figure 10). The influence of the Great Miami River on the upper aquifer is evident showing the portion adjacent to the Site as a losing reach and recharging the upper aquifer.

2.7.4.1.2.2 Lower Aquifer

Depth-to-water data from lower aquifer wells were collected on September 24 and 25, 2012 and surveyed TOC elevations were used to convert the measured data to potentiometric elevations (Tables 2 and 3). Groundwater elevations ranged from 704.13 ft. AMSL (GM-65D - southwest of the Site) to 709.92 ft. AMSL (A - northeast end of Site). A contour map of the potentiometric surface was manually drawn for the lower aquifer (Figure 6). Groundwater flow for the lower aquifer is generally from northeast to southwest towards IM pumping well DN-13. An estimated cone of depression surrounds pumping well DN-13 as indicated by surrounding monitoring wells and the estimated drawdown at DN-13 with inflected contours (Figure 6). Capture at DN-13 is discussed further in Section 2.7.6. A comparison of the September 2012 general groundwater flow conditions to the historical groundwater flow conditions documented in the annual groundwater monitoring reports for the lower aquifer post-2001, indicates a similar flow direction across the Site.

2.7.4.2 Groundwater Horizontal Gradients and Velocity

2.7.4.2.1 Upper Aquifer

Horizontal hydraulic gradients in the upper aquifer near the former Oil House Area above the upper clay till in 2012 range in magnitude from 5.4 $x10^{-4}$ feet per foot (ft./ft.) to 1.4 $x10^{-3}$ ft./ft. (Table 4). The values collected in this area may be influenced by the IM IRZs currently being operating at the former Oil House Area (Section 2.6.4). Horizontal hydraulic gradient values that may be more representative in the upper aquifer either below the upper clay till or in absence of the upper clay till typically range from 2.3 $x10^{-4}$ ft./ft. to 7.0 $x10^{-4}$ ft./ft. (Table 4). Considering the more representative values, the hydraulic gradients are flat with an average gradient of $4.7x10^{-4}$ ft./ft. for the upper aquifer.

Using the range of horizontal hydraulic gradients, horizontal groundwater velocities can be calculated using the following equation, based on Darcy's law:

$$v = \frac{K i_h}{n_e}$$

Where

v = horizontal groundwater flow velocity (ft./day)
K = hydraulic conductivity (ft./day)
I_h= horizontal hydraulic gradient (ft./ft.)
n_e = effective porosity

The calculated groundwater velocity range will depend on the range of K, I_h, and n_e used in the equation above. The effective porosity for the interbedded facies observed at the Process Sump Area and former Oil House Area were estimated to be approximately 5% to 7%, respectively. An average hydraulic conductivity value for the interbedded facies of the upper aquifer using recent testing results (geometric mean of solution results) at the Process Sump Area presented in Appendix F-Table 3 (intervals in ft. bls [PSA-2{30-35 and 40-45}, PSA-6 {52-57}, PSA-7 {59-64}, and PSA-8 {43-48}]) was calculated to be 120 ft./day. Using this average hydraulic conductivity, the median effective porosity of 6% and the average hydraulic gradient in the upper aquifer unit of 4.7×10^{-4} ft./ft., an estimated groundwater velocity of 0.9 ft./day was determined for the upper aquifer interbedded facies.

For the sand and gravel unit facies of the upper aquifer, the effective porosity was estimated to be approximately 10%. The range of hydraulic conductivity values for the sand and gravel facies from the 2012 pre-design investigation results (geometric mean of solution results), which includes the interbedded unit of the upper aquifer at the Process Sump Area with sand and gravel channels (Appendix F - Table 3), ranges from approximately 180 to 3,500 ft./day. This range is consistent with the hydraulic conductivity range estimated from the historic pump tests (Geraghty & Miller, Inc. 1990), 1,500 to 2,000 ft./day. Using this hydraulic conductivity, an effective porosity of 10% and the average hydraulic gradient in the upper aquifer unit of 4.7×10^{-4} ft./ft.; the estimated groundwater velocity ranges from of 0.8 to 16 ft./day for the sand and gravel facies.

The groundwater velocities calculated above provide an indication of the advective groundwater velocities based on the mobile fraction of total porosity (effective porosity) associated with the upper aquifer at the Site. Based on the relatively large range of hydraulic conductivities encountered within the upper aquifer, locally faster or slower transport velocities are likely. Estimates for mass transport velocity were based on plume movement, release times and performance measures associated with the IMs (RZ-1 and RZ-4). The transport conditions are based on estimated total porosity values of 40% and 35% for the Process Sump Area and former Oil House Area interbedded facies, respectively; and 40% for the sand and gravel facies. The hydraulic conductivity values used were estimated at 100 ft./day and 175 ft./day for the interbedded facies at the Process Sump Area and former Oil House Area, respectively; the hydraulic conductivity for the sand and gravel facies was estimated at 200 ft./day. The mass transport velocity estimates were calculated using the following equation with the average hydraulic gradient of 4.7x10^{-4} ft./ft.:

$$MTv = \frac{KI_h}{\emptyset t}$$

Where

MTv = mass transport velocity (ft./day)
K = hydraulic conductivity (ft./day)
I_h= horizontal hydraulic gradient (ft./ft.)
$\emptyset t$ = total porosity

The estimated mass transport velocity results are:

- Process Sump Area (interbedded facies): 0.1 ft./day.
- Former Oil House Area (interbedded facies): 0.2 ft./day.
- Remaining upper aquifer (sand and gravel facies): 0.2 ft./day.

These estimated mass transport velocities were used in the evaluation of the corrective measures options presented in Section 4. Given the variability of hydraulic conductivity values, and the uncertainties associated with the estimated porosities, further testing may be needed to identify the most representative values for the varying site conditions found in the upper aquifer.

2.7.4.2.2 Lower Aquifer

Horizontal hydraulic gradients in the lower aquifer in 2012 range in magnitude from 5.1 x10^{-4} ft./ft. to 6.8 x10^{-4} ft./ft. Overall, an average hydraulic gradient of 5.7x10^{-4} ft./ft was determined for the lower aquifer; however, further downgradient the hydraulic gradient increases with proximity to pumping well DN-13 (Section 2.7.6).

The calculated groundwater velocity range will depend on the range of K, I_h, and n_e used in the equation above for the upper aquifer. Using the hydraulic conductivity range of 260 and 440 ft./day, an estimated effective porosity of 10% and the average hydraulic gradient in the lower aquifer unit of 5.7×10^{-4} ft./ft., the estimated groundwater velocity ranges from 1.5 to 2.5 ft./day in the lower aquifer sand and gravel units.

The average groundwater velocities calculated above provide an indication of the advective transport velocities associated within the lower aquifer at the Site. Given the variability of hydraulic conductivities in the lower aquifer, locally faster or slower transport velocities are likely.

The lower aquifer characterization is based on a relatively small data set when compared to the upper aquifer. The estimate for mass transport velocity was based on plume movement and upper aquifer release times (lower aquifer source is upper aquifer source downward migration through regional clay till - Section 2.7.5.1.2.3). An estimated total porosity value of 40%, a hydraulic conductivity value of 400 ft./day and the observed hydraulic gradient of 6.8×10^{-4} ft./ft. (well pair GM-67D/RMW-87 [closest to the area of release for the lower aquifer] - Table 4) was used for the estimated mass transport velocity calculation. For the evaluation of corrective measures options presented in Section 4, an estimated contaminant mass transport velocity of 0.7 ft./day (sand and gravel facies) was used for the lower aquifer. Further testing may be needed to identify the most representative value or values for the lower aquifer.

2.7.4.3 Groundwater Vertical Gradients

Vertical hydraulic gradients between the upper aquifer above the upper clay till, upper aquifer and the lower aquifer were calculated for the groundwater-elevation data collected on September 24 and 25, 2012. Sixteen pairs of upper and lower aquifer wells were used to calculate the vertical hydraulic gradients upgradient, on-site, at the former Oil House Area, and off-site and downgradient (Table 5). One well pair at the former Oil House Area was used to calculate vertical hydraulic gradients within the upper aquifer (Table 5). Vertical gradients were calculated using the following equation:

$$I_V = \frac{h_{upper} - h_{lower}}{D_V}$$

Where

I_v = vertical gradient (ft./ft.)
h_{upper} = groundwater elevation in upper aquifer monitoring well (ft. AMSL)
h_{lower} = groundwater elevation in lower aquifer monitoring well (ft. AMSL)
D_v = distance between midpoint of lower screen and midpoint of saturated section of upper screen (ft.)

Table 5 summarizes the vertical gradients at the Site. Vertical gradients ranged between 2.1 x 10^{-2} ft./ft. downward to 6.0 x 10^{-3} ft./ft. upward. Based on the spatial distribution of the monitoring well pairs, it appears the overall vertical gradient for the upper aquifer upgradient, on-site, and downgradient is downward. However, there were three on-site well pairs (HR-3/HR-13, GM-68S/GM-68D, and GM-75S/GM-75D) with an upward gradient. There was no upper aquifer vertical gradient at well pair GM-23/GM-27.

2.7.5 Soil and Groundwater Quality

As described in previous sections, several investigations have been completed at the Site that evaluated extent of site-specific VOCs in soil, groundwater, and soil-gas. To these extents, historic and current IMs have addressed many areas of the Site (Section 2.6). Refinements of the distribution of site-specific VOCs have incorporated a historical view of the Site and recent data collected during the pre-design investigation (Appendix F), Landfill L1 investigation (Appendix E), and site-wide annual groundwater monitoring. This information has provided an enhanced-detailed view of the current distribution of site-specific VOCs.

In accordance with the *Site-Wide Groundwater Monitoring Plan* (ARCADIS Geraghty & Miller, Inc. 2002) and modifications from the *Site-Wide Groundwater Monitoring Report* for 2011 (ARCADIS, Inc. 2012b), 60 upper aquifer and lower aquifer monitoring wells were sampled for the site-wide monitoring event in September 2012. The locations of these wells are shown on Figure 2 and results for site-specific VOCs are presented in databox figures for the upper and lower aquifer, respectively (Figures 7 and 8), from the annual monitoring events.

2.7.5.1 Current Sources

2.7.5.1.1 Vadose Soil

During the RFI, Supplemental RFI, and supplemental investigations, areas were investigated with respect to evaluating the potential for soil source contamination, delineating source material, if present, and delineating groundwater concentrations. In addition, activities completed as part of the pre-design investigation involved soil sampling at areas not previously investigated and resampling of previously investigated areas, including Landfill L1. The findings of these investigations are summarized in Sections 2.4 and 2.5 and supporting documentation is presented in Appendices A through F. The current understanding of soil source contamination is summarized by the categories of primary and secondary sources based on known historical and current concentrations. A primary source is considered to be a major contributor to site-specific VOCs leaching to groundwater. A secondary source is considered to be a minor contributor to site-specific VOCs leaching to groundwater.

- The primary source area of PCE and TCE in the vadose zone is the former Oil House Area. Multiple phases of investigations were completed during the Supplemental RFI to delineate this area.

- Secondary source areas of PCE and TCE have been identified based on previous investigations and include the Box Sewer, West Tank Farm, WPSA, former Building 14, former Building 21, and Landfill L1.

- Shallow soil concentrations in the vadose zone at the Process Sump Area investigation did not indicate the presence of source material; however, deeper soil concentrations just above the water table (32-34 ft. bls) and saturated soil concentrations (e.g., samples collected between 50 and 68 ft. bls) do indicate the presence of source material. The lack of source material in the vadose zone above indicates that the source for the unsaturated material above the water table (e.g., capillary fringe) may be due to groundwater by mechanism of soil sorption by water table fluctuation and/or soil-gas (U.S. EPA 2005). The significance of this source material is further discussed in Section 2.7.5.1.2.

2.7.5.1.2 Groundwater

2.7.5.1.2.1 Upper Aquifer Groundwater Sources

Based on the historic and current data, the primary source of site-specific VOCs in the upper aquifer includes leaching from the vadose zone at the former Oil House Area and the source material present at depth beneath the water table at the Process Sump Area. Secondary source areas that may be contributing to downgradient plume concentrations, but to a lesser extent, include the Box Sewer, West Tank Farm, WPSA, former Building 14, former Building 21, and Landfill L1 (Figures 3 and 4).

The historic highest concentrations (prior to 2012) of site-specific VOCs in the upper aquifer across the Site was present at the former Oil House Area centered on monitoring well GM-23 screened above the upper clay till (screen depth of 24 to 34 ft. bls). At GM-23 in March 1998, the total site-specific VOC concentration was 19,706 µg/L from primarily parent PCE and TCE and daughter compound cis-1,2-DCE concentrations (ARCADIS Geraghty & Miller, Inc. 2000b). Current concentrations in 2012 are much lower at GM-23 due to ongoing IMs at RZ-1 above the upper clay till in the vicinity of GM-23 (Figure 7). The investigation data obtained in 2012 near the Process Sump Area has identified a significant occurrence of primarily parent products PCE and TCE with minor cis-1,2-DCE concentrations in groundwater within interbedded silts, sands, and clay that was not previously known (Appendix F). The highest total CVOC concentration was 63,000 µg/L consisting totally of PCE and TCE at vertical aquifer profiling sample point PSA-5(45-50 ft. bls) (Appendix F). This sampling location is in the lower portion of the upper aquifer just above the regional clay till.

