TRC

Remedial Investigation and Groundwater Environmental Indicator Report

RCRA-05-2010-0012
Former Tecumseh Products Company Site
Tecumseh, Michigan

September 2012

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Executive Summary

This Remedial Investigation and Groundwater Migration Stability Report (Report) provides comprehensive documentation of investigation activities conducted at the former Tecumseh Products Company (TPC) site located at 100 East Patterson Street in Tecumseh, Michigan. Preparation of a remedial investigation (RI) report is required under Section VI, Paragraph 11 of the Federal Resource Conservation and Recovery Act (RCRA) 3008(h) Administrative Order on Consent (AOC), effective March 29, 2010. Similarly preparation of a Environmental Indicator – Migration of Contaminated Groundwater Under Control report is required under Section VI, Paragraph 13(b) of the AOC. As allowed under the AOC, a single report was prepared which provides comprehensive documentation of investigation activities conducted to define the nature and extent of hazardous constituents at and migrating from the site, including an evaluation of groundwater migration stability to support completion of the RCRA Form CA750, Documentation of Environmental Indicator Determination – Migration of Contaminated Groundwater under Control.

TPC began manufacture and storage operations at the site in the 1930s. By June 2008, when manufacturing operations ceased at the site, TPC operations focused on the production and reconditioning of compressors and condensing units for refrigeration and air conditioning units. Solvents containing volatile organic compounds (VOCs), particularly chlorinated VOCs (CVOCs), were used for parts degreasing during past site operations. In 2008, a Phase I Environmental Site Assessment (ESA) was conducted as part of the sale of the property. The Phase I ESA report recommended that a Phase II Subsurface Investigation be conducted to address the recognized environmental conditions identified in the Phase I ESA. A Phase II ESA was performed between December 2008 and February 2009. Samples were collected for VOCs, semi-volatile organic compounds (SVOCs), metals, polychlorinated biphenyls (PCBs), and cyanide analysis. A review of the data collected during the Phase II ESA identified CVOCs as the primary constituents of concern (COCs) at the site.

Following receipt of the Draft Phase II ESA in February 2009, TPC retained RMT, Inc. (RMT), now TRC Environmental Corporation (TRC), to investigate soil and groundwater conditions at the site and surrounding area. In September 2009, a Current Conditions Report (CCR) was submitted to the United States Environmental Protection Agency (USEPA) for review and on March 29, 2010 the AOC for the Site (MID-005-049-440) was executed. In September of 2011, TPC submitted to USEPA the Documentation of Environmental Indicator Determination – Current Human Exposures Under Control determination for the site.

Since the AOC was executed, TPC has worked cooperatively with USEPA to complete investigation activities and remedial activities pursuant to Section VI, Work to be Performed, of the AOC. This Remedial Investigation and Groundwater Environmental Indicators Report was prepared to comply with Paragraph 11 of the AOC to define the nature and extent of releases of hazardous waste and hazardous constituents at or from the facility and Paragraph 13(b) of the AOC, demonstrating that migration of contaminated groundwater at or from the facility is stabilized and that any discharge of groundwater to surface water is either insignificant or currently acceptable according to an appropriate interim assessment (Groundwater Environmental Indicator).

Prior to development of this Report, extensive on- and off-site groundwater investigations were performed leading to the development of a robust conceptual site model (CSM) for groundwater flow and contaminant migration. This report provides a detailed description of the CSM which is includes site operations/ history, investigation activities, site setting including a description of site and regional geology and hydrogeology, COCs, risk-based screening levels, characterization of the contaminant source areas, the nature and extent of contamination, and distribution of COCs in various media. The following provides a summary of the conceptual site model (CSM).

- **Geology/Hydrogeology –** Data show that site geology generally consists of a surficial silty/sandy clay interval ranging from 3 to 7 feet thick, underlain by unconsolidated fine to coarse sand and gravel aquifer which is composed of almost entirely of permeably soils ranging in composition from silty sand to gravel. No significant areas of low permeability soil have been identified in this aquifer and this aquifer is shown to be generally homogenous. Under this sand and gravel is a low permeability clay layer that varies in elevation but is continuous across the study area. Groundwater flow in this sand and gravel deposit is generally east toward the River Raisin, the nearest body of water. The surface topography drops east of the site. In proximity to this change in surface elevation, the horizontal hydraulic gradient increases prior to groundwater discharge to the River Raisin. Data gathered to complete the CSM show that the soil underlying the River Raisin consists of the low permeability clay deposit, the sand and gravel deposit is stratigraphically higher than the River Raisin, and consequently precludes affected groundwater from flowing beneath the river.
- **Constituents of Concern (COCs)** – Investigations were performed at the site to determine potential COCs. Testing included VOCs, SVOCs, 1,4-dioxane, metals, cyanide, and PCBs. These data were screened against the generic cleanup criteria specified in Michigan Department of Environmental Quality (MDEQ) Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), also known as Part 201 criteria. Based on comparison of data to Part 201 Criteria,

VOCs, particularly trichloroethene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA) and their breakdown products: 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-DCE), trans-1,2-dichloroethene (trans-DCE), and vinyl chloride were identified as the primary COCs in on-site soil and/or groundwater.

- **Risk Based Screening Levels/Criteria** – TRC compared soil and groundwater data to various screening criteria including the generic cleanup criteria specified in the MDEQ Part 201. To evaluate the vapor intrusion pathway, TRC calculated indoor air criteria and vapor intrusion screening levels for groundwater and soil gas.
  - **Soil –** Comparisons of soil data to screening criteria showed that VOC concentrations in soil were detected at concentrations below direct contact (DC) criteria. Consequently, contact with affected soil is NOT a complete exposure pathway. VOCs were detected in on-site soil above the Part 201 drinking water protection (DWP) criteria. However, an extensive private well survey and subsequent well decommissioning activities were conducted to ensure that the drinking migration water pathway is not complete. Furthermore, the June 2011 Groundwater Use Ordinance adopted by the City of Tecumseh, ensures that the drinking water migration pathway remains incomplete. The generic groundwater/surface water interface protection (GSIP) criteria were exceeded in on site soils. However, VOC concentrations in groundwater are below a calculated mixing zone based GSI. Data were reported above the Soil Volatilization to Indoor Air Inhalation (SVIAI) screening levels. The volatilization to indoor air migration pathway is discussed further below.
  - **Groundwater** – Groundwater data were compared to the groundwater contact criteria; these criteria were not exceeded. VOCs were detected in groundwater above the screening levels for the drinking water (DW), groundwater/surface water interface (GSI), and the groundwater screening levels (GWSLs) for vapor intrusion. The volatilization to indoor air migration pathway is discussed further below.

    Ingestion of affected groundwater is not a complete exposure pathway, nor is it reasonably expected to be complete in the future, because all private wells in the vicinity of affected groundwater have been abandoned, and the June 2011 Groundwater Use Ordinance, serves as an institutional control to prevent the installation of new wells within the horizontal extent of affected groundwater. Ingestion of groundwater is a relevant but incomplete exposure pathway.

    As allowed under Michigan Part 201, a request was submitted to MDEQ for determination of a mixing-zone based groundwater/surface water interface (GSI) criterion for TCE in June 2012. As documented in this request, the surface water to groundwater mixing ratio is more than 2000:1. Therefore the incidental exposure to/ingestion of affected surface water by recreational users or workers is not a relevant exposure pathway.

- **Vapor Intrusion** – Concentrations of CVOCs in perimeter and off-site groundwater and soil gas have exceeded applicable risk-based screening levels for vapor intrusion. These exceedences have prompted further evaluation of the volatilization to indoor air migration pathway and response activities. Additional information/ data are being collected by TPC to address USEPA comments related to the Current Human Exposures EI. This information will be submitted to the USEPA in December 2012.
- **Surface Water** – CVOCs have not been detected in surface water. To evaluate potential groundwater discharges to surface water, TRC compared groundwater data to applicable surface water criteria. Additionally, as described previously, a request was submitted to MDEQ for determination of a mixing-zone based GSI criterion for TCE in June 2012. As documented in this request, the surface water to groundwater mixing ratio is more the 2000:1. Therefore the incidental exposure to/ingestion of affected surface water by recreational users or workers is not a relevant exposure pathway.

- **Contaminant Source Areas and Nature and Extent of Contamination** – In addition to investigating site and regional hydrogeology, TRC determined the vertical and horizontal extent of VOC-affected groundwater above the most restrictive Part 201 screening criteria, and investigated and characterized the potential sources of soil and groundwater contamination. Data show that VOC-affected groundwater resulted from two general source areas – the northern source area, which was used for machining and degreasing activities prior to unit assembly during the mid-1900s, when TCE was commonly used as a solvent; and a southern source area located in the vicinity of a former Distillation Solvent Recovery System (solid waste management unit 5 [SWMU 5]) in Area M, where solvent use included 1,1,1-TCA and TCE. Concentrations of TCE and 1,1,1-TCA observed in groundwater suggest that residual sorbed TCE and 1,1,1-TCA in the form of ganglia may be present in the vadose zone and upper aquifer. However, concentrations of TCE and 1,1,1-TCA decrease significantly with depth indicating that non-aqueous phase products have **NOT** accumulated at the interface of the clay confining unit.