2.7.5.1.2.2 Potential Residual DNAPL Upper Aquifer Source

The pre-design investigation soil data included continuous soil cores that were screened using a photo-ionization detector (PID) and visually inspected. All intervals that exhibited visible staining, or the presence of dense non-aqueous phase liquid (DNAPL), and/or elevated PID readings (>100 ppm) was also field screened for DNAPL using a hydrophobic dye test (Appendix F). At the Process Sump Area, globules were visible and the hydrophobic dye test was positive for PSA-6 (58-60 ft. bls). This confirmed that residual DNAPL is present in the interbedded facies at this location of the upper aquifer at the Process Sump Area. Additional lines of evidence indicating the potential presence of DNAPL was developed by evaluating PCE and TCE concentrations in groundwater and soil pore water. Concentrations exceeding 10% of the aqueous solubility of each compound were considered an indication of potential residual DNAPL presence. To support corrective measures screening and development of cost estimates, the volume of potentially affected soil and a range of potential residual DNAPL mass were estimated based on the following analysis.

Residual DNAPL is the presence of DNAPL as pore space saturation that is discontinuous, immobile, small in size and dominated by capillary forces. While residual DNAPL may only occupy a small fraction of the soil pore spaces, when considered in terms of the total volume of soil in an impacted area, residual DNAPL mass can be substantial. The calculated volume was used to determine the mass of residual DNAPL within this area, based on an appropriate range of estimates for the fraction of soil pore space containing DNAPL.

To determine the extent of potential DNAPL impacts at the Site in the vicinity of the Process Sump Area, the concentrations of PCE and TCE in soil pore water were calculated from soil samples collected from saturated soil material. The concentration within the saturated soil pore water was calculated using the equation below (Feenstra et al. 1991) and the soil characteristics and chemical properties provided in Table 6.

$$C_W = C_T \rho_b / (K_{oc} f_{oc} \rho_b + n_w)$$

Where:

C_T = measured total saturated soil concentration (milligrams per kilogram [mg/kg])
C_w = concentration in soil pore water (milligrams per liter [mg/L])
K_{oc} = organic carbon based partition coefficient (cubic centimeters per gram [cm^3/g])
f_{OC} = fraction of organic carbon in soil (dimensionless)
ρ_b = dry bulk density of soil sample (grams per cubic centimeter [g/cm^3])
n_w = water filled porosity

Soil pore water concentrations (Table 7) greater than a conservative value of 10% of the solubility were assumed to be indicative of residual DNAPL within the soil pore space. The solubility of PCE and TCE was assumed to be 150 mg/L and 1,100 mg/L, respectively (Montgomery and Welkom 1990). Where soil pore water concentration greater than the solubility was observed the concentration was stated as being saturated with PCE or TCE, as appropriate.

Soil pore water concentrations which indicated the presence of DNAPL were observed for PCE and TCE at the following Process Sump Area soil borings (Appendix F):

- PCE: PSA-5 (60-62 ft. bls), PSA-6 (58-60 ft. bls) and PSA-8 (56-58 ft. bls).

- TCE: PSA-5 (54-56 ft. bls), PSA-6 (50-53 ft. bls), PSA-6 (58-60 ft. bls) and PSA-7 (50-52 ft. bls).

The soil pore water concentrations for PCE at PSA-6 (58-60 ft. bls) and PSA-8 (56-58 ft. bls) were above the solubility of PCE and the data suggests that the fraction of pore space occupied by DNAPL at these locations was 0.23 and 0.02% respectively. The fraction of pore space occupied by DNAPL was calculated using the equation below (Feenstra et al. 1991). This was consistent with field data collected from the hydrophobic dye test which showed a positive detection for DNAPL at PSA-6 (58-60 ft. bls); however, observations from the PSA-8 (56-58 ft. bls) dye test was inconclusive. The data indicates that only a small fraction of the total pore space is occupied by residual DNAPL, and additionally it is interpreted that the distribution of residual DNAPL is not uniform across the entire area.

$$nDNAPL = (C_T\rho_b - (K_{oc}f_{oc}\rho_b S + Sn_w)) / \rho NAPL$$

Where:
nDNAPL = fraction of porosity occupied by DNAPL
S= Solubility
ρNAPL = density of DNAPL

Soil pore water concentrations above 10% of the solubility of PCE and TCE was used to establish a volume of potential DNAPL presence at the Site. This volume of potential DNAPL is shown for PCE and TCE in the three-dimensional analysis (Appendix J - Figures J-1 through J-11). The volume of potential DNAPL impacts was calculated and found to be 215,000 cubic ft. for PCE and 221,000 cubic ft. for TCE.

This volume estimate for the likely extent of DNAPL was used to predict a range of possible PCE and TCE DNAPL mass trapped within the interbedded finer grained sand, silts and clays at the Site (Process Sump Area) using the following equation:

$$M_{DNAPL} = V_{DNAPL} \times nDNAPL \times \rho NAPL$$

Where:
M_{DNAPL} = Mass of Residual DNAPL
V_{DNAPL} = Volume of DNAPL extent

The residual DNAPL mass was calculated for fractions of pore space occupied by DNAPL ranging from 0.12 to 0.4%, corresponding to a DNAPL saturation of 0.31 to

1%. The DNAPL saturation is equal to the fraction of pore space occupied by DNAPL divided by the total porosity (assumed to be 40%), and both of these parameters are shown in Table 8.

The minimum fraction of pore space occupied by DNAPL (0.12%) was the average of the fraction indicated at PSA-6 (58-60 ft. bls) and PSA-8 (56-58 ft. bls). The maximum value for the range of pore space occupied by DNAPL (0.4%) was based on observations from sites with similar geology which indicate DNAPL saturations of 1% are a reasonable assumed value for DNAPL saturation in coarse sand units.

The range of potential mass remaining for PCE and TCE DNAPL within the bounding envelope shown in the three-dimensional analysis (Appendix J) is provided in Table 8. The data suggests that a likely order of magnitude approximation for the residual DNAPL mass at the Site (Process Sump Area) is between 25,000 and 85,000 pounds for PCE and 25,000 and 80,000 pounds for TCE. While these numbers should only be considered order of magnitude estimates, it is important to note that there could be substantial mass of residual DNAPL stored within the finer grained silts and clays at the Site, which should be accounted for in any corrective measures assessment (Sections 4 and 5).

2.7.5.1.2.3 Lower Aquifer Groundwater Source

Based on historical and current concentrations of site-specific VOCs in the lower aquifer across the Site, the primary source for lower aquifer concentrations is the vertical migration of upper aquifer site-specific VOCs downward through the regional clay till. The area with the highest site-specific VOC concentrations correlates directly with the Process Sump Area upper aquifer source material (Appendix J - Figures J-1 through J-11). There are concentrations of cis-1,2-DCE present in the lower aquifer detected at upgradient profiling point NP-3 converted to monitoring well RMW-88 (Appendix F) that are not associated with the on-site VOC distribution.

2.7.5.1.2.4 Soil-Gas

The results of the vapor intrusion assessment activities are presented in Appendices D and E. The presence of PCE and TCE detected in the off-site soil-gas investigation is due to the upper aquifer plume. The sub-slab and indoor air samples collected from several buildings located within the Riverview Plat neighborhood indicates that a direct exposure pathway for vapor intrusion of PCE and TCE exists. Based on the spatial distribution of the upper aquifer PCE and TCE groundwater plumes (Appendix J -

Figure J-5), soil-gas containing PCE and TCE has the potential to affect structures on-site, as further discussed in the HHRA (Section 3.2 and Appendix G).

2.7.5.2 Distribution of Groundwater Site-Specific VOCs

The three-dimensional data analysis results indicate the extent of the site-specific VOCs in groundwater (Appendix J). The upper and lower aquifer plume depictions are illustrated in two-dimensional versions of the three-dimensional model shown in plan and profile views (Appendix J - Figures J-1 through J-11). As these data show the current understanding of the groundwater plume, it is important to note that current IMs have significantly reduced concentrations on-site. Groundwater concentration trends are presented on the databox figures for the upper and lower aquifers from baseline conditions in 1999 to 2012 (Figure 7 and 8).

2.7.5.2.1 Upper Aquifer

The upper aquifer plume area with the highest concentrations occurs in the potential area of residual DNAPL mass. The upper aquifer plume area of total CVOCs, on the order of 1,000 µg/L and greater, occur at depths just above the regional clay till and surrounds the area of potential residual DNAPL. This area is located at the Process Sump Area and may extend beneath Springboro Road towards the northern portion of the Box Sewer. The width of this source material perpendicular to groundwater flow is approximately 300 ft. across with a thickness of 20 to 25 ft. based on the 1,000 µg/L total CVOC concentration contour (Appendix J - Figure J-5). These concentrations of primarily PCE and TCE are stored in the interbedded units present within the deeper portion of the upper aquifer. Groundwater flow through this area is within the coarser grained sand and gravel channels that cut through the interbedded units and transport the site-specific VOCs. Migration to the east is limited due to the barrier of the upper clay till and the regional clay till thickening and pinching out the upper aquifer between the units (Figure 9 and Appendix J). Estimated remnant concentrations are present at the former Oil House Area above 1,000 µg/L to the northwest of the Process Sump Area with lower concentrations downgradient due to the ongoing effectiveness of IM RZ-1. As there is no direct link between concentrations at the Process Sump Area and the northern part of the Box Sewer with the former Oil House Area, it is evident that migration was not surficial as vadose zone soils are not impacted (Appendix F). There may be a potential for an impacted area to be present between the former Oil House Area and the Process Sump Area requiring further evaluation.

Plume migration follows groundwater flow downgradient under the former Moraine Engine and former Building 14, expanding to a width of approximately 1,200 ft. across the entire upper aquifer zone based on concentrations greater than 100 µg/L. Recognized secondary sources to groundwater may contribute to the downgradient plume (Section 2.7.5.1.1). Near the property boundary, the plume is partially cut off by current IMs RZ-3 west/east and RZ-4. Minor contributions are observed from Landfill L1. The west end of the main plume continues to migrate downgradient under the Riverview Plat neighborhood towards the Great Miami River. Concentrations greater than 50 µg/L total CVOCs extend beneath the river with concentrations slightly greater than 5 µg/L extending west towards the Moraine Air Park and south of Holes Creek.

Also observed is a southern migration of concentrations greater than 5 µg/L total CVOCs as far east as GM-2 and as far south as off-site well GM-78 (Appendix J - Figure J-5).

The extent of 5 µg/L for PCE and TCE is shown in Appendix J - Figures J-1 and J-3, respectively. This extent can also be viewed in the three-dimensional plume maps in Appendix J. Northern extents upgradient of primary sources are not observed. PCE concentrations above its MCL of 5 µg/L extend west of the Site bounded by non detections at GM-83S, HR-16, W-2-S, and GM-79. PCE concentrations above its MCL extend to the east of the Site bounded by GM-25, GM-53, GM-22, and GM-21. However, PCE concentrations re-occurred above its MCL at GM-78. TCE concentrations above its MCL of 5 µg/L extend west of the Site bounded by HR-7, GM-83S, HR-16, and GM-79. TCE concentrations above its MCL extending east of the Site are bounded by PSA-1, BOX-4, GM-22, and downgradient of the Site are bounded by GM-2, GM-55, and GM-26. Concentrations above the MCL for TCE extend as far downgradient as off-site well GM-80.

2.7.5.2.2 Lower Aquifer

The lower aquifer plume area with the highest concentrations on the order of 100 µg/L total CVOCs and greater occurs at depths just below the regional clay till to approximately 75 to 90 ft. This occurrence is in the vicinity of the highest concentrations in the upper aquifer at the Process Sump Area (Appendix J - Figure J-8).

Plume migration follows groundwater flow towards IM lower aquifer pumping well DN-13 (Section 2.7.6). The lower aquifer total CVOC plume maximum width is 2,300 feet. The plume is bounded by GM-83D to the west and GM-84 to the east. Concentrations do not extend downgradient of DN-13. However, low concentrations occur to the southeast of DN-13 at off-site well GM-9 which is the southernmost extent.

The extent of 5 µg/L for PCE and TCE is shown in Appendix J - Figures J-2 and J-4, respectively. Cis-1,2-DCE upgradient of the Site is below its MCL (70 µg/L) for well RMW-88; however, concentrations were slightly above its MCL for vertical aquifer profiling sample NP-2(95-100 ft. bls). PCE concentrations above its MCL extend west of the Site bounded by non detections at on-site wells RMW-87 and GM-15. PCE concentrations above its MCL extend to the east of the Site bounded by GM-84 and to the south by GM-1. TCE concentrations above its MCL extend to the west bounded by GM-83D and to the east by GM-84. The southern extent of TCE is bounded by off-site well GM-65D.

2.7.6 DN-13 Capture Zone Analysis

Pumping well DN-13 is utilized to capture site-specific VOCs in lower aquifer groundwater. To determine the effectiveness of DN-13 hydraulic capture, lines of evidence were evaluated and have been produced following the general procedures outlined in the U.S. EPA guidance, A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems (U.S. EPA 2008b).

1. Review site data, site conceptual model, and remedial objectives.

2. Define site-specific target capture zone(s).

3. Interpret groundwater levels.

4. Complete calculations for basis of hydraulic capture.

5. Evaluate groundwater concentration trends.

6. Interpret site capture.

2.7.6.1 Review of Site Data, Site Conceptual Model, and Remedial Objectives

The initial steps for capture zone analysis included review of the conceptual site model, including hydrogeologic structure, hydraulic conductivity, Site groundwater elevations (Table 3), Site groundwater horizontal and vertical gradients (Tables 4 and 5), and DN-13 pumping rates.

A depiction of the lower aquifer, the location of the predominantly continuous regional clay till unit, and the screened interval of monitoring wells and DN-13 is presented in three-dimensional view of the Site (Appendix J). The lower aquifer hydraulic conductivity ranges from 260 to 440 ft./day (Section 2.7.4.1.1.2). Site groundwater elevations for the lower aquifer are depicted on Figure 6 and show groundwater flow trending northeast to southwest across the site. From January through November 2012, DN-13 pumping rates ranged from 0.84 to 1.4 MGD.

2.7.6.2 Define Site-Specific Target Capture Zone

The target capture zone for DN-13 is the plume extent within the lower aquifer (Section 2.7.5.2.2). The pumping program is utilized to control the migration of the plume and capture the plume downgradient of the source areas. The hydraulic capture is focused entirely on the lower aquifer. The lower aquifer plume extent in 2012 is depicted on Appendix J - Figure J-8 and three-dimensional views provided in Appendix J. The maximum plume width (perpendicular to groundwater flow) for the lower aquifer total CVOC plume was estimated to be 2,300 ft. To account for some uncertainty in this delineation an additional 250 ft. was added (i.e., 125 ft. on either side) which results in an approximate plume width of 2,550 ft.

2.7.6.3 Interpret Groundwater Levels

Groundwater elevation data are lines of evidence used to demonstrate hydraulic capture and are measured on an annual basis at the Site (Table 3) as discussed in Section 2.7.4.1.2.2. In general, the lower aquifer groundwater flow in 2012 is primarily from the northeast to the southwest directly in line with DN-13 (Figure 6). Groundwater elevation data of surrounding monitoring wells and known drawdown at DN-13 of greater than 50 ft. indicate a cone of depression is evident in the vicinity of pumping well DN-13 with groundwater flow towards the pumping well (Figure 6).

2.7.6.4 Complete Calculations for Basis of Hydraulic Capture

To verify the interpretation of field data, such as a groundwater level potentiometric map, additional flow calculations were completed to evaluate the extent of capture.

2.7.6.4.1 Groundwater Flux Calculation

As outlined in the guidance, A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems (U.S. EPA 2008b), the simplest and most commonly applied horizontal capture zone calculation is the estimated flow rate calculation. Through application of Darcy's law, this calculation provides an estimated pumping rate required to capture the groundwater flux through the extent of the plume. This estimated groundwater flux/required pumping rate can then be compared to the actual pumping rates measured in the field to assess whether or not the system is pumping at a rate sufficient to capture the plume.

Simplifying assumptions for this calculation include the following:

- Homogeneous, isotropic aquifer of infinite extent.
- Confined aquifer, uniform aquifer thickness.
- Fully penetrating recovery well(s).
- Uniform regional horizontal hydraulic gradient.
- Steady-state flow.
- Negligible vertical gradient.
- Net recharge is accounted for in the regional hydraulic gradient.
- No other sources of water to the recovery well (e.g., flux from rivers or from other aquifers), except as represented by the "factor" in the estimated flow rate calculation.

The recovery rate or groundwater flux was calculated using the following equation:

Q = K*i*(b*w)*factor

where:

Q is the volumetric recovery rate or groundwater flux (ft^3/day)

K is the hydraulic conductivity (ft/day)

i is the regional hydraulic gradient (ft./ft.)

b is the saturated thickness (ft.)

w is the plume width (ft.)

factor is intended to account for other contributions to the pumping well such as flux from a river or induced vertical flow from other stratigraphic unit; the assumed value is 1.5 to 2.0 (U.S EPA 2008)

As noted in the U.S. EPA guidance document, this calculation requires an estimate of the regional hydraulic gradient, without the influence of pumping. Because regional hydraulic gradients often change with time, U.S. EPA (2008) suggests that, in some cases, groundwater level data obtained cross-gradient or even up-gradient, collected during the remedy implementation, may be more appropriate than pre-remedy groundwater level data for calculating regional hydraulic gradient. The average hydraulic gradient for the lower aquifer in 2012 is 5.7×10^{-4} ft./ft. (Table 4).

The hydraulic conductivity, K, for the lower aquifer ranges from 260 to 440 ft./day.

As noted in Section 2.7.6.2, the plume is conservatively estimated to be approximately 2,550 ft. wide. The estimated saturated thickness of the lower aquifer is 85 ft.

Using the parameter values listed above, the groundwater flux/required pumping rate was calculated for the Site and shown in the table below.

Condition	Hydraulic Conductivity (ft./day)	Hydraulic Gradient (ft./ft.)	Saturated Thickness (ft.)	Lower Aquifer Plume Width (ft.)	Factor	Groundwater Flux/Pumping Rate (MGD)
2012 Minimum	260	5.7 x 10-4	85	2,550	2	0.48
2012 Maximum (Conservative)	440	5.7 x 10-4	85	2,550	2	0.81

Note that a maximum factor of 2 was applied in all cases to provide a conservative range in groundwater fluxes. For the given range in hydraulic conductivity values, the minimum and maximum estimated groundwater fluxes through the target capture zone are approximately 0.48 and 0.81 MGD, respectively. Compared to the current recovery rate range at DN-13 of 0.84 to 1.4 MGD, the estimated DN-13 groundwater flux/required pumping rate under both hydraulic conductivity conditions is less than the current range of operating pumping rates at DN-13.

Therefore, even after incorporating an overly conservative set of parameters and a maximum factor of safety, the results of this calculation suggests that the current operating rate of the DN-13 is sufficient to capture the plume.

As with the calculations used to measure the capture zone dimensions presented in the following section, it is important to note that this analysis cannot account for aquifer heterogeneities (e.g., changes in transmissivity) nor does it account for system complexities (e.g., boundary effects, recharge, and off-site pumping), so these results represent a very simplified and idealized version of the actual flux through the aquifer.

2.7.6.5 Vertical Gradients

Vertical gradients were calculated from available upper and lower aquifer well pairs within the vicinity of DN-13 including GM-10/GM-9, GM-16/GM-15, GM-18/GM-13, and GM-17/GM-11. The calculated gradients presented in Table 5 indicated that a negative (downward) gradient is present.

2.7.6.6 Horizontal Hydraulic Gradients

In addition to capture interpretation via potentiometric surface maps, observed water level data were also used to approximate the extent of hydraulic capture by calculating the magnitude and direction of hydraulic gradients between sets of adjacent monitoring wells located in the vicinity of the extraction wells. This triangular irregular network analysis provides a means of evaluating observed water level data.

Generally, monitoring well pairs are used as gradient control points for capture evaluation (i.e., used to demonstrate inward gradients to the pumping well). However, the current distribution of monitoring wells in the vicinity of DN-13 prohibits the designation of practical well pairs in close proximity to DN-13 to provide an accurate measure of the cone of depression. Instead, hydraulic gradients were calculated to evaluate the flow direction (gradient angle and magnitude) using water level data from sets of three adjacent monitoring wells (Devlin 2003). This method of analysis is consistent with and presented in U.S. EPA's A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems (U.S. EPA 2008b).

The hydraulic gradients were evaluated using 2011 and 2012 groundwater elevation data to better assess the hydraulic influence of DN-13. Results of the evaluation are presented, including the hydraulic gradient and flow direction, in Tables 9 and 10 for 2011 and 2012, respectively. Seven sets of three groundwater elevations of adjacent monitoring wells in the vicinity of DN-13 were evaluated. Locations of the selected monitoring well sets relative to DN-13 are shown in Figures 5 and 6. The groundwater flow directions (hydraulic gradients) in the lower aquifer displayed on Figures 11 and 12 (2011 and 2012, respectively) demonstrate DN-13 capture. As depicted on Figures 11 and 12, the primary direction of groundwater flow is directed towards DN-13.

2.7.6.7 Concentration Trends

Plume migration follows groundwater flow towards pumping well DN-13 (Figure 6 and Appendix J). Concentrations of site-specific VOCs above MCLs do not extend downgradient of DN-13 except for cross gradient monitoring well GM-9 (TCE detected at 16 µg/L in 2012; Figure 8). The concentrations at GM-9 have been steady since 1999 and indicate that the well is being captured. Concentrations of site-specific VOCs detected at DN-13 have been steady since 2001 (Figure 8) indicating DN-13 is capturing the plume. Section 2.7.5.1.2.3 presents the details on the distribution of site-specific VOCs in groundwater in the lower aquifer.

2.7.6.8 Interpret Capture

The lines of evidence evaluated indicate sufficient capture within the lower aquifer exists to mitigate and control the migration of contaminants off-site. The lines of evidence and a summary follows:

1. Interpret Groundwater Levels - the lower aquifer groundwater elevation data indicated that groundwater flows from the northeast to the southwest towards pumping well DN-13.

2. Groundwater Flux Calculation - the groundwater flux calculation based on conservative data inputs indicated that the DN-13 pumping rate is sufficient to capture the width of the plume.

3. Vertical Gradients - the vertical gradients calculated indicated an overall negative (downward) gradient from the upper to lower aquifer.

4. Horizontal Hydraulic Gradients - the horizontal gradient evaluation indicated that there is capture in the vicinity of pumping well DN-13.

5. Evaluate Groundwater Concentration Trends - this evaluation indicated that VOC concentrations at DN-13 have remained steady. In addition, concentrations of

VOCs in off-site lower aquifer groundwater monitoring wells downgradient of DN-13 indicate there is no migration of VOCs beyond pumping well DN-13.

All lines of evidence suggest that sufficient hydraulic capture within the lower aquifer at the Site has been achieved.

2.7.7 Groundwater Flow Model Refinement

The 2008 Groundwater Flow Model Update presented the revised three-dimensional groundwater flow model (2008 CMP [ARCADIS, Inc. 2008]). In 2008, it was deemed necessary to revise the previous 1994 version of the flow model and incorporate supplemental investigation acquired hydrogeologic information. The objectives of the modeling study in 2008 were to update and refine the numerical groundwater flow model to support the 2008 CMP.

The updates/refinements to the previous model included the following:

- Finite-difference grid refinement (horizontally and vertically).
- Minor adjustment to active model domain (i.e., no-flow boundaries) based on the updated topographic information.
- Identification and delineation of the upper clay-till and incorporation into the previous groundwater flow model.
- Revised delineation of the areal extent of the regional clay-rich aquitard.
- Revised recharge distribution.
- Updated river stage elevations and riverbed conductance values (Great Miami River and Holes Creek).
- Updated extraction well data (i.e., municipal water supply well and remediation well locations and pumping rates).
- Updated observed water elevations (i.e., re-calibration targets).

The refined numerical groundwater flow model was then re-calibrated to 2005-2006 flow conditions and results indicated that the re-calibrated groundwater flow model is able to effectively simulate the current groundwater flow conditions at the Site.

The re-calibrated model, therefore, is an effective tool that can be used to support a variety of environmental management/remedial strategy decisions. The model was used to support dilution factor calculations for the HHRA (Appendix G and Section 3.2) and GSI calculations (Appendix K and Section 2.7.8) in this 2012 CMP.

2.7.8 Groundwater-Surface Water Interaction

As requested by the U.S. EPA and Ohio EPA in correspondence from May 2010 through March 2011, the GSI assessment provides information on:

- GSI for surface water reaches downgradient of the Site.
- Waste load allocation (WLA) calculations for discharge of pollutants to receiving surface water reaches downgradient of the Site for the site-specific list of VOCs.
- Comparison of WLA calculated values to current groundwater concentrations of site-specific VOCs.
- Human health and ecological screening assessment to include recreational fishing.
- Evaluation of potential sediment exposures.

Detailed information on the calculations and risk screening are presented in Appendix K.

In summary, the Great Miami River and Holes Creek are losing reaches adjacent to the Site with groundwater flux equal to 0 cubic ft. per second. To calculate WLAs for the associated surface water bodies, a hypothetical (conservative) scenario was used with no regional or Site groundwater pumping occurring. Only the Great Miami River reach was gaining under this hypothetical scenario and a groundwater flux was calculated to use for the WLAs.

Groundwater concentrations from monitoring wells adjacent to the Great Miami River are below associated WLAs, which are derived using both ecological and human health benchmarks (i.e., Ohio Surface Water Criteria, U.S. EPA Region 5 ESLs, and U.S. EPA MCLs). Therefore, even under a conservative scenario, off-site groundwater concentrations are not expected to result in surface water or pore-water concentrations in the Great Miami River that would pose a risk to human health or the environment. Additionally, the fish consumption pathway is not expected to be of significant concern in the Great Miami River because the site-specific constituents (primarily PCE and TCE) in groundwater are not expected to bioaccumulate. Similarly, there are no data to suggest that either of these constituents would accumulate in sediment over time. Further, fish consumption in these water bodies is not expected to be a significant pathway because a subsistence fishing population does not likely exist in the City of Moraine and the current fish consumption advisory would be expected to mitigate potential fish consumption in the area.