  Robust reductive dechlorination is occurring in and downgradient of the northern source area as described in detail in this Report. This is due to the presence of total organic carbon sources within the soil matrix in this area of the site. Reductive dechlorination is not nearly as robust in the southern source area; likely attributable to limited organic carbon in the soil profile that can serve as a food source for reductive dechlorination. However, the

Permeable Reactive Barrier (PRB) installed downgradient of the southern source area has significantly reduced downgradient contaminant flux. This source area characterization data will be useful in development of the Final Corrective Measures proposal.

- **Stability of Plume** – As described in USEPA guidance, a positive "Migration of Contaminated Groundwater Under Control Environmental Indicator" (EI) determination indicates that groundwater migration of contaminated groundwater has stabilized, and that monitoring will be conducted to confirm that the contaminated groundwater remains in the "area of contaminated groundwater". According to guidance, this is intended to be a qualitative assessment.

  Based on data collected over the past three years from a comprehensive groundwater monitoring network, data show that prior to establishment of the monitoring network, CVOC-affected groundwater had migrated off site towards the north and east as described in detail in this Report. Using the data from the past three years of monitoring, TRC evaluated plume stability in accordance with the requirements of the EI determination and USEPA associated guidance, *i.e.* a plume is stabilized if it remains within the existing area of contaminated groundwater and it does not represent an unacceptable impact to a receiving surface water body.

  TRC reviewed isoconcentration figures and other groundwater data to determine the stability of the plume. Data were used to prepare a statistical evaluation of groundwater stability to support completion of the Contaminated Groundwater Under Control Environmental Indicator (EI) Determination as required under the AOC. This statistical evaluation of groundwater stability was documented in a report titled "Statistical Evaluation of Groundwater Chemistry" which was submitted to USEPA in June 2012. The groundwater stability evaluation was conducted using quarterly groundwater monitoring data from 40 monitoring wells (previously 41 monitoring wells), including 14 upgradient/sidegradient wells, 12 on-site monitoring wells (including MW-09s which was excavated during installation of the permeable reactive barrier), and 15 downgradient wells. Groundwater chemistry data collected between March 2009 and April 2012 were used to conduct intra-well data comparisons and trend analysis for the evaluation of groundwater stability. As demonstrated in the June 2012 report, no significant upward trends were observed and the evaluation shows that concentrations within the groundwater plume are stable, and that the plume is not expanding.

  A network of monitoring wells, including source area, perimeter, and downgradient sentinel wells are currently sampled quarterly. This network of wells includes shallow and deep sentinel wells around the perimeter of the groundwater plume. Data from these sentinel wells are below appropriate screening levels. Furthermore, surface water monitoring of the River Raisin has been performed and surface water data are also below applicable screening levels. These monitoring points will continue to be sampled to verify that contaminated groundwater remains within the existing areas of contaminated groundwater, and that it does not represent an unacceptable impact to a the River Raisin.

- **Acceptable Discharges to Surface Water and Environmental Risk Analysis** – TRC evaluated data collected during implementation of remedial investigations to identify the potential for CVOCs to discharge to surface water. Conservatively estimated discharge concentrations are well below MDEQ's Rule 57 Aquatic Maximum Value (AMV) screening level. Therefore, exposure of ecological receptors to affected surface water is not a relevant exposure pathway, and the potential for groundwater discharge to the River Raisin and the adjoining wetland is acceptable from an environmental risk perspective.

This Report includes text, tables, and figures which summarize relevant site conditions, environmental work related to the characterization of the nature and extend of contaminated soil and groundwater as required by the AOC, and the information necessary to support the Groundwater Environmental Indicator Determination. Data from this Report will be utilized by TPC to develop the proposed Final Corrective Measures as required by the AOC.

Section 1
Introduction

This Remedial Investigation Report and Groundwater Environmental Indicator (Report) provides comprehensive documentation of investigation activities conducted at the former Tecumseh Products Company Site located in Tecumseh, Michigan. Preparation of a remedial investigation report is required under Section VI, Paragraph 11 of the Federal Resource Conservation and Recovery Act (RCRA) 3008(h) Administrative Order on Consent (AOC), effective March 29, 2010. Similarly preparation of a groundwater migration stability environmental indicators report is required under Section VI, Paragraph 13(b) of the AOC. As allowed under the AOC, a single report was prepared which provides comprehensive documentation of investigation activities conducted to define the nature and extent of hazardous constituents at and migrating from the site, including an evaluation of groundwater stability to support completion of the RCRA Form CA750, Documentation of Environmental Indicator Determination – Migration of Contaminated Groundwater under Control. This Report was prepared by TRC Environmental Corporation (TRC)[1] on behalf of the Respondent, Tecumseh Products Company (TPC). The United States Environmental Protection Agency (USEPA) facility identification number for the site is MID-005-049-440 and the AOC identification number is RCRA-05-2010-0012.

1.1 Site Description

The former TPC Site is located at 100 East Patterson Street in Tecumseh, Michigan (Figure 1). The site is located in Lenawee County in southeast Michigan. The latitude and longitude are 41° 59' 51" north and 83° 56' 37" west, respectively.

The site is comprised of two parcels which occupy a total of approximately 50.5 acres. Parcel number 325-0250-00 is a 3.4-acre grass-covered area located outside of the southern site fence. Parcel number 325-0241-00 occupies 47.1 acres and is located along the northern portion of the site. This parcel includes an expanse of interconnected buildings/building additions that occupy approximately 750,000 square feet near the western perimeter of the site. Letter designations are used to distinguish the various buildings and building areas. The letter designations, *i.e.*, Area K, P-Building, etc., for each building/building addition are shown on Figure 2. East of the main building, the site is occupied by the former parking area in the north and a grassy area in the south (Figure 1).

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[1] On June 6, 2011 TRC acquired the Environmental Business Unit of RMT, Inc. For purposes of this and future reports, references to TRC are inclusive of RMT, Inc., prior to its acquisition by TRC.

Adjacent land use is described below.

- The property is bounded by a railroad right of way to the west. The area beyond the railroad is comprised of an industrial facility (a corrugated box manufacturer) and residential properties.
- The property is bounded to the north by a mix of industrial/commercial operations (two substations, a towing and auto repair facility, a limousine garage, and a cable company).
- The property is bounded to the east by a mix of industrial/commercial operations and three residences, including a warehouse owned by TPC, a greenhouse, a phone company field operations center, a specialty auto parts store, a school bus garage, and a furniture warehouse.
- The property is bounded to the south by a mix of industrial/commercial operations including the City of Tecumseh fire station and a furniture warehouse.

1.2 Purpose and Scope

This Report provides comprehensive documentation of investigation activities conducted at the former TPC site in Tecumseh, Michigan. These remedial investigation activities were conducted to define the nature and extent of hazardous constituents at and migrating from the site, including an evaluation of groundwater migration stability to support completion of the RCRA Form CA750, Documentation of Environmental Indicator Determination – Migration of Contaminated Groundwater under Control.

This Report is required under the AOC as described below.

- Paragraph 11 of the AOC states that TPC “shall identify and define the nature and extent of releases of hazardous waste and hazardous constituents at or from the facility. In doing so, Tecumseh Products shall perform an investigation to identify the nature and extent of any releases of hazardous waste and hazardous constituents at or from the facility which may pose an unacceptable risk to human health and the environment, and provide this information in the Remedial Investigation Report to the USEPA. The Report shall also describe the nature and extent of releases of hazardous waste and hazardous constituents at or from the facility which do not pose an unacceptable risk to human health and the environment, and provide a basis for those conclusions, including an evaluation of risks.”
- Paragraph 13(b) of the AOC requires that TPC prepare an Environmental Indicators Report demonstrating that: “Migration of contaminated groundwater at or from the facility is stabilized. That is, the migration of all groundwater known or reasonably suspected to be contaminated with hazardous wastes or hazardous constituents above acceptable levels is stabilized to remain within any existing areas of contamination as defined by monitoring

locations designated at the time of the demonstration. In addition, any discharge of groundwater to surface water is either insignificant or currently acceptable according to an appropriate interim assessment. Tecumseh Products shall collect monitoring and measurement data in the future necessary to verify that migration of any contaminated groundwater is stabilized."

- As required under Paragraph 14 of the AOC, TPC will complete the following in order to support completion of the **Contaminated Groundwater Under Control Environmental Indicator (EI) Report and Demonstration** (Groundwater Stability EI):
  - "Determine appropriate risk screening criteria under current use scenarios and provide the basis and justification for the use of these criteria."
  - "Determine any current unacceptable risks to human health and the environment and describe why other identified risks are acceptable."
  - "Stabilize the migration of contaminated groundwater. This includes implementing any corrective measures necessary to stabilize the migration of contaminated groundwater."
  - "Conduct groundwater monitoring to confirm that any contaminated groundwater remains within the original area of contamination."
  - "Prepare a report, either prior to or as part of the Environmental Indicators Report, that describes and justifies any interim actions performed to meet the requirements of Section VI, Work to Be Performed, including sampling documentation, construction completion documentation and/or confirmatory sampling results."