2.7.9 Off-Site Private Well Survey Results

In 2007, an off-site private well survey was conducted in five areas surrounding the Site to the west, southwest, south, southeast, and east to update information from all previous surveys completed in these five areas. A summary of the off-site well survey is presented in Appendix I and the findings of the well survey are presented in the following paragraphs.

The boundaries for the five areas (Appendix I - Figure 1) were established by reviewing the site-specific VOC concentrations in the upper and lower aquifers using data collected through 2007 and incorporating the off-site areas where the groundwater plume is believed to be present above drinking water criteria (i.e., MCLs or, for constituents without MCLs, risk-based equivalent drinking water levels [EDWLs]). A review of the ODNR well log files was conducted for Areas 1 through 5 in December 2007. Well logs for located and unlocated wells were obtained from ODNR and are included in this summary report in Attachments I-1 through I-5 in Appendix I. A located well is defined as a well that the ODNR has a well log record for and can confirm its location on a map. An unlocated well is defined as a well that the ODNR has well log record for but cannot confirm its location on a map.

In addition, an internet search of Montgomery County's Real Estate Tax Information System was completed to identify each parcel in each of the five areas and the property address/owner, and telephone correspondence with the Montgomery County Water Department and the City of West Carrollton was conducted to confirm public water supply usage to each property address. Site visits were made to confirm property addresses and current property development. If a well was observed during the property drive by but there was no ODNR well log available for that well, it was defined as a "known well" in the summary tables in Attachments I-1 through I-5 in Appendix I.

Based on the well survey, there are two properties located near the Site that use well water, all other properties have public water service provided. Former GM Corporation worked with these property owners and collected samples from these wells.

- **3571/3573 Dryden Road** - While no well log was found during a search of records at the ODNR, a known well exists at this property located west of the Site at 3571/3573 Dryden Road. Field verification confirmed the location of the well at the north end of the building located at the above referenced address. According to Montgomery County Water Department, this address does not have public water service provided. The well water is used for the restroom facilities and bottled water is used for potable purposes. This property's well was sampled in July 2002 and June 2003. VOCs detected in these samples included 1,2-DCA, cis-1,2-DCE, and vinyl chloride. For both samples collected, the results for 1,2-DCA and cis-1,2-DCE were below MCLs and the vinyl chloride results (2.4 µg/L) slightly exceeded its MCL of 2 µg/L.

- **2651 Blanchard Avenue** - While no well log was found during a search of records at the ODNR, a known well exists at this property located east of the Site at 2651 Blanchard Avenue. According to the Montgomery County Water Department, this address has received public water service in the past, but disconnected service in 1996. This property's well was sampled in October 2004. VOCs detected in the samples included chloroethane, 1,1-DCA, and cis-1,2-DCE at concentrations below the drinking water criteria (MCLs and EDWLs). Carbon vessels used for water treatment at this property are operated by the current owner.

- **4000 Miller Valentine** - This property is located west of Dryden Road. According to the Montgomery County Water Department, this address has public water service. The well located at 4000 Miller Valentine Court is screened in the lower aquifer and is used on a seasonal basis to water the lawn. This property's well was sampled in July and August 2002. VOCs detected in the samples included cis-1,2-DCE and vinyl chloride at concentrations below the MCLs.

RACER Trust will work with the owners of 3571/3573 Dryden Road and 2651 Blanchard Avenue to abandon their private wells and connect them to public water supply. The property located at 4000 Miller Valentine already has public water service.

3. Risk Assessment Summary

As presented in Section 2, risk assessments have been completed for all previous investigations. A summary of the risk screening criteria and identified facility risks is presented in this section. The risk assessment findings were then used to develop the CMOs presented in this section.

3.1 Risk Screening Criteria

Over the past 20 years of investigation work at the Site, U.S. EPA guidance and industry standards have changed in regards to use of risk screening criteria in the risk assessments completed for the Site. As a result, different methods and criteria have been utilized. For simplicity, the current risk screening criteria used in the updated HHRA (Appendix G) is presented below:

- Soil - U.S. EPA RSLs for Industrial Soil (May 2012).

- Groundwater - U.S. EPA MCLs. (Although MCLs are generally not risk-based, these values are used as screening criteria to be consistent with previous risk assessments for the Site and because these values represent promulgated standards. If MCLs are unavailable for a particular constituent, the U.S. EPA RSL for tap water is used as a screening criterion.)

- Soil gas - U.S. EPA Vapor Intrusion Screening Levels (VISLs) for commercial receptors.

3.2 Summary of Identified Risks

The following presents a summary of identified risks for each investigation area:

3.2.1 RFI Baseline Risk Assessment (2000)

A BRA was conducted for the former Delphi Thermal Moraine (ENVIRON 2000a), which focused on 14 SWMUs investigated in the RFI including SWMUs undergoing closure under Ohio EPA's RCRA program (i.e., closed North and South Settling Lagoons). Potential exposures to constituents in soil and waste at the SWMUs via direct contact and airborne transport to ambient air and groundwater transport were evaluated to identify whether soil/waste at the SWMUs (and transport to groundwater) posed a human health risk that warranted corrective measures. The BRA concluded:

- No unacceptable risks for all soil- and air-related pathways.
- No unacceptable risks for groundwater under current use conditions.
- No unacceptable risks for surface water/sediment.

The RFI BRA was approved by the U.S.EPA in 2000.

3.2.2 Supplemental RFI Baseline Risk Assessment (2000)

A Supplemental BRA was conducted for the former Moraine Engine and former Moraine Assembly facilities (ENVIRON 2000b), which focused on six AOIs and evaluated potential exposures to soil via direct contact, airborne transport to ambient air, and groundwater transport. The Supplemental BRA concluded:

- No unacceptable risks associated with soil- and air-related exposure pathways.
- No unacceptable risks associated with soil to groundwater transport based on the 10 groundwater scenarios evaluated.
- Groundwater constituents at the former Oil House Area were found to have the potential to migrate to the extent that future use of the lower aquifer may be affected.

The Supplemental BRA was approved by the U.S. EPA in 2000.

3.2.3 Box Sewer Investigation (2001)

The Box Sewer Investigation (ARCADIS, Inc. 2002) focused on soils and groundwater transport in the immediate vicinity of the Box Sewer to evaluate whether there were unacceptable risks associated with these media. The risk evaluation concluded no unacceptable risks for soil and groundwater pathways.

3.2.4 Waste Pile/Staging Area Investigation (2004)

Soil and groundwater investigations were conducted as part of the WPSA Investigation (ARCADIS, Inc. 2004a). The risk evaluation concluded:

- No current exposure pathways for soil because the Site was inactive at the time.

- If pavement were removed within the WPSA, there could be potentially significant soil exposures for a future industrial/commercial scenario if the Site were redeveloped.

- Soil to groundwater transport was not identified as a significant pathway. With the removal of impacted soils (IM completed in 2005), no significant risks were identified for soil and groundwater pathways under a future industrial/commercial scenario.

Limited soil removal was conducted at the WPSA during September/October 2005 (ARCADIS, Inc. 2006). As part of the remedy, an institutional control was recommended to be part of the final site-wide remedy to limit future subsurface activities and mitigate potential exposures of direct contact to soil or vapor intrusion exposure to soil (ENVIRON 2008).

3.2.5 Building 14 Supplemental Investigation (2005)

Soil and groundwater samples were collected as part of this investigation (ARCADIS, Inc. 2005a). The data were compared to human health-based screening criteria and the evaluation concluded no unacceptable risks because concentrations were below screening criteria.

3.2.6 Updated Risk Evaluation (2008)

A supplemental risk evaluation was conducted for the former Moraine Facility (ENVIRON 2008), which built upon the RFI BRA (ENVIRON 2000a), the Supplemental RFI BRA (ENVIRON 2000b), the Box Sewer Investigation (ARCADIS, Inc. 2002a), the Waste Pile/Staging Area Investigation (ARCADIS, Inc. 2004a; 2006), and the Building 14 Investigation (ARCADIS, Inc. 2005a). Specifically, the risk analysis included an updated evaluation of potential risks and hazards associated with on-site and off-site groundwater exposures based on data collected since the RFI/Supplemental RFI and evaluation of potential soil and groundwater exposure pathways and receptors identified since the completion of the RFI/Supplemental RFI. This supplemental HHRA was presented as Appendix G to the 2008 CMP (ENVIRON 2008).

3.2.7 Sediment and Surface Water Assessment

A GSI and Human Health Screening Assessment were previously conducted for the Site (Appendix K). This assessment presents information for the former Delphi Thermal Moraine, former Moraine Engine, and former Moraine Assembly.

Groundwater concentrations from monitoring wells adjacent to the Great Miami River are below associated WLAs, which are derived using both ecological and human health benchmarks (i.e., Ohio Surface Water Criteria, U.S. EPA Region 5 ESLs, and U.S. EPA MCLs). Therefore, even under a conservative scenario, off-site groundwater concentrations are not expected to result in surface water or pore-water concentrations in the Great Miami River that would pose a risk to human health or the environment. Additionally, the fish consumption pathway is not expected to be of significant concern in the Great Miami River because the site-specific constituents (primarily PCE and TCE) in groundwater are not expected to bioaccumulate. Similarly, there are no data to suggest that either of these constituents would accumulate in sediment over time. Further, fish consumption in these water bodies is not expected to be a significant pathway because a subsistence fishing population does not likely exist in the City of Moraine and the current fish consumption advisory would be expected to mitigate potential fish consumption in the area.

3.2.8 Off-Site Vapor Intrusion Investigation and Mitigation

An off-site field investigation was completed in October and November 2010 and March 2011 to evaluate the potential for a complete vapor intrusion pathway using a phased approach. During the field investigation, soil-gas and groundwater table samples were collected near potential off-site receptors (residential and commercial structures) located in proximity to the Site. The areas of the investigation were the areas located to the east and southwest (the Riverview Plat neighborhood) of the Site. The groundwater and soil-gas data were used as part of the overall weight of evidence for evaluating the vapor intrusion pathway. Based on the results of this vapor intrusion verification investigation, the following conclusions were made:

- PCE and TCE were the primary chemicals of concern identified in soil-gas.

- Concentrations of PCE and TCE in soil-gas increased with depth which indicated that groundwater was the primary source of the PCE and TCE detected in soil-gas.

- Based on the concentrations of PCE and TCE in soil-gas, indoor air and sub-slab sampling at properties in the Riverview Plat neighborhood was completed.

Based on the lack of a site-specific VOC source in soil or groundwater and confirmation that VOCs were not detected above the soil-gas Action Levels in the samples collected, a future phase of investigation to the east of the Site was not warranted.

Beginning in March 2011, sub-slab and indoor air sampling was completed at properties where an access agreement was signed by the property owner. Since concentrations of PCE, TCE, and 1,1-DCA were detected in the sub-slab and indoor air samples collected from the properties in the Riverview Plat neighborhood at concentrations that were greater than or equal to the Action Levels, mitigation systems were offered to the property owners. Beginning in September 2011, mitigation systems were installed at properties where an access agreement was signed by the property owner. A summary of the off-site vapor intrusion investigation and mitigation are presented in Appendix D.

3.2.9 Updated Human Health Risk Assessment (2012)

The 2012 HHRA focused on investigation areas that were not previously evaluated for potential human health risks and those areas for which recent data were collected (e.g., 2011, 2012). These areas include Landfill L1, the West Tank Farm, the Box Sewer, the Process Sump Area, the Historic Fill Area, and former Building 21. Soil and groundwater were the primary focus of this HHRA. The Site is currently inactive and reasonably anticipated future land use is expected to be of an industrial/commercial nature. The selection of receptors for this HHRA mirrored those receptor groups that were evaluated in previous risk assessments and included on-site routine workers, on-site maintenance workers, on-site construction workers, off-site residents exposed to potable groundwater at public wells (i.e., Dryden North Well, Miami Shores well field, and West Carrollton well field), and off-site routine workers at several properties with private wells located at 3571/3573 Dryden Road, 2651 Blanchard Avenue, and 4000 Miller Valentine Court.

Constituents of potential concern (COPCs) were identified for soil and groundwater by comparing maximum detected concentrations to human health screening criteria (i.e., U.S. EPA RSLs and U.S. EPA MCLs). For the vapor intrusion pathway, soil-gas and groundwater concentrations were compared to U.S. EPA vapor screening levels. Identified COPCs for soil and groundwater were carried through a quantitative evaluation of potential carcinogenic risks and non-carcinogenic hazards. The on-site evaluation of the vapor intrusion pathway was a screening level assessment.

Lead was identified as a COPC for Landfill L1 soils, specifically waste material. The Adult Lead Model was used to evaluate potential lead risks for receptors at Landfill L1 and modeling results indicated that lead concentrations in soil do not pose a significant risk.

The majority of carcinogenic risks were within or less than U.S. EPA's target risk range of 1.E-04 to 1.E-06. Likewise, the majority of non-carcinogenic hazards were less than U.S. EPA's target HI of 1. The following exposure scenarios had cancer risks and/or non-cancer hazards above U.S. EPA benchmarks:

- Direct contact with groundwater at Landfill L1 for on-site construction workers.
- Direct contact with groundwater at the Box Sewer for on-site routine workers.
- Direct contact with groundwater at the Process Sump Area for on-site routine workers and on-site construction workers.
- Ingestion of potable groundwater under Pumping Scenarios #1, #2, #3, and #4.

Direct contact with groundwater in these areas of the Site may present a health concern. However, as mentioned previously, depth to groundwater across the Site averages 23 ft. bls, which most likely precludes direct contact exposures. Likewise, although risks associated with ingestion of potable groundwater under Pumping Scenarios #1, #2, #3, and #4 are above USEPA benchmarks, this pathway is based on hypothetical future scenarios which assume inactive wells are turned on in the future; this assumption is very conservative because current groundwater supply wells are adequately serving off-site residents and it is also expected that on-site source control will continue to mitigate the migration of the on-site groundwater plume to these off-site wells (i.e., Dryden North well, Miami Shores Well field, and West Carrollton Well field).

The evaluation of off-site routine workers at properties with private wells included the comparison of groundwater concentrations to U.S. EPA MCLs. Groundwater concentrations at the property location of 3571/3573 Dryden Road had a slight exceedance of the vinyl chloride MCL; however, well abandonment will be recommended as part of the final remedy. Groundwater concentrations of COPCs at the 2651 Blanchard Avenue property and the 4000 Miller Valentine Court property were below MCLs.

A screening level vapor intrusion evaluation was conducted for Landfill L1 using available soil-gas data. Several VOCs exceeded soil-gas screening levels; however, Landfill L1 will not likely be developed in the future and if it is, vapor barriers would be used to mitigate potential exposures. The site-wide vapor intrusion evaluation was conducted using groundwater data. PCE, TCE, and vinyl chloride exceeded target groundwater concentrations for the protection of indoor air. To address this issue, vapor barriers with engineering controls will be used in future on-site construction to mitigate exposures.

3.3 Site-Wide Corrective Measures Objectives

The CMOs are based on the RFI, Supplemental RFI, and supplemental investigation results, including the BRA conclusions; Supplemental BRA conclusions; CMP supplemental risk assessment; requirements of the AOC; and U.S. EPA guidance (U.S. EPA 1994). The CMOs address the site-specific VOCs in soil and groundwater, exposure routes and receptors identified in the BRA, Supplemental BRA, CMP supplemental risk assessment, and a media-specific cleanup standard.

The CMOs for the protection of human health for the upper aquifer are as follows:

1. Address VOC mass from historic releases from the primary source area (former Oil House Area), including the VOC mass delineated near the Process Sump Area.

2. Limit future migration of VOCs from the primary source area to downgradient portions of the upper aquifer and into the lower aquifer.

3. Prevent the migration of VOCs at concentrations exceeding the MCLs beyond the existing plume boundary.

4. Continue implementing the final corrective measures until the CMOs are achieved on-site and MCLs can be met and maintained at the property line point of compliance without active remedial measures.

The CMOs for the protection of human health for the lower aquifer are as follows:

1. To maintain the lower aquifer as usable groundwater for potential off-site, downgradient drinking water uses.

2. Prevent the migration of VOCs at concentrations exceeding MCLs beyond the existing plume boundary.

3. To meet and maintain MCLs at the downgradient property line point of compliance without active remedial measures.

The CMOs for the protection of human health for the vapor intrusion pathway are as follows:

1. Limit future migration of VOCs from groundwater and soil-gas to indoor air in on-site buildings through the use of institutional controls that require use of engineering controls in future construction.

2. Limit future migration of VOCs from on-site sources in groundwater to downgradient receptors and soil gas to indoor air in off-site buildings through the placement of vapor intrusion mitigation systems in existing structures and by limiting downgradient migration of on-site constituents in the upper and lower aquifers.

4. Summary of Corrective Measures Options

The identification and screening process of potentially applicable final corrective measures technologies for implementation at the Site is presented in this section. The purpose of this section is to identify and comparatively evaluate appropriate remedial technologies, taking the current IMs into consideration, and identify which technology(s) are best suited to achieve the adapted CMOs presented in Section 3.3.

Site-specific CMOs were established to evaluate the capability of the corrective measures alternatives to meet those objectives. The objectives are based on the RFI, Supplemental RFI, and supplemental investigation results, including the BRA conclusions; Supplemental BRA conclusions; CMP supplemental risk assessment included as Appendix G; requirements of the AOC; and U.S. EPA guidance (U.S. EPA 1994). The CMOs address the VOCs in groundwater, exposure routes and receptors identified in the BRA, Supplemental BRA, CMP supplemental risk assessment, and a media-specific cleanup standard. Section 3.3 outlines the CMOs for protection of human health, the final corrective measures were evaluated to achieve these CMOs.

As discussed in Section 2.7, the distribution of contamination and hydrogeology vary significantly when comparing the upper and lower aquifer units. Similarly, the CMOs for on-site groundwater vary when comparing the CMOs for off-site groundwater. Therefore, corrective measures options for groundwater have been divided into sub-categories to select corrective measures tailored to each sub-category specific set of objectives and conceptual site model. The sub-categories include:

1. Groundwater source areas including:
    - The Process Sump Area
    - The former Oil House Area
2. Diffuse groundwater (e.g., all remaining groundwater not addressed as part of a source strategy) including:
    - On-site Upper Aquifer
    - On-site Lower Aquifer
    - Off-site Upper Aquifer

- Off-site Lower Aquifer

A description of the corrective measures screening process, technology evaluation, and selection for each sub-category is provided below.

4.1 Corrective Measures Options Screening Process

In general, the U.S. EPA's Treatment Technologies Screening Matrix (FRTR, Version 4.0) was used as the primary means for the identification and screening of technologies for the various corrective measures options presented herein. The first step of the technology screening evaluation was to develop a short-list of remedial technologies from the Treatment Technologies Screening Matrix that were potentially applicable for remediation of the target compounds within the site-specific hydrogeologic framework. This step was completed to eliminate technologies that were presumptively not applicable due to technical impracticability, applicability/effectiveness, and/or cost. The second step of the technology screening evaluation was to complete a more detailed comparison of retained technologies.

The following factors were used to screen the corrective measures.

- <u>Effectiveness</u>: Considers whether the technology has been used effectively under analogous site conditions, if failure of the technology would have an immediate impact on potential receptors, and the useful life span of the alternative. Specifically, the effectiveness of remedial technologies which have been implemented at the Site (e.g., IMs and pilot studies) was considered.

- <u>Implementability</u>: Considers the administrative activities needed to implement the alternative, the constructability of the remedy, and the availability of materials and specialized services required for remedy implementation and operation. Site-specific conditions (e.g., access) are considered as part of evaluating the implementability of a remedial technology.

- <u>Reduction in the Toxicity, Mobility or Volume of Wastes</u>: Considers whether the alternative is capable of eliminating or substantially reducing the potential for the contaminants to cause future environmental damages or risks to human health and the environment.

- Estimated Timeframe: Where technically feasible, provides a relative estimated timeframe to achieve the site-specific CMOs.

- Sustainability: The U.S. EPA and RACER Trust are dedicated to the use of best management practices for sustainable remediation at contaminated sites. Sustainable practices result in cleanups that minimize the environmental and energy "footprints" of remedial actions taken during a project's duration. Examples of sustainable practices include reducing energy demands, minimizing waste generation, and minimizing land use and building footprints.

- Cost: Considers the relative cost of remedies that offer equivalent protection of human health and the environment. Cost estimates include: site preparation, materials, construction, engineering, waste management and disposal, permitting, health and safety measures, and operation and maintenance (O&M).

A summary of the corrective measures screening results for each sub-category is provided below.

4.2 Source Area Corrective Measure Options

As described above, the Process Sump Area and former Oil House Area have been identified as groundwater source areas for targeted/aggressive remediation. Aggressive remediation of these targeted source areas should address the CMO of meeting MCLs at the property boundary. A summary of the corrective measures screening and selection process for source area treatment options is presented below. The subsections below identify and comparatively evaluate appropriate remedial technologies, taking the current IMs into consideration, and determine which technology(s) are best suited to achieve the CMOs.

4.2.1 Process Sump Area

The identification and screening process of potentially applicable corrective measures technologies for implementation at the Process Sump Area is presented in this section. The CMOs adapted for the Process Sump Area include:

- Control VOC mass in the upper aquifer groundwater above the regional clay till.

- Limit future migration of VOCs to downgradient portions of the upper aquifer and into the lower aquifer.

- Achieve a significant reduction in VOC mass within the area of highest contamination. For purposes of evaluating remedial technologies in this CMP, the area targeted for remediation at the Process Sump Area is bound by the 1 part per million total CVOC iso-concentration contour (Appendix J - Figure J-5).

- Treatment of saturated zone soils and associated groundwater only (Section 2.7.5).

A summary of the Process Sump Area technology screening evaluation is provided in the sections below. While some technologies were not retained and other technologies not identified in this evaluation, there is potential for implementing technologies not included in this evaluation for this area or at the Site. The following technologies were retained for detailed evaluation:

- In-Situ Stabilization and Treatment (ISST)

- ERD

- Air Sparging with Soil Vapor Extraction (AS/SVE)

- In-Situ Thermal Treatment (ISTT) with Hot Air/Steam Injection with Soil-Vapor Extraction (SVE)

- In-Situ Chemical Oxidation (ISCO)

- Groundwater and Land Use Restrictions

A comparative summary of the technologies retained for detailed evaluation is provided in Table 11. As shown in Table 11, three of the six retained short-list technologies were eliminated from further consideration following the detailed evaluation. Conclusions and rationale for retaining or not retaining a specific technology are provided in Table 11. A description of each technology retained as applicable for source remediation at the Process Sump Area is provided below.

4.2.1.1 Enhanced Reductive Dechlorination

ERD has successfully been implemented as an IM at the former Oil House Area and has demonstrated effectiveness in preventing impacted groundwater migration to further downgradient areas and the ability to provide significant reductions in total mass within an area of comparable starting concentrations as the Process Sump Area. ERD is typically established through biostimulation of native microbial populations capable of dechlorinating CVOCs. Biostimulation is achieved by injecting readily degradable organic carbon substrates (e.g., molasses, corn syrup, emulsified vegetable oil [EVO]) into groundwater targeted for treatment. The zone in which conditions are conducive for ERD within the subsurface is commonly referred to as an IRZ. The biological activity stimulated within an anaerobic IRZ also enhances the rate of nonaqueous phase liquid (NAPL) dissolution by disrupting the natural dissolved-phase/adsorbed-phase equilibrium in the subsurface. Specifically, the reductive dechlorination process can serve to increase dissolution rates by decreasing CVOC concentrations at the NAPL/groundwater interface, thereby increasing the overall mass transfer rate into the aqueous phase (Cope and Hughes 2001). Finally, the mild surfactants produced through enhanced biological activity and the chemical properties of the injected carbon substrates contribute to the overall dissolution rate. Literature has shown that microbially-enhanced NAPL dissolution rates may be up to 16 times greater than rates achievable by physical processes (Cope and Hughes 2001).

As shown in Table 11, ERD has the following advantages when compared to the other retained technologies:

- Demonstrated effective for treating site-specific VOCs at similar starting concentrations and within a similar hydrogeology.

- Demonstrated implementable at the Site and would not require demolition of existing Site features for implementation of the remedial activities.

- High sustainability compared to other evaluated technologies by enhancing biodegradation processes of native microbial populations and using readily biodegradable organic carbon substrates for treatment.

- Low capital costs for installation of injection well network and system and moderate long term O&M costs.

The primary disadvantage of ERD is that the technology is not as aggressive as for the remediation of NAPL when compared to ISTT. Although ERD enhances the rate of NAPL dissolution, remediation of NAPL is still limited by the rate of mass transfer from the NAPL phase to the dissolved phase. Similarly, the remedial timeframe of ERD can be extended if a significant quantity of mass is trapped within mass storage zones (e.g., areas of low permeability). As such, remedial timeframes using ERD for NAPL remediation are typically greater than 10 years in similar hydrogeologies.

4.2.1.2 In-Situ Thermal Treatment with Hot Air/Steam Injection and Soil Vapor Extraction

ISTT technologies are effective and aggressive remediation approaches relying on introducing heat to subsurface for in-situ treatment of soil and/or groundwater impacted with VOCs. The introduced heat can chemically destroy or induce hydrolysis of organic compounds, or physically volatize VOCs into gaseous phase. As VOCs volatize into gaseous phase, their mobility increases, and can be captured via SVE wells and treated by an ex-situ treatment system. Given the treatment process involved, ISTT technologies can be particularly effective and successful for addressing dense or light nonaqueous phase liquids (DNAPLs or LNAPLs) and for geological formations of complex hydrogeology and low permeability. ISTT is also a proven and widely implemented technology capable of removing the site-specific contaminants (i.e., CVOCs) found at the Process Sump Area.