In order to provide comprehensive documentation of the findings of investigation activities conducted to define the nature and extent of hazardous constituents at and migrating from the site, this Report includes text, tables, figures and appendices inclusive of information included in previous reports. The Report also includes recently collected data, namely:

- Soil and groundwater data from samples collected during the July-August 2012 Source Area Remedial Investigation Activities, and
- Groundwater data from the July 2012 groundwater monitoring event.

As required in Paragraph 10 of the AOC, Work related to this Determination was conducted in compliance with RCRA and other applicable federal and state laws, and consistent with relevant USEPA guidance documents. Among other cited authority sources, the "Documentation of Environmental Indicator Determination Guidance" which was obtained via the EPA website at www.epa.gov/osw/hazard/correctiveaction/eis/ provides for the use of the Determination Form CA750. In addition to this Report, TPC has also prepared and submitted, concurrently with this Report, a draft of the Determination Form CA750. Consistent with the USEPA EI Guidance, this Migration of Contaminated Groundwater Under Control Environmental Indicator evaluation is intended to be a **qualitative** assessment of **groundwater migration stability** including an evaluation of the **significance of any discharge of groundwater to surface water**. Consistent with the USEPA EI Guidance, the Migration of Contaminated Groundwater Under Control Environmental Indicator is not intended to provide the sole risk assessment on which final corrective measures are based.

1.3 Project Background

In 2008, a Phase I Environmental Site Assessment (ESA) was conducted by Atwell-Hicks, LLC as part of the sale of the approximately 750,000 square foot manufacturing facility and associated property to Consolidated Biscuit Company (CBC). The Phase I ESA report recommended that a Phase II Subsurface Investigation be conducted to address the recognized environmental conditions identified in the Phase I ESA. A Phase II ESA was performed by ATC Environmental Consultants (ATC) on behalf of CBC between December 2008 and February 2009. A copy of the Draft Limited Phase II ESA report was provided to TPC in February 2009. The Phase II ESA report was finalized on September 4, 2009.

Following receipt of the Draft Phase II ESA, TPC retained RMT, Inc. (RMT), now TRC, to investigate soil and groundwater conditions at the site and surrounding area. Between February and September 2009, TPC performed on-site and investigations to define the extent of the chlorinated volatile organic compounds (CVOCs) in soil and groundwater. In September 2009, RMT submitted a Current Conditions Report (CCR) to the USEPA and the Michigan Department of Environmental Quality (MDEQ). The CCR described and summarized the physical setting of the site, the historical operations, sampling data, potentially complete exposure pathways, and voluntary remedial activities undertaken by TPC (RMT, 2009).

During a USEPA site visit conducted on October 27, 2009, Michelle Mullin of USEPA provided feedback on the CCR, and TPC agreed to conduct an additional off-site investigation related to the off-site migration of volatile organic compounds (VOCs). The findings of these investigation activities were submitted to USEPA on February 12, 2010 in a Technical Memorandum titled “Status Update – Characterization of Volatile Organic Compounds in Groundwater, Former Tecumseh Products Company Site, Tecumseh, Michigan” (RMT, 2010a).

On March 29, 2010 the RCRA 3008(h) Administrative Order on Consent (RCRA-05-2010-0012) for the site (MID-005-049-440) was executed. Since that time TPC has been working cooperatively with USEPA to complete investigation activities and remedial activities pursuant to Section VI, Work to be Performed, of the AOC. Pursuant to the requirements of the AOC, TPC has communicated with the USEPA frequently and in good faith as investigation activities were conducted. As such, the majority of investigation activities have been summarized in a series of documents, which were previously submitted to USEPA for review. A list of these documents, including a brief description of contents, is provided in Appendix A.

In March 2012, TPC met with USEPA to discuss the current project status and USEPA's expectations for an adequate remedial investigation report and a complete Contaminated Groundwater Under Control Environmental Indicator Demonstration. As documented in USEPA Project Manager Michelle Mullin's May 30, 2012 Summary of the March 5-6, 2012 Meeting, USEPA provided a number of comments during that meeting. Since that time, TPC has worked diligently to address those comments. USEPA comments related to the remedial investigation and groundwater stability determination, as well as TPC activities, to address each comment, are listed below.

- **Perform source characterization, including the identification of carbon sources.** TPC conducted additional investigation activities, as described in the Workplan for Proposed Source Area Remedial Investigation Activities, including collection and analysis of soil and groundwater samples for total organic carbon. Data collected at these locations are included in this Report.
- **Installation of an additional well(s) between the source area and the permeable reactive barrier (PRB).** Soil boring B-68 and monitoring well MW-35d were installed in July 2012. Data collected at these locations are included in this Report.
- **Analyze the homogeneity of the aquifer.** Source area remedial investigation activities included continuous soil sampling to the clay confining unit and performance of gamma logging at investigation locations. An evaluation of aquifer homogeneity is included in Section 4 of this Report.
- **Installation of an additional well upgradient of PRB performance monitoring well PRB-09s.** Monitoring well PRB-16s was installed and sampled in August 2012. Data collected at this location are included in this Report.
- **Prepare and submit groundwater isoconcentration maps for USEPA's use prior to submittal of this Report.** Groundwater isoconcentration maps were submitted to USEPA in June 2012.
- **Prepare and submit a statistical evaluation of groundwater stability for USEPA's review prior to submittal of this Report.** The Statistical Evaluation of Groundwater Stability was submitted to USEPA in June 2012.
- **Provide a description of contaminant concentrations with depth.** Data collected during July through August 2012 source area remedial investigation activities were used to supplement existing vertical concentration profile data. A description of source area

contaminant concentrations with depth is provided in Section 7, and a description of the vertical profile of contaminant concentrations in perimeter and off-site groundwater is provided in Section 9.

- **Evaluation of potential discharges to the wetland and River Raisin.** TPC submitted a request to the MDEQ for mixing-zone based groundwater to surface water interface criteria in June 2012. A complete evaluation of potential discharges to the wetland and River Raisin is provided in Section 10.

- **Inclusion of an environmental risk evaluation in this Report, including:**

  - **Collection of a surface water sample from the seep near the former Blood Road Bridge.** A surface water sample was collected from the seep near the former Blood Road Bridge in April and again in July 2012. Analytical data are included in this Report.

  - **Comparison of all analytes (*i.e.,* metals, semi-volatile organic compounds, etc.) to MDEQ Rule 57 values.** Tables comparing all analytes to MDEQ Rule 57 surface water quality values are included in this Report.

Section 2
Site History

2.1 Historical Uses of the Site

The Tecumseh Products Company (TPC) site consisted of farmland (undeveloped woodlands/farmland) until it was first developed for industrial use in the late 1800s and early 1900s. Prior to TPC's acquisition of the site in 1934, portions of the property had been occupied by the following manufacturing facilities: Tiffany Iron Works (iron foundry); Heesen Brothers and Company (feed cookers, hog rings and hollowware); Carson Foundry and Manufacturing/Bruce Manufacturing (job castings and food cookers); Anthony Fence Company/American Steel and Wire Company (steel wire and woven wire fencing); and H. Brewer Company (concrete mixers and general foundry products). The site was occupied by various divisions of TPC between 1934 and 2009. Historical documents indicate that the uses of the site have not changed significantly since 1934, other than changes in some product lines, several episodes of facility expansion, and an increasing level of development until June 2008.

2.2 Site Operations

The TPC site is occupied by a series of interconnected buildings/building additions that occupy approximately 750,000 square feet (main building). There are other buildings on site, but they are significantly smaller in size, and were typically not utilized for manufacturing operations. Letter designations, *i.e.*, Area K, Building Q, etc., for each building/building addition are shown on Figure 2.

The oldest portion of the main building, referred to as Area B (Figure 2), is located in the northern portion of the site; subsequent building expansions and additions have grown the main building to the south and east. Areas H, J, and Z in the northwestern portion of the building have historically housed the TPC corporate headquarters, as well as, TPC research and development (Engineering Department). The rest of the main building was used primarily for the manufacture and storage of TPC products. The first products manufactured by TPC included automotive parts, refrigeration systems, small tools, and toys. By June 2008, when manufacturing operation ceased at the site, TPC operations focused on the production and reconditioning of compressors and condensing units for refrigeration and air conditioning units. Significant manufacturing processes formerly conducted at the site are listed below:

- Parts degreasing (trichloroethene [TCE], 1,1,1-trichloroethane [1,1,1-TCA], and water)
- Unit assembly

- Paint preparation (water, citric acid, iron phosphate, fix solution)
- Unit painting
- Unit reconditioning
- Shipping and receiving, including use of an on-site rail spur until the 1960s

The site was purchased by Tecumseh Bakery, LLC, a holding company for Consolidated Biscuit Company (CBC), in December 2009. When CBC was purchased by Healthside Food Solutions, in April 2010, Tecumseh Bakery, LLC, became an independent entity, and plans to occupy the site for bakery operations were terminated. In February 2012, the site was purchased by Tecumseh Food Machinery & Engineering, LLC (TFME). TFME is the current owner.

The bulk of the facility has remained unoccupied since June 2008. Limited site operations since that time are described below:

- Between June 2008 and February 2012, the site was routinely occupied by on-site security (S-building). In February 2012, when TFME purchased the site, on-site security was dismissed.
- Between June 2008 and June 2012, up to 30 TPC employees continued to lease and occupy the office and engineering portions of the main building (Areas H, J, and Z).
- Since February 2012, the site has been occupied by the new TFME site manager who works out of an office located in the old security area (S-Building), and several temporary TFME employees who are in the process of scrapping the equipment that TFME has stored on site.

Currently, TFME plans to separate P-Building and S-Building from the remainder of the plant, so that P-Building can be leased or sold as a separate parcel, and to demolish the remainder of the facility.

2.3 Types of Waste Generated and Waste Management

Several waste streams were generated during the former TPC production processes. The primary wastes generated at TPC were solvent distillation sludges (F001), spent mineral spirits (D001), paint waste (D007), waste oil (F002), scrap metal, metal fines, and an iron phosphate and citric acid solution. The following is a summary describing the documented waste generation and treatment processes at TPC.

Wastewater treatment was performed at two locations at the site. The first wastewater treatment system operated in the Area K-1 of the main building. This wastewater system is also described as solid waste management unit 1 (SWMU 1) later in this Report, and is not to be confused with the newer wastewater treatment system that was built in 1994 and operated in a separate building (Building R) on the eastern side of the main building (Figure 2). These wastewater treatment systems were used to treat process wastewater that contained suspended solids, water-based cleaning compounds, coolants, and a trace amount of oil and solvents. Wastes generated during the water treatment process included filtercake from water filtration, solids generated during the settling process, and residual oil that was skimmed off and managed with all other waste oil generated at the site (solvent waste code F002). Treated wastewater was discharged to the City of Tecumseh publicly-owned treatment works (POTW).

TPC operated a Distillation Solvent Recovery System used to distill spent 1,1,1-TCA that was generated by two vapor degreasers (Area M). The vapor degreasers were used to clean used motors during reconditioning and to clean the tubes and valves used in the assembly of new units. Spent 1,1,1-TCA was distilled and the clean solvent was recycled back into the vapor degreasers. The distillation sludge was stored in the Hazardous Waste Drum Storage Area (outside of Area L-1), before being sent to Safety-Kleen of Hebron, Ohio for treatment and disposal. Prior to use of the Distillation Solvent Recovery System, TPC managed spent 1,1,1-TCA by storing it in the Former Spent Solvent Storage Tank (Area TD), which was taken out of service in 1979. The Distillation Solvent Recovery System operated until the early 1990s.

TPC generated waste citric acid solution and iron phosphate solution during the cleaning and priming of the units prior to the painting process. These solutions were collected in 55-gallon drums at the Citric Acid and Iron Phosphate Solution Accumulation Area (Area V-2) until they were emptied into the Wastewater Treatment System.

Paint waste was generated when the paint areas were cleaned-out. TPC representatives reported that the site switched from solvent-based paint to water-based paint in 1984. Paint waste was still treated as a hazardous waste because it contained chromium. As part of the painting process, manufactured units, hanging on a conveyor belt, were sent through an enclosed structure open at the front and back for the conveyor to move through. The paint was applied in this enclosed structure. When the paint areas were cleaned, all four sides were scraped. These scrapings, which included tubes or fixtures that fell off of the conveyor, were accumulated in 55-gallon drums and stored at a Paint Waste Accumulation Area (Area G-2) until enough paint waste (D007 chromium) accumulated to be transferred to the Hazardous Waste Drum Storage Area. Paint waste was picked up by Chem-Met in Wyandotte, Michigan, for treatment and disposal.

Waste oil was generated at the site in several areas. Compressors and motors brought in for reconditioning were drained of residual oil. The oil skimmers that operated as a part of the wastewater treatment system collected oil. Maintenance of machinery as a part of site operations generated waste hydraulic oil. Waste oil was collected in the 6,000-gallon Waste Oil Storage Tank, which was located in Area TD of the main building.

Metal fines were generated during the machining process. Iron castings were machined to specifications and the resulting iron fines were collected at the Metal Fines Storage Area (outside of Area B-2). These fines were sold to Jackson Iron and Metal in Adrian, Michigan, who in turn sent the fines to a foundry.

Scrap metal was generated at several different areas of the plant. When used compressors and motors were brought in to be reconditioned, worn parts were replaced. Worn metal parts were collected and placed in one of the Scrap Metal Bins (outside of Areas B-2 and L-1). Scrap metal was also generated during equipment maintenance. Scrap metal was sold to recycling facilities.

2.4 Summary of Historic Waste Management Permits and Licenses

2.4.1 RCRA Part A Permit

TPC filed a Federal Resource Conservation and Recovery Act (RCRA) Part A permit application with the United States Environmental Protection Agency (USEPA) on March 17, 1981. The permit application allowed for container (S01) and tank (S02) storage for solvent wastes (F002 and F017). On June 10, 1982, the USEPA granted TPC interim status for the container storage and the tank storage areas, identified as SWMU 6 and SWMU 10, respectively, in a USEPA Preliminary Assessment/Visual Site Inspection (PA/VSI) conducted in April 1982. The approximate locations of the SWMUs are shown on Figure 2. On June 21, 1982, TPC submitted a closure plan for its container storage and 2,500-gallon spent solvent storage tank and reported that the site would discontinue storage of hazardous waste for more than 90 days. USEPA granted approval of TPC's closure plan and reported that it would consider closure final with the submittal of a certification of closure for the storage tank. On November 12, 1982, an engineering firm representing TPC submitted a certificate of closure for the storage tank. TPC was regulated as a generator of hazardous waste with less-than-90-day storage until 2008.

2.4.2 National Pollution Discharge Elimination System Permit

TPC was granted a National Pollution Discharge Elimination System (NPDES) permit on April 16, 1979. The permit was issued by the Michigan Water Resources Commission and authorized TPC to discharge to the Raisin River via a Patterson Street storm sewer, Permit Number MIO000256. TPC was required under their NPDES permit to submit sampling results for the following parameters: 1) total suspended solids, 2) total dissolved solids, 3) temperature, 4) oil and grease, 5) pH, and 6) 1,1,1-TCA.

2.4.3 Air Permits

TPC was reported to have had two air permits with the state of Michigan. One permit was issued for the application of water-based paints, Permit Number 312-83. The second permit was for one 1,1,1-TCA vapor degreaser, Permit Number 726-86. TPC reported that its second 1,1,1-TCA degreaser was covered by a “grandfather clause,” which did not require that a permit be issued because it was installed before the regulations became effective. In early 2000, TPC operated under a minor operating permit, as source ID 26091000031.

2.5 On-site Treatment Facilities

Prior to 1990, TPC operated a wastewater treatment system with a capacity of up to 20,000 gallons per day (SWMU 1 on Figure 2). This system, located in Area K-1 of the main building, was used to treat process wastewater that contained suspended solids, water-based cleaning compounds, coolants, and a trace amount of oil and solvents. The system managed all process wastewater, and the resulting by-product consisted of filtercake that was scraped off and stored in a hopper at the point of generation. TPC then transported the filtercake to the Laidlaw Landfill in Adrian, Michigan, for disposal. The solids generated during the settling process were collected in a hopper at the point of generation and then transferred to a 20-cubic-yard steel Metal Solids Bin located directly outside of the wastewater treatment system building. Chem-Met of Wyandotte, Michigan, picked up the solids consisting of metal chips and metal fines for treatment and disposal. Any residual oil was skimmed off and transferred to a waste oil storage tank. Because trace amounts of solvents remained in this residual oil, which was mixed in with all other waste oil generated at the site, all waste oil was classified with a solvent waste code (F002). The wastewater was sent through sand filters prior to being discharged to the City of Tecumseh POTW. A new Waste Water Treatment Plant (Building R) was constructed in 1994 and placed in its own 2,000-square-foot building, located east of the main manufacturing building (Figure 2).

Prior to 1979, TPC managed spent 1,1,1-TCA by storing it in the Former Spent Solvent Storage Tank. After the tank was taken out of service TPC operated a Distillation Solvent Recovery System used to recycle spent 1,1,1-TCA that was generated by two vapor degreasers. This is also referred to as SWMU 5 in latter portions of this Report; the location is shown on Figure 2. The vapor degreasers were used to clean used motors during reconditioning and to clean the tubes and valves used in the assembly of new units. Spent 1,1,1-TCA was distilled and the clean solvent was recycled back into the vapor degreasers. The distillation sludge was stored in the Hazardous Waste Drum Storage Area, before being sent to Safety-Kleen of Hebron, Ohio, for treatment and disposal.

2.6 On-Site Storage Facilities

Eighteen underground storage tanks (USTs) and numerous above ground storage tanks (ASTs) have been identified at the site. Appendix B provides a copy of a TPC table, created in 1986, with a summary of the storage tanks in place at the time the table was created, including the eighteen identified USTs and 8 bulk ASTS. A figure showing their corresponding locations is also included in Appendix B. Additional smaller ASTs were identified in the Phase I Environmental Site Assessment (ESA) report and the USEPA PA/VSI report.