During implementation, heat can be introduced to the subsurface through various methods, including electrical resistance heating, radio frequency heating, dynamic underground stripping, thermal conduction, or injection of hot water, hot air, or steam. Although most ISTT technologies will have limited implementability due to the depth of contamination below the top of the water table and the regionally high groundwater flux, treatment using hot air/steam injection combined with SVE is least affected by these conditions and is therefore likely the most applicable thermal treatment option for the Process Sump Area.

For remedial technology screening purposes, ISTT with hot air/steam injection and SVE has been selected for further inclusion within this report. However, additional ISTT methods are likely viable at the Site. Although remediation of the vadose zone soil is not required based upon the discussion in Section 2.7.5.1.2, a potential fortuitous side effect of implementing this technology is additional mass reduction within the vadose zone soil through SVE.

As shown in Table 11, ISTT with hot air/steam injection and SVE have the following advantages when compared to the other retained technologies:

- Highly effective for treating and removing site-specific VOCs in both the dissolved and NAPL phases via destruction, hydrolysis, volatilization, and capture.

- Demonstrated effective at sites with similar hydrogeology (i.e., the technology is more effective at removing mass from mass storage zones when compared to other technologies).

- ISTT will typically achieve remedial goals within six to 12 months depending on treatment volume and quantity of mass to be removed.

- Has the potential to remove residual contaminants in vadose zone, if present, via SVE as an added benefit.

The primary disadvantages of ISTT are that the technology has a comparatively low sustainability due to the significant energy consumption to generate and introduce heat (via injection of hot air/steam) into subsurface for treatment and to operate SVE for capturing and treating soil vapor. In addition, ISTT requires a comparatively complex remedial infrastructure and treatment system. Combined with the significant short-term energy demand, ISTT requires a significant capital expenditure.

4.2.1.3 Groundwater and Land Use Restrictions

Groundwater and land use restrictions are effective remediation approaches relying on institutional controls and are important components of many remedial strategies to provide for long term protection of human health and the environment under restricted use of groundwater and land other than identified and permitted. Groundwater and land use restrictions are normally implemented via property deed restrictions and groundwater use restrictions through development of an Environmental Covenant. However, impacted soil and groundwater are not actively treated, and thus no reduction of toxicity, mobility, and volume of contaminant mass are achieved. Although under certain circumstances, groundwater and land use restrictions can be implemented as a standalone remedial approach, they are typically combined with active remedial measures to achieve CMOs.

For remedial technology screening purposes for the Process Sump Area, groundwater and land use restrictions have been selected to be combined with other active remedial technologies for further inclusion within this CMP.

4.2.2 Former Oil House Area

The identification and screening process of potentially applicable final corrective measures technologies for implementation at the former Oil House Area is presented in this section. The CMOs adapted for the former Oil House Area include:

- Control VOC mass in the upper aquifer groundwater above the upper clay till.
- Limit future migration of VOCs to downgradient portions of the upper aquifer and into the lower aquifer.
- Achieve a significant reduction in VOC mass within the area of highest contamination. For purposes of evaluating remedial technologies in this CMP, the area targeted for remediation at the former Oil House is bound by the one part per million total CVOC iso-concentration contour (Appendix J - Figure J-5).
- Treatment of saturated zone soils and associated groundwater only (Section 2.7.5).

A summary of the former Oil House Area technology screening evaluation is provided in the sections below. While some technologies were not retained and other technologies not identified in this evaluation, there is potential for implementing technologies not included in this evaluation for this area or at the Site. The following technologies were retained for detailed evaluation:

- ISST
- ERD
- AS/SVE
- ISTT with SVE
- ISCO
- Groundwater and Land Use Restrictions

A comparative summary of the technologies retained for detailed evaluation is provided in Table 12. As shown in Table 12, two of the six retained short-list technologies were eliminated from further consideration as a result of the detailed evaluation. Conclusions and rationale for retaining or not retaining a specific technology are provided in Table 12. A description of each technology retained as applicable for source remediation at the former Oil House Area is provided below.

4.2.2.1 In-Situ Stabilization and Treatment

ISST technologies are effective and aggressive remediation approaches by in-situ mixing of solidification, stabilization, and treatment agents (e.g., bentonite or Portland cement, zero-valent iron or permanganate) with impacted soil and/or groundwater. ISST reduces soil permeability and groundwater flux through the treatment area to prevent further leaching of VOCs to groundwater or migration of VOCs in groundwater to downgradient areas. Contaminant mass is destroyed through direct contact of the contaminants with the treatment agents. Following the completion of ISST, long term monitoring would be performed to evaluate changes in VOC concentrations downgradient of the treatment areas. ISTT is implemented using the same techniques commonly used for soil stabilization such as deep soil mixing augers or traditional equipment such as excavators and backhoes.

As shown in Table 12, ISST has the following advantages when compared to the other retained technologies:

- Highly effective for immobilizing and treating site-specific VOCs.

- Technology success is not limited by geology (e.g., technology uses mechanical mixing techniques to ensure adequate delivery of stabilizing and treatment agents; when compared to in-situ injection techniques that rely on proper reagent delivery through discrete injection points).

- Shortest remedial timeframe to eliminate the former Oil House Area as a continuing source of mass to downgradient areas.

ISST has the following disadvantages when compared to the other retained technologies:

- High capital cost for implementation.

- Low to moderate sustainability due to short-term waste generation, materials, and energy demand during construction.

In addition to the above, ISST will require long-term monitoring to evaluate the continued effectiveness of the technology since it does not aggressively destroy contaminant mass in the short-term. Finally, since two previous IMs have already significantly reduced mass at the former Oil House Area (e.g., ISCO using Fenton's chemistry and ERD), ISST is likely an over aggressive strategy for the former Oil House Area. Specifically, this technology is typically implemented for untreated source areas containing NAPL.

4.2.2.2 Enhanced Reductive Dechlorination

A description of ERD technology is provided in Section 4.1.1.1.

As shown in Table 12, ERD has the following advantages when compared to the other retained technologies at the former Oil House Area:

- Demonstrated implementable and effective for treating site-specific VOCs at the former Oil House Area through operation of the existing IM. The technology has reduced contaminant mass by an order of magnitude downgradient of existing remedial transect RZ-1. Implementation of the remedy would include expansion of the existing local injection well infrastructure.

- High sustainability compared to other evaluated technologies by enhancing biodegradation processes of native microbial populations and using readily biodegradable organic carbon substrates for treatment.

- Low capital costs for installation of injection well network and system and moderate long term O&M costs.

The primary disadvantage of ERD is that the technology is not as aggressive for the remediation of contaminant source areas when compared to ISTT or ISST. It is anticipated that the remedial timeframe for ERD would be greater than 10 years for the expanded treatment areas (e.g., areas that have not been treated with ERD yet), based on the historical performance of existing transect RZ-1 (e.g., an order of magnitude reduction in contaminant mass was achieved in approximately 10 years of operation at RZ-1).

4.2.2.3 In-Situ Thermal Treatment with Hot Air/Steam Injection and Soil Vapor Extraction

A description of ISTT with hot air/steam injection and SVE technology is provided in Section 4.1.1.2.

As shown in Table 12, ISTT with SVE has the following advantages when compared to the other retained technologies at the former Oil House Area:

- Highly effective for treating and removing site-specific VOCs in all phases via destruction, hydrolysis, volatilization and capture.
- Demonstrated effective at sites with similar hydrogeology (i.e., the technology is more effective at removing mass from mass storage zones when compared to other technologies).
- ISTT will remove and destroy the most contaminant mass within a short duration (six to 12 months) depending on treatment volume and quantity of mass to be removed.
- Has the potential to remove residual contaminants in vadose zone, if present, via SVE as an added benefit.

ISTT has the following disadvantages when compared to the other retained technologies:

- High capital cost for implementation.
- Low to moderate sustainability due to short-term waste generation, materials, and energy demand during construction.

Finally, since two previous IMs have already significantly reduced mass at the former Oil House Area (e.g., ISCO using Fenton's chemistry and ERD), ISTT is likely an over aggressive strategy for the former Oil House Area. Specifically, this technology is typically implemented for untreated source areas containing NAPL and/or compounds that are recalcitrant to remediation by other techniques.

4.2.2.4 Groundwater and Land Use Restrictions

A description of groundwater and land use restrictions and its associated advantages and disadvantages on-site is provided in Section 4.1.1.3.

4.3 Diffuse Groundwater Corrective Measures Options

The following sections describe corrective measures options for on-site and off-site groundwater not addressed as part of the source area corrective measures described previously. As discussed in Section 2.7.5, the distribution of contamination and hydrogeology vary significantly when comparing the upper and lower aquifer units. Similarly, the CMOs for on-site groundwater vary when comparing the CMOs for off-site groundwater. Therefore, corrective measures options for groundwater have been subdivided in the following four sub-categories:

- On-Site Upper Aquifer
- On-Site Lower Aquifer
- Off-Site Upper Aquifer
- Off-Site Lower Aquifer

A description of the corrective measures screening and selection process for each of the groundwater sub-categories is presented below.

4.3.1 On-Site Upper Aquifer

As discussed in Section 2.7.5, the on-site upper aquifer is impacted by CVOCs resulting from historical activities primarily at the former Oil House Area with additional source mass detected at the Process Sump Area. The resultant groundwater plume extends to the south/southwest of these areas consistent with observed groundwater flow at the Site. The CMOs adapted for the on-site upper aquifer include:

- Prevent the migration of VOCs at concentrations exceeding the MCLs beyond the existing plume boundary.

- Continue implementing the final corrective measures until the CMOs are achieved on-site and MCLs can be met and maintained at the property line point of compliance without active remedial measures.

As described previously, the CMO is to limit future migration of VOCs from groundwater and soil-gas to indoor air in on-site buildings through the use of institutional controls that require use of engineering controls in future construction.

Remediation of the source areas, as discussed in Section 4.2, will result in a reduction of the continuing source of mass to the downgradient upper aquifer. In summary, the strategy for the on-site upper aquifer will include:

- Continued operation of engineering controls until concentrations of VOCs in groundwater have been reduced such that the engineering controls are no longer required.

- Long-term groundwater monitoring to verify that the off-site upper aquifer plume is stable through natural attenuation processes.

- Groundwater use restrictions.

If long-term groundwater monitoring indicates that reduction of the source areas does result in a meaningful reduction within the remainder of the on-site upper aquifer plume, the strategy for on-site upper aquifer will be reevaluated and additional corrective measures will be implemented, if necessary.

4.3.2 On-Site Lower Aquifer

As discussed in Section 2.7.5, the on-site lower aquifer is impacted by CVOCs resulting from historical activities primarily at the former Oil House Area with additional source mass detected at the Process Sump Area. The resultant groundwater plume extends to the south/southwest of these source areas primarily consistent with current observed groundwater flow at the Site and to the southwest. The CMOs adapted for the on-site lower aquifer include:

- Prevent the migration of VOCs at concentrations exceeding the MCLs beyond the existing plume boundary.

- Continue implementing the final corrective measures until the CMOs are achieved on-site and MCLs can be met and maintained at the property line point of compliance without active remedial measures.

In general, the concentrations of VOCs in the on-site lower aquifer are significantly lower than in the on-site upper aquifer. In addition, and as described in Section 2.7.5, mass within the on-site lower aquifer is likely migrating vertically through the source areas identified previously. As such, the remedial strategy for the on-site lower aquifer is to remediate the bulk mass in the upper aquifer at the source areas. Remediation of the source areas will reduce the continuing source of mass to the lower aquifer. In summary, the strategy for the on-site lower aquifer will include:

- Remediation of identified source areas.

- Monitored natural attenuation (MNA) of the downgradient plume.

- Groundwater use restrictions.

If long-term groundwater monitoring indicates that reduction of the source areas does result in a meaningful reduction within the remainder of the on-site lower aquifer plume, the strategy for on-site lower aquifer will be reevaluated and additional corrective measures will be implemented, if necessary.

4.3.3 Off-Site Upper Aquifer

As discussed in Section 2.7.5, the off-site upper aquifer is impacted by CVOCs resulting from historical activities primarily at the former Oil House Area with additional source mass detected at the Process Sump Area. The resultant groundwater plume extends to the south/southwest of the former Oil House Area consistent with observed groundwater flow at the Site and to the southeast. The CMOs adapted for the off-site lower aquifer include:

- Prevent the migration of VOCs at concentrations exceeding the MCLs beyond the existing plume boundary.

- Continue implementing the final corrective measures until the CMOs are achieved on-site and MCLs can be met and maintained at the property line point of compliance without active remedial measures.

As described previously, the CMO is to limit future migration of VOCs from on-site sources in groundwater to downgradient receptors and soil gas to indoor air in off-site buildings through the placement of vapor intrusion mitigation systems in existing structures and by limiting downgradient migration of on-site constituents in the upper and lower aquifers. The post-installation proficiency sampling data has demonstrated that, to date, all the vapor intrusion mitigation systems within the neighborhood have effectively reduced the concentrations to below Action Levels. This engineering control will continue to be implemented until the vapor intrusion pathway is not a concern.

In summary, the remedial strategy for the off-site upper aquifer will be similar to the on-site upper aquifer and will include:

- Continued operation of engineering controls until concentrations of VOCs in groundwater have been reduced such that engineering controls are no longer required.

- Long-term groundwater monitoring to verify that the off-site upper aquifer plume is stable through natural attenuation processes.