2.6.1 Underground Storage Tanks

Eighteen USTs have been identified at the site. These USTs are described below. Additional information and a map showing the locations these USTs are provided in Appendix B. UST areas are also shown on Figure 2.

The Michigan Department of Environmental Quality (MDEQ) UST database contains records for 15 of these USTs. The USTs listed in the MDEQ database were previously used by the site for storage of lubricating oils, lap oil, kerosene, used oil, fuel oil, and hazardous substances. The USTs, located immediately west of the central part of the building, were installed between 1946 and 1970, and ranged in size from 6,000 to 20,000 gallons. All of the USTs were closed between July 1990 and November 1990. The UST database indicates that three of the tanks were abandoned in place and the remaining tanks were removed from the ground. According to an October 25, 1990, letter from TPC to the Michigan Fire Marshall, the five tanks that were removed in July 1990 were cleaned and inspected; none of the tanks reportedly exhibited evidence of leakage. No other documentation is available concerning removal of the former USTs or any sampling conducted at the time of removal. The MDEQ UST database reports no active USTs and fifteen tanks either removed from the ground or closed in ground. The TPC site is not listed on the Leaking Underground Storage Tank (LUST) database.

In addition to the fifteen USTs listed in the MDEQ UST database and discussed above, the March 1993 PA/VSI report identified a 20,000-gallon tank divided into two 10,000-gallon compartments, located beneath the floor of the former wastewater treatment area, which were used to hold untreated wastewater. These tanks were reportedly constructed of stainless steel with a fiberglass lining and were installed in the early 1980s. According to site personnel, these tanks were pumped out and filled with sand in 1990. Based on their construction, it is unlikely that significant releases were associated with the historical usage of these former wastewater holding tanks.

The site records, included in Appendix B, also show two additional USTs (a 20,000-gallon quench oil tank and a 6,000-gallon alcohol tank) that were removed in November 1987. These tanks do not appear in the UST database searched by Environmental Data Resources (EDR); likely because they were process tanks.

2.6.2 Aboveground Storage Tanks

Through a review of site records, the Phase I ESA report and the USEPA PA/VSI report, numerous ASTs have been identified at the site. These ASTs are described below. Additional information and a map showing the locations the 8 bulk ASTs are provided in Appendix B.

According to the 1986 tank inventory table and figure in Appendix B, there were eight bulk ASTs at the site, with capacities ranging from 6,000 to 12,000. Three of the tanks contained used oil; the remaining tanks contained compressor oils. All of these bulk tanks were located inside buildings in areas that have concrete floors and concrete dike walls for secondary containment. Currently all of the bulk ASTs are empty and out of service.

In addition to the eight large ASTs, a Phase I ESA report and the USEPA PA/VSI report noted additional smaller tanks. A summary of these tanks is provided below:

- Five small tanks located in Area E (estimated capacities of between 500 and 1,000 gallons) that were used to hold and distribute refrigeration oils. These tanks are now empty.
- Two aboveground storage tanks that were used to hold wastewater in the former wastewater treatment area (Area K-1).
- Several aboveground vessels, including reactor tanks, holding tanks, and an oil-water separator in the newer wastewater treatment building (Building R).
- Two propane tanks located in the southwest corner of the site (both 1,000-gallon capacity) that provided propane for the site forklifts.
- One oxygen tank (1,000-gallon capacity), located in the western portion of the site, supplied oxygen used in the brazing operations.
- Four tanks located in the Engineering Department contained refrigerants used to charge refrigeration units for testing purposes (capacities ranging from 1,350 to 1,750 pounds).

- The site also had two emergency diesel generators, which had tanks with a combined capacity for 733 gallons of fuel. The diesel tanks were equipped with secondary containment.
- A 2,800-gallon "used oil burn tank" in Area TD contained oils from compressor tear-downs that was later used to fuel the boilers.
- A 5,000-gallon AST in Area TD contained 1,1,1-TCA.
- A 3,500-gallon AST outside of Building L held acid from de-rust operations.
- A 2,500-gallon spent solvent (1,1,1-TCA) AST located near Area K (RCRA-closed in 1982).

Site personnel were not aware of any leaks or spills relating to the ASTs, and the Phase I ESA report did not note any observed evidence of staining or past releases at the time of the site visit.

2.6.3 Drum and Other Storage Areas

New oils and non-flammable chemicals were stored in a separate building (Building Q). The walls and floor of the building provided adequate secondary containment. A partitioned self-contained flammable chemical storage building located adjacent to Building Q was used for the storage of flammable chemicals (*e.g.*, paints, non-hazardous parts washer solvent, acetone, and alcohols), as well as hazardous waste. Maintenance oils, used oil, and smaller containers of oils and greases were once stored in the maintenance shop. Drums containing oil-contaminated solids (mostly absorbents used for minor spills/leaks) and empty drums were stored in Area TD. Drums containing compressor oil were stored and maintained in the compressor room. Containers of boiler treatment chemicals were once stored in the boiler room (Area N-2). Drip pans provided secondary containment for drums used to dispense the water treatment chemicals. A roll-off container for grinding swarf was staged in a shed located in the western part of the site that is no longer present. Cylinders of compressed gases were staged in a shed located north of the Engineering Department. Drums and totes containing various chemicals were once stored in the de-rust area (Area W-1). Totes containing a two-part diisocyanate foam packaging system were once used in the shipping department (Area P-2). Three parts washers that contained a non-hazardous petroleum-based solvent were used in the maintenance shop (one washer) and the Engineering Department (two washers). Several drums and smaller containers with machine oils, greases, and used oil were stored in the Engineering Department. All of these containers were provided with secondary containment.

According to the Phase I ESA, site personnel were not aware of any significant spills or releases of materials nor did the report note any observed evidence of significant spills or uncontrolled releases from these storage areas. In addition, Tecumseh Fire Chief Joseph Tuckey had no knowledge of any spills at the site.

2.7 Disposal Activities

The Phase I ESA did not identify any on-site disposal areas, ponds or apparent evidence of solid waste dumping (*i.e.*, unusual mounding, debris piles, or depressions), suspect fill material, or landfilling on the TPC property during site reconnaissance. A pile of concrete rubble was observed on the south side of the subject site building. Although the source was unknown, based on its appearance and inert nature, this concrete rubble was not considered to be an environmental concern.

2.8 Summary of Past Releases

Two spills have been documented at the site.

- **1992 Spill:** The site is listed in the Emergency Release Notification System (ERNS) database as having had a reported release of 200 gallons of oil from overfilling of an aboveground storage tank in 1992. The release reportedly entered a storm sewer outfall. No further documentation was available concerning this spill response and no documented enforcement action was taken.
- **2003 Spill:** The site is listed in the Michigan Pollution Emergency Alerting System (PEAS) database as having had a release of compressor oil onto a loading dock in August 2003. The spill was reportedly cleaned up and did not enter the storm sewer system.

2.9 Summary of Potential Sources of Contamination

This section summarizes the potential sources of contamination identified at the site in the USEPA PA/VSI report and the Phase I ESA. This section describes each SWMU in detail including historical use, current status, and any corrective action taken.

2.9.1 1992 USEPA Preliminary Assessment/Visual Site Inspection

According to the USEPA Final PA/VSI report resulting from an inspection of the TPC site on April 28, 1992, twelve SWMUs were identified (Figure 2). The PA/VSI did not identify any other areas of concern. A general summary of each SWMU is as follows:

- **SWMU 1: Old Wastewater Treatment System**
  - Capacity: 20,000 gallons of wastewater per day
  - Location: Area K-1

- § Dates of Operation: 1975 through 1994
- § Unit Description: Composed of a settling tank with attached oil skimmers, a treatment tank with attached oil skimmers, a deep bed filter and a filter press
- § Functionality: Managed process wastewater that contained suspended solids, water-based cleaning compounds, coolants, and a trace amount of oil and solvents
- § Environmental Protection: Concrete floor with minimum thickness of 8 inches
- § Status: Decommissioned in 1994

– **SWMU 2: Metal Solids Bins**

- § Capacity: 20 cubic yards
- § Location: Area TD
- § Dates of Operation: Early 1970s through 2008
- § Unit Description: Steel bin
- § Functionality: Containment for metal fines separated at the waste water settling tank
- § Environmental Protection: Concrete pad
- § Status: Bins have been removed

– **SWMU 3: Underground Wastewater Storage Tank**

- § Capacity: 20,000 gallons, two 10,000-gallon compartments
- § Location: Area K-1
- § Dates of Operation: Early 1980s through 1990
- § Unit Description: Fiberglass-lined stainless steel underground storage tank divided into two compartments
- § Functionality: Holding tanks to control flow of process wastewater
- § Status: Pumped out and filled with sand in 1990

– **SWMU 4: Final Holding Tank**

- § Capacity: 3,500 gallons
- § Location: Area G-2
- § Dates of Operation: 1975 through 1990
- § Unit Description: Steel tank with oil skimmer and connected sand filters
- § Functionality: Used to settle solids, skim residual oil, and filter wastewater prior to discharge to the City of Tecumseh POTW

- Environmental Protection: Oil collected was transferred to the Waste Oil Storage Tank (SWMU 11)
- Status: Decommissioned in 1990

– **SWMU 5: Distillation Solvent Recovery System**
  - Location: Area M
  - Dates of Operation: 1984 through early 1990s
  - Unit Description: Water vapor conveyed heated solvents through the system's separator and the recovered solvents were pumped into 55-gallon drums for reuse in the degreasing process
  - Functionality: Distillation of spent 1,1,1-TCA generated during degreasing operations
  - Status: Decommissioned in early 1990s

– **SWMU 6: Hazardous Waste Drum Storage Area**
  - Area: 8 feet by 25 feet
  - Location: Outside of Area L-1
  - Dates of Operation: Late 1970s through 1990
  - Unit Description: Sloped concrete pad with a covering over the top and 4-foot concrete walls on three sides
  - Functionality: Storage and containment drums containing solvent distillation sludge, spent mineral spirits, and paint waste
  - Environmental Protection: Managed under a Part A Interim Status but closed in 1982 as a permitted unit and then managed as a less-than-90-day unit from 1982 to 1990
  - Status: Closed

– **SWMU 7: Citric Acid and Iron Phosphate Solution Accumulation Area**
  - Capacity: 55 gallons
  - Location: Area V-2
  - Dates of Operation: 1976 until June 2008
  - Unit Description: Drum on a wooden pallet located in the interior of the site
  - Functionality: Accumulation and temporary storage of spent non-hazardous citric acid and iron phosphate solution from the wash process
  - Status: Removed June 2008

– **SWMU 8: Scrap Metal Bins**
  - § Capacity: Multiple units ranging in size from 55-gallon drums to an 8-foot by 5-foot hopper
  - § Location: Outside of Areas L-1 and B-2
  - § Dates of Operation: 1934 through June 2008
  - § Unit Description: Steel bins
  - § Functionality: Contain scrap parts from the production processes and site maintenance operations. Aluminum parts were separated from the copper and steel parts. All other parts were stored outside of bins.
  - § Status: Bins and all scrap metal have been removed

– **SWMU 9: Paint Waste Accumulation Area**
  - § Capacity: Two 55-gallon drums
  - § Location: Area G-2
  - § Dates of Operation: 1960s through June 2008
  - § Unit Description: Steel drums
  - § Functionality: Collection of paint waste generated during the cleaning of the paint process areas
  - § Environmental Protection: Concrete floor
  - § Status: Drums and paint waste have been removed

– **SWMU 10: Former Spent Solvent Storage Tank**
  - § Capacity: 2,500 gallons
  - § Location: Area TD
  - § Dates of Operation: Unknown through 1982
  - § Unit Description: Aboveground storage tank
  - § Functionality: Storage of spent solvents
  - § Environmental Protection: Concrete floor
  - § Status: RCRA closure in 1982

– **SWMU 11: Waste Oil Storage Tank**
  - § Capacity: 6,000 gallons
  - § Location: Area N-1
  - § Dates of Operation: 1976 through June 2008
  - § Unit Description: Aboveground storage tank
  - § Functionality: Managed waste oil generated during manufacturing, from maintenance of on-site machinery, from the draining of compressors that

came back to the plant, and by the oil skimmers that were part of the old wastewater treatment system

  - § Environmental Protection: Concrete floor
  - § Status: Tank is empty

– **SWMU 12: Metal Fines Storage Area**

  - § Location: Outside of Area B-2
  - § Dates of Operation: 1940s through June 2008
  - § Unit Description: Area with concrete base, surrounded on three sides by the building walls
  - § Functionality: Storage of metal fines generated during the machining processes
  - § Environmental Protection: Drain leading to the wastewater treatment plant to collect all run-off from the area
  - § Status: Bins and metal fines have been removed

2.9.2 Phase I Environmental Site Assessment

In October 2008, Atwell Hicks, LLC conducted a Phase I ESA to evaluate the presence of recognized environmental conditions (RECs) or other environmental concerns at the TPC site. This evaluation identified two general RECs, which are described below:

– **REC 1:** According to a report prepared by EDR, the TPC site is listed on the following environmental databases: Comprehensive Environmental Response, Compensation, and Liability Information System-No Further Remedial Action Planned (CERCLIS NFRAP); a Corrective Action Report (CORRACTS); a Resource Conservation Recovery Act-Treatment, Storage, and Disposal Facility (RCRA-TSDF); a NPDES, PEAS, and a UST database. Lacking information on site assessment activities related to the RCRA, CERCLIS, UST, CORRACTS listings, or the PEAS incident. The Phase I report identified “release(s) associated with the subject site activities” as a REC.

– **REC 2:** A potential for subsurface impact by releases of petroleum products and/or other hazardous substances related to the long-term industrial operations or the railroad siding represents a REC to the site.

2.9.3 Assessment of SWMUs and RECs

Soil and analytical data indicate that operations in the vicinity of SWMU 5, the Distillation Solvent Recovery System, may be a significant source area for 1,1,1-TCA and TCE in soil and groundwater. Although concentrations of chlorinated VOCs (CVOCs) are elevated throughout the site, there is no evidence that other units (SWMUs, USTs, ASTs, etc.) are the source of on-site CVOCs. Rather, on-site CVOCs appear to be a result of long-term industrial operations at the site (REC 2). The subsurface contamination has been the focus of site-wide remedial investigation activities and corrective measures.

Section 3
Summary of Site Investigation Activities

3.1 Summary of Investigation Activities by Others

In 2008, a Phase I Environmental Site Assessment (ESA) was conducted by Atwell-Hicks, LLC, as part of the potential sale of the Tecumseh Products Company (TPC) manufacturing site to Consolidated Biscuit Company (CBC). The Phase I ESA report recommended that a Phase II Subsurface Investigation be conducted to determine the nature and extent of the recognized environmental conditions.

A Phase II ESA was conducted by ATC Environmental Consultants (ATC) on behalf of CBC between December 2008 and February 2009. The Limited Phase II Investigation included the advancement of 30 on-site soil borings. Soil borings conducted by ATC are designated as GP-XX (installed with a Geoprobe®) or HB-XX (installed with a hand auger). The results of the Phase I ESA were used to identify sample locations and to select parameters for analysis. Soil and groundwater samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), metals, and/or cyanide. A table summarizing the rationale for each investigation location, as well as parameters analyzed is provided in Appendix C, and sample locations are shown on Figure 3.

3.2 Remedial Investigation Activities by TPC

In February 2009, TRC Environmental Corporation (TRC) reviewed the Draft Limited Phase II ESA report on behalf of TPC. Based on this review, TRC identified two likely source areas: the Northern Source Area and the Southern Source Area. The Northern South Area is in the vicinity of soil borings GP-14 and GP-15 (Figure 3) where the highest concentration of trichloroethene (TCE) was found in the soil, and up gradient of GP-2 where high concentrations of TCE were found in the groundwater. As described in Section 2, there is no single known source for TCE in the Northern Source Area. Rather TCE is detected at varying concentrations throughout the area. The distribution suggests incidental usage during the manufacturing processes (recognized environmental condition 2 [REC 2]). Potential sources of TCE include use of TCE during machining and degreasing processes, a former railroad spur where various chemicals, including TCE, were off-loaded from rail cars, and an above ground solvent distribution system. The Southern Source Area is in the vicinity of GP-21 and GP-22 where high concentrations of TCE and 1,1,1-trichloroethane (1,1,1-TCA) were found in the groundwater. A Distillation Solvent Recovery System (solid waste management unit 5 [SWMU 5]) located in

Area M of the main building is in the vicinity of the Southern Source Area is the most likely source of the constituents of concern (COCs) in this area (Figure 2).

After review of the Draft Phase II ESA report, TRC concluded that there was a potential for off-site migration of VOCs above the Michigan Department of Environmental Quality (MDEQ) Part 201 generic cleanup criteria (Part 201 criteria). Therefore remedial investigation activities, conducted by TRC on behalf of TPC, were initiated. See Section 6 for a more complete evaluation of site COCs.

In March 2009, TPC initiated a phased series of investigations to support a risk-based evaluation of potential exposure pathways, including:

- On-site source area investigation activities to:
  - Determine the nature and extent of COCs in soil, , including non-aqueous phase parent products;
  - Determine the nature and extent of COCs in groundwater, including non-aqueous phase parent products;
  - Evaluate the physical parameters of the source area aquifer that might affect contaminant fate and transport;
  - Evaluate the stability of COCs in source area groundwater;
  - Identify potential receptors, and evaluate risk to those receptors; and
  - Support the design and selection of final corrective measures.
- Source area, perimeter and off-site groundwater investigation activities to:
  - Determine the horizontal and vertical extent of COCs in groundwater;
  - Evaluate the stability of the groundwater plume;
  - Identify potential receptors, and evaluate risk to those receptors; and
  - Support the design and selection of final corrective measures.
- Surface water investigation activities to:
  - Define current discharges to surface water, if any;
  - Identify potential receptors, and evaluate risk to those receptors; and
  - Support the design and selection of corrective measures.
- Soil gas and indoor air investigation activities to:
  - Determine the area over which indoor air may be affected above risk-based screening levels;

- Identify potential receptors, and evaluate risk to those receptors; and
- Support the design and selection of corrective measures.