- Groundwater use restrictions.

If long-term groundwater monitoring indicates that reduction of the source areas does result in a meaningful reduction within the remainder of the off-site upper aquifer plume, the strategy for off-Site upper aquifer will be reevaluated and additional corrective measures will be implemented, if necessary.

4.3.4 Off-Site Lower Aquifer

As discussed in Section 2.7.5, off-site is impacted by CVOCs resulting from historical activities primarily at the former Oil House Area with additional source mass detected at the Process Sump Area. The resultant groundwater plume extends to the south/southwest consistent with the groundwater flow direction at the Site. The corrective measures objectives adapted for the off-site lower aquifer include:

- To maintain the lower aquifer as usable groundwater for potential off-site, downgradient drinking water uses.

- Prevent the migration of VOCs at concentrations exceeding MCLs beyond the existing plume boundary.

- To meet and maintain MCLs at the downgradient property line point of compliance without active corrective measures.

A summary of the off-site lower aquifer technology screening evaluation is provided in the sections below. The following technologies were retained for detailed evaluation:

- MNA
- ERD
- AS/SVE
- ISCO
- In-Well Air Stripping
- Permeable Reactive Barrier
- Groundwater Extraction
- Groundwater Use Restrictions

A comparative summary of the technologies retained for detailed evaluation is provided in Table 13. As shown in Table 13, five of the eight retained short-list technologies were eliminated from further consideration as a result of the detailed evaluation. Conclusions and rationale for retaining or not retaining a specific technology is provided in Table 13. A description of each technology retained as applicable for diffuse groundwater remediation for the off-Site lower aquifer is provided below.

4.3.4.1 Monitored Natural Attenuation

MNA has been selected to be combined with other active remedial technologies for the off-site lower aquifer. A general description of MNA and its applicability to the Site is provided in Section 4.3.1.1. A description of the advantages and disadvantages of MNA specific for the off-site lower aquifer are provided in Table 13.

4.3.4.2 Groundwater Extraction

Groundwater extraction is primarily used as a containment strategy, although some benefit of mass removal can be realized for dissolved contaminants. Groundwater extraction wells can be used to control the migration of groundwater contaminants by altering the hydraulic gradient of the aquifer. Impacted groundwater recovered by the extraction well(s) are typically treated on-site with an on-site water treatment system or discharged into a sanitary sewer for off-site treatment. Groundwater extraction has been implemented as an IM in the off-site lower aquifer at Montgomery County well DN-13 since March 1990. Well DN-13 pumps at an approximate rate of 600 gpm (Table 1) and maintains capture in the lower aquifer downgradient of the Site. The capture analysis presented in Section 2.7.6 confirms that DN-13 is suitably located and pumping at a flow rate to maintain capture of the lower aquifer plume.

4.3.4.3 Groundwater Use Restrictions

A description of groundwater use restrictions and its associated advantages and disadvantages is provided in Section 4.1.1.3. A comparative evaluation of groundwater use restrictions specific to the off-site lower aquifer is provided in Table 13.

4.4 Landfill L1 Corrective Measures Options

The purpose of this section is to identify and comparatively evaluate appropriate corrective measure options for Landfill L1, with the ultimate goal of selecting the option best suited to achieve the CMOs. The CMOs adapted for Landfill L1 include:

- Prevent the migration of VOCs at concentrations exceeding the MCLs beyond the existing plume boundary and maintain MCLs at the downgradient property line point of compliance without active corrective measures.

The following two options were chosen for detailed evaluation:

- Installation of clay barrier final cover system.

- No modification to current cover.

The following presents a description of the two options chosen for further evaluation.

4.4.1 Installation of Clay Barrier Final Cover System

Currently, the L1 Landfill cover consists of soil and fill of varying depths which is locally vegetated. The landfill is shaped like a bowl that is built up relative to the surrounding land (Appendix E). To prevent water from entering the waste mass, which could ultimately result in leaching of VOCs from the waste and migration of these VOCs to the groundwater, installation of a more robust clay barrier cap was evaluated. However, based on the Landfill L1 investigation, leaching to groundwater is not expected to occur to the extent that groundwater concentrations at the downgradient wells would exceed MCLs due to the composition of the waste material in the landfill (Appendix E). Therefore, the evaluation of a clay barrier is considered to be an extremely conservative measure. This engineered cap would consist of 2 ft. of compacted low permeability clay, with an additional 6 inches of vegetative cover placed above the clay. The clay barrier cap would be installed to promote positive drainage of water off of the cap.

The advantages of the clay barrier cap would be that a more impermeable soil in the cap system would decrease the amount of water entering into the waste mass, further reducing the potential for VOCs to migrate to the underlying groundwater. The properly graded cap (promoting positive drainage off of the landfill) would also result in less water being able to infiltrate into the waste mass.

The primary disadvantage of installation of the clay barrier cap is that the more impermeable clay could cause soil-gas containing VOCs and methane generated in the landfill waste mass to migrate laterally and off of the landfill property. Soil-gas will follow the path of least resistance, in this case laterally vs. vertically. In order to prevent this lateral migration of soil-gas, some sort of passive venting or active gas collection system would be necessary. A passive venting system would likely result in major odor problems at the Site due to the presence of VOCs with low-odor thresholds which are present in the waste material. An active gas collection system with some sort of thermal destruction (i.e., flare), would be significantly capital intensive, and likely difficult to keep running, as the methane quality and quantity may not be high enough to maintain continual operation of a flare system, requiring installation of a thermal oxidizer. Operation of a thermal oxidizer would necessitate the use of natural gas creating a significant carbon footprint. In addition, installation of the active system would result in significant disturbance of the existing waste mass, thus creating significant odor problems and other health and safety issues. The option to install a clay barrier was not retained for further evaluation due to the disadvantages listed above and the significant costs associated with addressing issues created by installing the cap.

4.4.2 No Modification to Current Cover

This option would include leaving the existing cover in place. Minor regrading may be considered in the future to fill in some of the low spots on the cover which would prevent ponding of water. In addition, minor regrading may be completed to promote positive drainage off of the landfill. Any areas disturbed during the regrading activities would be revegetated upon completion of the work.

The advantages of this option include the fact that the existing cover system would be utilized and that there would be minimal if any disturbance of the waste in the landfill. The existing cover system has functioned well in preventing migration of odors off-site, provided for effective vector control, and for the most part, promoted drainage of surface water away from the landfill (very little standing water present). In addition, utilizing the existing more permeable cover would decrease the chance of any off-site migration of methane from the landfill to the surrounding properties.

The results of groundwater monitoring have not indicated significant impacts to groundwater from the landfill in the monitoring wells located immediately downgradient of the landfill. Leaching calculations were completed to evaluate groundwater impacts by Landfill L1 VOCs (Appendix E). The evaluation concluded that advective flow in the waste mass is hindered by the low permeability clay and sludge within the landfill. Transport is then limited to vapor diffusion, which is too slow for leaching BTEX constituents before they can degrade. The CVOCs will take so long to reach the saturated zone that it would take centuries to reach 1.0 µg/L in groundwater given dilution, even if the CVOCs could leach through the low-permeability layer in the upper saturated zone. Therefore, this option is retained for further evaluation.

4.5 Site-Wide Groundwater Monitoring

A key component of the final corrective measures will be the site-wide groundwater monitoring program as defined in the Site-Wide Groundwater Monitoring Plan (ARCADIS, Inc. 2002b). This program has been implemented since 1999 but will require future modifications to address performance monitoring of the final corrective measures and groundwater plume concentrations over time. The current objectives of this program are to:

- Monitor groundwater quality upgradient and downgradient of the closed North and South Settling Lagoons.

- Monitor groundwater quality upgradient and downgradient of Landfills L1, L2, and L3.

- Monitor the effectiveness of current groundwater capture systems in the lower aquifer.

- Monitor the effectiveness of corrective measures remediation activities in the reactive zones to address VOCs.

- Monitor an appropriate list of wells once CMOs have been met to verify that these objectives continue to be met without active measures.

With the exception of the lagoons and landfills, these objectives will be reevaluated and modified, as necessary, to address the final corrective measures. The point of compliance wells at the property boundary will be defined when the final corrective measures are determined.

As discussed in the Site-Wide Groundwater Monitoring Plan, an annual report will be prepared and submitted to the U.S. EPA by March 1st of the following year. The annual report will include a discussion of field activities (groundwater sampling, corrective measures, water-level measurements) and a presentation of analytical results. Data evaluation and any recommendations for changes to the corrective measures, or site-wide groundwater monitoring plan will be included in this annual report.

4.6 Off-Site Well Abandonment

As indicated in Section 2.7.9, based on the well survey, there are two properties located near the Site at 3571/3573 Dryden Road and 2651 Blanchard Avenue where well water is used instead of public water supply. Confirmation regarding connection to public water would be completed during an initial phase of the work along with a site visit to the property to identify site-specific details.

If access is granted by the property owner, the well will be abandoned and the property connected to public water. Abandonment procedures will be completed in accordance with the Ohio EPA Technical Guidance Document dated February 1995, *State of Ohio Technical Guidance for Sealing Unused Wells* (State Coordinating Committee on

Ground Water 1996), and the appropriate permits will be obtained and inspections completed by the City of Moraine and Montgomery County.

On April 30, 2010, MLC sent the U.S. EPA a letter to provide documentation that MLC proposed to implement the abandonment of private wells located at 3571/3573 Dryden Road and 2651 Blanchard Avenue. Well abandonment and connection of these properties to the public water service (Montgomery County) were proposed to be part of the final site-wide corrective measures for the Site within this letter.

RACER Trust will be working with these property owners to abandon both private wells. RACER Trust will contract a driller licensed in the State of Ohio to complete the well abandonment work. RACER Trust will also complete the work necessary to connect these properties to Montgomery County water service. Costs associated with the well abandonment activities described above are included in Table 14.

4.7 Engineering/Institutional Controls

Institutional controls are an important component of the final corrective measures to provide for long-term protection of human health and the environment under the current industrial land use. Institutional controls for the WPSA will include property deed and land use restrictions to reduce the potential for direct contact or vapor intrusion exposure to soil. Property deed and land use restrictions placed on the land-based units (Landfills L1, L2, and L3) will prevent non-industrial use of this land and prevent exposure for long-term management of these units. Property deed and land use restrictions have already been placed on the closed North and South Settling Lagoons as part of the previous closure activities.

Property deed restrictions placed on groundwater (upper and lower aquifers) at the Site will prevent its use as a potable/industrial water supply. These controls are in addition to existing state regulations governing development and use of groundwater for a potable water supply and local zoning of the land use at and surrounding the facilities. RACER Trust will implement on-site property deed restrictions and groundwater use restrictions through completion of an Environmental Covenant.

As presented in Appendix G, the on-site vapor intrusion evaluation was conducted using groundwater data. PCE, TCE, and vinyl chloride exceeded target groundwater concentrations for the protection of indoor air. To address this issue, engineering controls will be used in future on-site construction to mitigate exposures.

5. Remedy Recommendation

Using the information provided in the previous sections, the final recommended site-wide remedy has been assembled. The recommended final remedy is protective of human health and the environment by reducing toxicity, mobility, and volume of waste through treatment; will meet the CMOs (Section 4); and will be cost effective. As with most full-scale remedy implementations, it is anticipated that additional pre-design investigation activities and data evaluation will be completed prior to design of the final individual remedy components (e.g., tracer testing may be implemented to further quantify groundwater flow direction and velocity, supplemental investigation samples may be collected to optimize remedial target footprints, etc.). Furthermore, and as described previously, most remedial target areas have multiple technologies capable of achieving the specific CMOs for that target area. To that extent, performance based final remedy components have been provided below except where known/specific components have been already selected and identified herein.

The components of the final corrective measures are as follows:

1. Remediation of the identified source areas including:

    a. Former Oil House Area: Focused remediation of total CVOC concentrations greater than or equal to 1 part per million (ppm) in the upper aquifer. Operation of the remedy would be completed until an order of magnitude reduction in contaminant mass is observed within performance monitoring locations associated with the former Oil House Area, or until the limit of technical practicability of the technology has been reached.

    b. Process Sump Area: Focused remediation of total CVOCs greater than or equal to 1 ppm in the upper and lower aquifers. Operation of the remedy would be completed until an order of magnitude reduction in contaminant mass is observed within areas targeted for remediation from 1 ppm to 5 ppm and until a two order of magnitude reduction is achieved for areas targeted for remediation with groundwater concentrations greater than 5 ppm, or until the limit of technical practicability of the technology has been reached.

2. Remediation of the on-site upper aquifer through:

    a. Remediation of source areas, as described above.

   b. MNA, groundwater and land use restrictions, and engineering controls for areas located downgradient of the source areas.

   c. Discontinue operation of existing ERD IRZ transects RZ-3 and RZ-4 upon implementation of the source remedies.

3. Remediation of the on-site lower aquifer through:

   a. Remediation of source areas, as described above.

   b. MNA and groundwater use restrictions for groundwater located downgradient of the source areas.

4. Remediation of the off-site upper aquifer through:

   a. Remediation of source areas, as described above.

   b. MNA.

   c. Operation of the existing vapor intrusion monitoring and engineering control systems, as described below, until groundwater no longer serves as a source of contamination to soil vapor.