A detailed chronology of investigation activities is provided in Appendix D.

Section 4
Site Setting

4.1 Regional and Site Climate

Based on long-term regional weather records, southeast Michigan receives an average of 33 inches of rainfall per year (MSU, 2012). Winds in the area are predominately from the west with an average wind speed of 4.5 meters/second.

4.2 Topography and Surface Drainage

Topographically, the region is relatively flat sloping downward to the east, toward the Raisin River, which is located approximately 2000 feet east of the site. However, as illustrated on Figure 3, the surface topography drops steeply east (downgradient) of the southern half of the site from an approximate elevation of 780 feet above mean sea level (ft MSL) to an approximate elevation of 750 ft MSL in the wetland area adjacent to the River Raisin.

On-site the topography slopes predominately to the east at an approximately 1-percent grade. The bulk of storm water that accumulates during rainfall events drains to the storm sewer in the Maumee Street right-of-way located immediately east of the site. Storm water in the loading area west of P-Building drains to a storm sewer located in that loading area. The loading dock storm sewer drains to the City of Tecumseh storm sewer system at Patterson Street. Storm sewers around the perimeter of the site discharge to the River Raisin flood plain as illustrated on Figure 4.

4.3 Geology

The site is located near the southeast rim of the Michigan Basin. Topographically, the region is relatively flat (Figure 3) and characterized by glaciofluvial sediments at the surface. The geology consists of a series of unconsolidated Holocene and Pleistocene age glacial deposits, predominantly gravel and sand with areas of silt and clay overlying Mississippian age shales. The thickness of the glacial deposits varies from a few feet to over 200 feet thick throughout the region. Local water well logs within one mile of the site indicate that bedrock in the area is 150 to 200 feet below ground surface (ft bgs).

TRC Environmental Corporation (TRC) evaluated the unconsolidated materials underlying the site through a review of logs from soil borings advanced at the site during field activities conducted by TRC between April 2009 and August 2012. A complete set of soil borings logs and monitoring wells construction forms from all sub-surface investigation activities through

August 2012 is included as Appendix E. Cross sections developed from these boring logs illustrate the geology underlying the former Tecumseh Products Company (TPC) site and vicinity. Figure 5 shows the orientation of the cross-section transects (A-A’, B-B’, C-C’, D-D’, E-E’ and F-F’), while Figures 6 through 11 present the cross sections.

As shown on the cross sections, the site geology generally consists of a surficial silty/sandy clay interval ranging from 3 to 7 feet thick, underlain by unconsolidated fine to coarse sand and gravel. Visual classification as recorded on soil boring logs (Appendix E) found that the aquifer is composed almost entirely of permeably soils ranging in composition from silty sand to gravel. Gamma logging was conducted at six locations (NS-18, NS-19, NS-20, SS-9, SS-10, and MW-35d/B-68) to supplement visual classification (locations are shown on Figure 3). Results of gamma logging are included on soil boring logs. No significant areas of low permeability soil have been identified in the source area aquifer. A deep clay layer having a hydraulic conductivity between 1.8×10^{-8} centimeters per second (cm/s) to 1.9×10^{-8} cm/s is present beneath the site (Appendix F). Soil boring data suggests that this second clay layer is continuous across the study area. The elevation of the top of the clay confining unit clay ranges from approximately 745 ft MSL along the western perimeter of the site to an elevation ranging from approximately 745 ft MSL to 765 ft MSL along the eastern extent of the area of affected groundwater.

In the area northeast of the site, an intermediate clay layer is observed between the surficial clay and the deep clay confining unit. The top of this intermediate clay layer ranges from approximately 779 ft MSL to 785 ft MSL, with the observed clay thickness ranging from approximately 1 foot to 6 feet. The intermediate clay layer appears to be continuous in the study area east of Maumee Street and north of Patterson Street. Perched groundwater has consistently been observed in this area during soil boring and monitoring well installation activities. The intermediate clay layer and associated perched groundwater are discontinuous west of Maumee Street and in the south where ground surface elevations approach the elevation of the top of intermediate clay, as illustrated on Cross Section F-F’ (Figure 11). The approximate aerial extent of the intermediate clay unit and associated perched groundwater is illustrated on Figure 12.

4.4 Hydrogeology

Data collected from the soil borings and monitoring wells installed during subsurface investigation activities indicate that shallow groundwater typically ranges in depth from 3 to 30 ft bgs within the sand and gravel aquifer. The variation in groundwater depth is largely a result of site topography, which slopes downward to the east, toward the Raisin River. The deep clay unit represents a significant confining layer for vertical groundwater movement into deeper aquifers.

Groundwater elevation data are collected quarterly (Table F1 in Appendix F). Each quarter a groundwater contour map is constructed. Groundwater contour maps, developed using data from the four most recent quarterly sample events, October 2011, January 2012, April 2012 and July 2012, are included as Figures 13 through 16, respectively. The depth to groundwater and the direction of groundwater flow has been generally consistent. Groundwater flow at the TPC site is generally east toward the River Raisin, the nearest body of water located 1,500 to 2,500 feet east of the site. The River Raisin is located topographically below the top of the clay confining unit, and as such is the regional discharge feature for groundwater beneath the TPC site, as illustrated on Cross Section D-D' (Figure 9). A mean horizontal hydraulic gradient of 0.001 has consistently been measured across the former TPC site. Data from *in situ* hydraulic conductivity tests were used to calculate a geometric mean hydraulic conductivity for the unconfined sand and gravel aquifer. The geometric mean hydraulic conductivity is 9.5×10^{-3} cm/s with an upper 95-percent confidence limit of 2.2×10^{-1} cm/s and a lower 95-percent confidence limit of 4.2×10^{-4} cm/s feet per day (Appendix F). Assuming an effective porosity of 0.3, the resultant estimated groundwater flow velocity is 3.2×10^{-5} (33 feet per year).

The vertical hydraulic gradient in the upper sand/gravel aquifer was evaluated at nine of the ten nested well pairs (MW-10s/d, MW-12s/d, MW-19s/d, MW-20s/d, MW-24s/d, MW-27s/d, MW-28s/d, MW-29s/d, and MW-30s/d). Because water at MW-14s is perched with an unsaturated zone between MW-14s and MW-14d, the vertical gradient at this nested well pair was not evaluated. See Table F2 in Appendix F for a table of calculated vertical gradients. At MW-19s/d, MW-24s/d, and MW-28s/d along the western (upgradient) portion of the site, the measured vertical hydraulic was essentially neutral (ranging from -0.003 to 0.003). Northeast of the site the hydraulic gradient varied from downward at MW-29s/d (-0.046 to -0.077) and MW-12s/d (-0.014 to -0.018) to near neutral at MW-30s/d (0.001 to 0.008). At MW-10s/d (-0.11 to -0.23), MW-20s/d (-0.21 to -0.33), and MW-27s/d (-0.67 to -0.68) east/southeast (downgradient) of the site, a downward hydraulic gradient was measured, with the downward hydraulic gradient increasing to the south. This significant vertical downward gradient in the upper sand/gravel aquifer east/southeast of the site, is the result of the presence of a higher hydraulic conductivity sand and gravel deposit that underlies the sand deposit and a significant change in surface topography.

The surface topography drops steeply downgradient of the southern half of the site from an approximate elevation of 780 ft MSL to an approximate elevation of 750 ft MSL in the wetland area adjacent to the River Raisin. East of the site, in proximity to the change in surface elevation, the horizontal hydraulic gradient increases (Figures 13 through 16). The relatively steep drop in groundwater elevation east of the southern portion of the site is illustrated on Cross Section D-D' (Figure 9).

Section 5
Risk Based Screening Levels

5.1 Risk-Based Screening Levels for Soil

The generic cleanup criteria specified in the Michigan Department of Environmental Quality (MDEQ) Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), also known as Part 201 criteria are the risk-based screening levels used to evaluate soil data. The following Part 201 criteria were considered:

- Residential Drinking Water Protection (DWP) Criteria;
- Non-Residential DWP Criteria;
- Groundwater to Surface Water Interface Protection (GSIP) Criteria;
- Residential Direct Contact (DC) Criteria;
- Non-Residential DC Criteria;
- Residential Soil Volatilization to Indoor Air Inhalation (SVIAI) Criteria; and
- Non-Residential SVIAI Criteria.

5.2 Risk-Based Screening Levels for Groundwater

Risk-based screening levels used to evaluate groundwater data include:

- **Generic Part 201 Criteria**:
  - Health-Based Residential Drinking Water (DW) Criteria
  - Health-Based Non-Residential DW Criteria
  - Groundwater to Surface Water Interface (GSI) Criteria
  - Groundwater Contact Criteria

  Note: Few, if any, sites meet the requirements under which the Part 201 Groundwater Volatilization to Indoor Air Inhalation [GVIAI] criteria apply. Therefore United States Environmental Protection Agency (USEPA) has requested that calculated site specific groundwater screening levels (GWSLs) for vapor intrusion be used in place of GVIAI criteria.