5. Remediation of the off-site lower aquifer through:

   a. Treatment of on-site source areas, as described above.

   b. MNA.

   c. Hydraulic containment through operation of existing well DN-13.

6. Long-Term Management of Landfill L1 through:

   a. Utilization of existing cover system with periodic maintenance and monitoring to provide for proper drainage and the integrity of the existing cover system.

   b. Institutional controls in the form of land and groundwater use restrictions.

7. Long-Term management and mitigation of off-site soil vapor through:

a. Sub-slab and indoor air sampling at properties located within the Riverview Plat neighborhood, where access is provided.

b. Continued installation, operation, post-installation proficiency sampling, and system operation and maintenance of existing vapor mitigation systems.

8. Corrective Measures Groundwater Monitoring: completion of monitoring groundwater quality associated with land-based units, performance monitoring for corrective measures presented above, MNA, and point of compliance wells at the property boundary.

9. Engineering/Institutional Controls: maintain industrial land use, implement of land and groundwater use restrictions via Environmental Covenants for the entire facility, and implement engineered controls, as necessary, for future on-site construction to mitigate exposures.

5.1 Final Remedy Components

Remedial technologies capable of achieving the CMOs and performance based treatment remedies described above have been selected for cost evaluation purposes and are described below. The final corrective measures program will be implemented following an adaptive design and implementation strategy to accommodate the potential for changes in environmental quality, site use and limitations, and risks to human health and the environment during the long-term operation of the recommended corrective measures. Any future changes to the final remedy configuration will be made in a manner that will not affect the capacity of the final remedy to achieve the CMOs presented in Section 4. As described previously, the final remedial component selections for performance based remedy components may vary from the technologies selected below depending on the results of pre-design testing and investigation activities. Table 14 outlines the costs associated with the components of the final corrective measures described below. In addition, operation and maintenance of the closed North and South Settling Lagoon as outlined in the Post-Closure Plan described in Section 2.6.1 and well abandonment/connection to public water supply activities for the properties located at 3571/3573 Dryden Road and 2651 Blanchard Avenue as described in Section 4.6 have been included on Table 14.

The components of the final corrective measures are presented in the following sections.

5.1.1 Source Area Remedy Selection

The following remedies were selected for source area remediation:

a. Former Oil House Area: Expansion of the existing ERD IRZ using a dilute molasses solution as the organic carbon donor has been selected as the preferred, most cost effective technology. ERD IRZ has already been demonstrated successful at the former Oil House Area through operation of the existing IM at remedial transect RZ-3. A conceptual layout of the expanded ERD IRZ is provided on Figure 13. As shown on Figure 13, approximately 25 wells would be installed in remedial transects spaced 70 ft. downgradient from each other. It is anticipated that injections will be completed using a semi-automated injection system. Operation of the expanded ERD IRZ would be implemented until an order of magnitude reduction in contaminant mass is observed within performance monitoring locations associated with the former Oil House, or until the limit of technical practicability of the technology has been reached.

b. Process Sump Area: ERD IRZ using EVO has been selected as the preferred technology for total CVOC concentrations between 1 ppm and 5 ppm. ERD IRZ has already been demonstrated successful at the former Oil House Area through operation of the existing IM at remedial transect RZ-1 for concentrations within this range. A conceptual layout of ERD IRZ treatment zone using EVO is provided on Figure 13. As shown on Figure 13, approximately 80 well pairs would be installed in remedial transects spaced 40 feet downgradient from each other. It is anticipated that injections will be completed using a semi-automated injection system. Operation of the ERD IRZ would be implemented until an order of magnitude reduction in contaminant mass is observed within applicable performance monitoring locations, or until the limit of technical practicability of the technology has been reached.

   ERD IRZ using EVO has been selected as the preferred technology for total CVOC concentrations of greater than 5 ppm. ERD IRZ is a proven technology to address high dissolved phase concentrations. As described in Section 2.7, only potential residual DNAPL is present in this area and the selection of an overly aggressive technology is not warranted. A conceptual layout for the ERD IRZ is provided on Figure 13. As shown on Figure 13, approximately 90 injection well pairs would be installed in a grid pattern within the 5 ppm iso-concentration contour.

5.1.2 On-Site Upper Aquifer

The following remedies were selected for remediation of the on-site upper aquifer:

a. Remediation of source areas, as described above.

b. MNA and land and groundwater use restrictions (through property deed restrictions) for areas located downgradient of the source areas. Implementation of property deed restrictions and groundwater use restrictions will be completed through the development of an Environmental Covenant. Engineering controls for future on-site construction.

c. Discontinue operation of existing ERD IRZ transects RZ-3 and RZ-4 upon implementation of the source remedies. Following discontinuation of injections, the former injection wells will be maintained to provide flexibility for future adaptive design decisions, if necessary.

5.1.3 On-Site Lower Aquifer

The following remedies were selected for remediation of the on-site lower aquifer:

a. Remediation of source areas, as described above.

b. MNA and land and groundwater use restrictions (through property deed restrictions) for areas located downgradient of the source areas. Implementation of property deed restrictions and groundwater use restrictions will be completed through the development of an Environmental Covenant.

5.1.4 Off-Site Upper Aquifer

The following remedies were selected for remediation of the off-site upper aquifer:

a. Reduction of the source of off-site upper aquifer groundwater contamination through remediation of the source areas, as described above.

b. MNA.

c. Vapor monitoring, and O&M of the existing vapor intrusion mitigation systems, as described below, until groundwater no longer serves as a source of contamination to soil vapor.

5.1.5 Off-Site Lower Aquifer

The following remedies were selected for remediation of the off-site lower aquifer:

a. Treatment of on-site source areas, as described above.

b. MNA.

c. Hydraulic containment through operation of existing well DN-13. Operation of existing well DN-13 will continue until it can be demonstrated that treatment of the off-site plume through MNA alone is sufficient to reduce concentrations to below MCLs before reaching the Miami Shores well field.

5.1.6 Landfill L1

As presented in Section 4.4, the benefits of capping Landfill L1 are minimal and by creating an impermeable cap there is a potential to create a direct exposure pathway to receptors for soil-gas (methane and VOCs) requiring treatment. Therefore, the option of no modification to the current cover has been selected for the following reasons:

- Utilization of existing cover system.
- Minor if any disturbance of waste.
- Odor control not an issue.
- Health and safety issues minimized.
- No gas control system needed.
- Decreased chance of off-site gas migration.
- Low capital costs.

The current cover on Landfill L1 will be monitored to determine if any future minor grading is necessary to support drainage and document the integrity of the existing landfill cap. In addition, institutional controls in the form of land and groundwater use restrictions will be emplaced so the landfill area and cap remain undisturbed and to eliminate the use of groundwater as an exposure pathway. Finally, long-term groundwater monitoring will be implemented to document that the landfill is not a continuing source of contamination to groundwater (Section 4.5). Costs associated with operation and maintenance of Landfill L1 have been included on Table 14.

5.1.7 Off-Site Soil Vapor

As indicated in Section 2.6.7, vapor intrusion mitigation systems were recommended for most of the sampled properties within the Riverview Plat neighborhood, and systems have been installed in the properties where access was provided. The objective of vapor intrusion mitigation is to reduce the concentrations of site-specific VOCs in indoor air to concentrations that are below the Action Levels. Based on the results of post-installation proficiency sampling, the vapor intrusion mitigation systems installed to date have effectively reduced site-specific VOCs in indoor air to concentrations that are below the Action Levels.

RACER Trust will continue community outreach efforts, in coordination with the U.S. EPA, to attempt to access all properties within the Riverview Plat neighborhood to complete sub-slab and indoor air sampling and install vapor intrusion mitigation systems, as appropriate. Costs for initial sub-slab and indoor air sampling for all properties within the Riverview Plat which have not been sampled to date have been included in the capital cost for the vapor intrusion corrective measures outlined in Table 14.

5.1.8 Corrective Measures Groundwater Monitoring

Groundwater monitoring will be an element to the corrective measures program. A description of the corrective measures groundwater monitoring program is provided in Section 4.5.

5.1.9 Engineering/Institutional Controls

Engineering and institutional controls will be an element to the corrective measures program. Engineering and institutional controls will be implemented as described in Section 4.6.

5.2 General Remedy Standards

Overall Protection - The selected final corrective measures described in Section 5.1 are protective of human health through reduction of groundwater source areas through:

- On-site land and groundwater use restrictions and implementation of engineering controls.
- Implementation of engineering controls for the off-site receptors.
- Capture of the off-site groundwater plume in the lower aquifer.

Attainment of Media Cleanup Standards - The selected final corrective measures include long-term groundwater monitoring to evaluate groundwater quality upgradient and downgradient of land-based units, for performance monitoring of the active remedies, and to evaluate groundwater quality at the point of compliance wells. MCLs will be used for the media cleanup standards at the point of compliance wells (property boundary).

Controlling the Sources of Releases - The selected final corrective measures are focused on source treatment for the control of the source of releases. Reduction of the source areas will result in the migration of clean water to downgradient portions of the upper and lower aquifers.

Compliance with Applicable Standards for Waste Management - Wastes generated through source treatment will be managed to comply with all applicable standards.

Long-term Reliability and Effectiveness - The selected final corrective measures contain components that have already been implemented for 10 or more years and have proven to be effective to treat and/or contain VOCs and prevent further migration. In addition, the final corrective measures provide for a reduction of known groundwater source areas which should result in the long-term remediation of downgradient groundwater through natural attenuation processes. The groundwater monitoring data will be used to confirm the long-term reliability and performance effectiveness of the final remedy. The data will be continually evaluated and additional corrective measures may be implemented if long-term monitoring data indicate that the remediation of known source areas and subsequent/ongoing natural attenuation processes do not result in adequate long-term remediation of the downgradient plume.

Corrective measures have already been established and demonstrated effective for the vapor intrusion pathway at off-site receptors.

Reduction of Toxicity, Mobility, or Volume of Wastes - The selected final corrective measures contain components to significantly reduce the contaminant toxicity, mobility, and volume through aggressive source treatment. It also contains components to reduce the mobility and volume of contaminants by preventing contaminant migration (hydraulic containment in the lower aquifer).

Short-term Effectiveness - Most components of the selected final corrective measures have already been implemented for 10 or more years. When combined with aggressive source treatment, existing vapor mitigation systems, and hydraulic control components, the selected corrective measures will be effective in the short-term. Additional components of the final remedy discussed in Section 5.1 can achieve effectiveness in the short-term timeframe.

Implementation - Most components of the selected final corrective measures have already been implemented for 10 or more years. The existing vapor mitigation systems have been demonstrated effective and implementable. The retained additional source treatment corrective measures have been documented implementable in similar site conditions at numerous sites. Implementability of source treatment at the Process Sump Area will require further review of any access issues due to the presence of a building and public roads. Environmental Covenants are implementable and will require agency review and approval.

Cost - Components of the selected final corrective measures have already been implemented and continued operation of these components will be cost effective. The additional costs will be associated with implementation of the proposed components of the final remedy and continuation of corrective measures groundwater monitoring program. A summary of the estimated cost for implementation of the selected corrective measures is provided in Table 14.

5.3 Sustainability Evaluation

As discussed previously, the U.S. EPA and RACER Trust are dedicated to the use of best management practices for sustainable remediation at contaminated sites. Sustainable practices result in cleanups that minimize the environmental and energy "footprints" of remedial actions taken during a project's duration. Examples of sustainable practices include reducing energy demands, minimizing waste generation, and minimizing land use and building footprints. The selected corrective measures program includes the following sustainable practices:

- Protection of groundwater supply resources through operation of existing hydraulic containment well DN-13.
- Where applicable, the use of injection amendments, such as organic carbon substrates, that relies on enhancing natural biological processes.
- Using existing equipment and infrastructure wherever possible.
- Minimal equipment footprints to minimize land disturbance.
- Minimal long-term operation and maintenance resulting in a minimal long-term energy demand, carbon footprint, and waste stream.

Opportunities for implementation of sustainable practices will continually be evaluated during the pre-design phase, final selection of full-scale remedial technologies, and long-term operation of the corrective measures. Examples of opportunities for the implementation of additional sustainable practices include:

- Specify energy-efficient equipment; use variable frequency drives to reduce energy demands.
- Use green structures for housing equipment (e.g., Leadership in Energy and Environmental Design-certified materials).
- Conduct remedial system evaluations to routinely assess and optimize system performance and evaluate opportunities to reduce energy needs and downsize or reduce equipment, as appropriate.

5.4 Corrective Measures Conclusions

Based on information currently available, the selected recommended final corrective measures for the Site provide the most appropriate balance of corrective measures options with respect to the evaluation criteria, sustainability, and cost. Final selection of the source area corrective measures will be completed following additional pre-design testing to corroborate conceptual design assumptions. Long-term success of the corrective measures will be continuously evaluated through an adaptive design approach based on the results of long-term corrective measures groundwater monitoring. Additional corrective measures may be recommended based on these evaluations.

Future reports will be prepared for the final corrective measures that includes proposed pre-design investigation plans and full-scale design of the propose source remedies, the revised corrective measures groundwater monitoring program, and the Environmental Covenant.

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