- **GWSLs for Volatilization to Indoor Air:**
  - Residential GWSLs
  - Non-Residential GWSLs

  Note: GWSLs for volatilization to indoor air were calculated in accordance with applicable MDEQ and USEPA guidance using the most recent chemical specific toxicity values accepted and/or published by the USEPA as of February 1, 2012. GWSLs were used to evaluate whether constituents of concern (COCs) in shallow groundwater (*i.e.*, at the water table, where volatile organic compounds (VOCs) in groundwater have the potential to volatilize) have the potential to volatilize to indoor air above appropriate risk-based screening levels.

- **MDEQ Rule 57 Water Quality Values (Rule 57 Values) for Surface Water**:
  - Non-Drinking Water Human Non-Cancer Value (HNV)
  - Non-Drinking Water Human Cancer Value (HCV)
  - Final Chronic Value (FCV)
  - Aquatic Maximum Value (AMV)
  - Final Acute Value (FAV)

  Note: Rule 57 values for surface water were used to evaluate whether venting groundwater has the potential to affect surface water above appropriate human (HNV, HCV, FCV, FAV) and environmental (AMV) risk-based criteria. These screening levels are only applicable at sample locations nearest the receiving surface water body.

- **Site Specific Groundwater Contact Criteria:**

  During the March 2012 project meeting, USEPA requested that the site specific groundwater contact criteria be calculated for trichloroethene (TCE) to reflect TCE toxicity values which were updated by USEPA on September 29, 2011. This site specific groundwater contract criterion (13,000 ug/L) is used in place of the generic Part 201 groundwater contact criterion for TCE (22,000 ug/L) in this Report. A calculation package describing the calculations used to determine the site specific groundwater contact criterion for TCE is included in Appendix G.

5.3 Risk-Based Levels for Screening Levels for Surface Water

Risk-based screening levels used to evaluate surface water data include:

- **Part 201 Criteria**:
  - Groundwater to Surface Water Interface (GSI) Criteria

- **MDEQ Rule 57 Water Quality Values (Rule 57 Values) for Surface Water**:
  - Non-Drinking Water Human Non-Cancer Value (HNV)
  - Non-Drinking Water Human Cancer Value (HCV)
  - Final Chronic Value (FCV)
  - Aquatic Maximum Value (AMV)
  - Final Acute Value (FAV)

5.4 Risk-Based Screening Levels for Indoor Air

5.4.1 Introduction

Manufacturing operations at the former Tecumseh Products Company (TPC) site were discontinued in 2008, therefore no current on-site activities are a significant source of COCs to indoor air. Rather COCs in soil and groundwater may volatilize and migrate into indoor air. Typically GWSLs and/or soil gas screening levels (SGSLs) for volatilization to indoor air are used to determine whether indoor air is potentially affected above risk-based screening criteria. These groundwater and soil gas screening levels are calculated by applying an attenuation factor to indoor air screening criteria. Alternatively, concentrations in indoor air may be evaluated directly and compared to risk-based screening criteria for indoor air. Direct comparison of indoor air concentrations to risk-based screening criteria may be complicated by the presence of background indoor air concentrations that are near or even above risk-based screening levels.

5.4.2 Current Regulation

On a federal level, the United States Department of Labor, Occupational Safety and Health Administration (OSHA) has published permissible exposure limits (PELs) for COCs in indoor air. OSHA PELs are only applicable for occupational exposures. USEPA has issued draft vapor intrusion guidance, but currently there are no federal regulations which specify risk-based screening levels for residential indoor air.

On a state level, Michigan does not have indoor air screening levels. Part 201 of the Michigan NREPA, as amended March 25, 2011, does provide residential and non-residential soil volatilization to indoor air inhalation (SVIAI) criteria and groundwater volatilization to indoor air inhalation (GVIAI) criteria (Michigan Administrative Code R 299.5714 and R 2099.5724). Soil and groundwater concentrations above these Part 201 SVIAI and GVIAI criterion may be used to determine that indoor air is potentially affected.

- **Soil:** The current 2002 USEPA Office of Solid Waste and Emergency Response (OSWER) **DRAFT** Guidance for Evaluating the Vapor Intrusion in Indoor Air Migration Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) (2002 USEPA Draft Guidance) states that "Soil sampling and analysis is not currently recommended for assessing whether or not the vapor intrusion pathway is complete. This is because of the large uncertainties associated with measuring concentrations of volatile contaminants introduced during soil sampling, preservation, and chemical analysis, as well as the uncertainties associated with soil partitioning calculations."
- **Groundwater:** MDEQ Admin Rule 299.5714(2) provides that the generic GVIAI criteria shall not apply, and a site specific evaluation of indoor inhalation risks shall be conducted, where any of the following conditions exist:
  - a structure does not have a concrete block or poured concrete floor and walls; or
  - the highest water table elevation of a contaminated saturated zone, considering seasonal variation, is within 3 meters of the ground surface; or
  - a sump is present that is not completely isolated from the surrounding soil by its materials of construction, or there is other direct entry of contaminated groundwater into the basement.

  Few, if any, sites meet the requirements under which generic GVIAI criteria apply. At the former TPC site, groundwater is within 3 meters (10 feet) of ground surface over much of the study area.

Given the limitations of current regulations regarding risk-based screening levels for vapor intrusion, state and federal vapor intrusion guidance was also used to assess the potential for vapor intrusion above risk-based screening criteria.

5.4.3 Current Vapor Intrusion Guidance

The following vapor intrusion guidance documents were considered when developing risk-based screening levels:

- In June 2008, the MDEQ Remediation and Redevelopment Division (RRD) published a **PEER REVIEW DRAFT** of RRD Operational Memorandum No. 4: Site Characterization and Remediation Verification: Attachment 4 – Soil Gas and Indoor Air (MDEQ Draft Guidance). Criteria and screening levels in this document were calculated as described in the 2009 MDEQ Background Document. MDEQ recommends the use of a generic deep (>5 feet) soil gas attenuation factor of 0.002, a generic sub-slab soil gas attenuation factor of 0.02, and a generic groundwater attenuation factor of 0.001.

- In November 2002, USEPA published the OSWER **DRAFT** Guidance for Evaluating the Vapor Intrusion in Indoor Air Migration Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance) (2002 USEPA Draft Guidance). This document, which focuses on single-family residential properties, recommends a screening process under which site data are first compared to generic screening levels calculated using a deep (>5 feet) soil gas attenuation factor of 0.01, a sub-slab soil gas attenuation factor of 0.1, and a groundwater attenuation factor of 0.001. If generic screening levels are exceeded and/or if site conditions warrant further evaluation site-specific attenuations factors may be developed.

In 2009, USEPA published a report highlighting the fact that the lack of final guidance impedes efforts to address indoor air risks. As a follow-up to the review, USEPA conducted a review of its 2002 Draft Guidance. This review found that current guidance is lacking, particularly with respect to the evaluation of soil gas data. Final guidance from USEPA is scheduled for release in November 2012.

During this period of uncertainty in state and federal policy, TPC has undertaken significant efforts to understand the current state of the science in this rapidly developing field, and has employed a combination of conservative risk assessment procedures and aggressive mitigation strategies to address the potential vapor intrusion migration pathway.

5.4.4 Background Indoor Air Concentrations

Measureable concentrations of VOCs, including the COCs for the site, are often present in background indoor air samples. In June 2011, USEPA published a study which provided a summary of typical indoor air concentrations in North American residences. VOCs are detected in a significant number of residences where no potential vapor intrusion source is present. Of approximately 2000 background samples collected, 62.5 percent contained detectable concentrations of tetrachloroethene (PCE); and 42.6-percent contained detectable concentrations of TCE. In some cases, background concentrations may be near or even exceed indoor air screening criteria. For example the calculated residential indoor air criterion for PCE is 0.62 parts per billion by volume (ppbv). The 95th-percentile background indoor air concentration for PCE is 1.4 ppbv. Background indoor air concentrations are included with tabulated indoor air concentrations.

5.4.5 Indoor Air Screening Criteria

According to the 2002 USEPA Draft Guidance and USEPA clarification of guidance related to environmental indicator (EI) determinations (USEPA 2011b), OSHA will typically take the lead when assessing occupational exposure to affected or potentially affected indoor. OSHA has published PELs for COCs. OSHA PELs, which assume occupational exposure over an eight-hour period (time weighted average), are included with tabulated indoor air concentrations.

In February 2010, residential and non-residential indoor air screening criteria were calculated in accordance with the 2009 MDEQ Background Document and the 2002 USEPA Draft Guidance, using both residential and non-residential exposure scenarios and the most recent chemical specific toxicity values accepted and/or published by the USEPA at that time. At the request of USEPA, non-residential indoor air screening criteria were revised in May 2010 to reflect a slightly more conservative non-residential exposure frequency (250 days per year) and duration (25 years), and again in February 2012 to reflect TCE toxicity data which were updated by USEPA on September 28, 2011. Calculations sheets are provided in Appendix H.

Both OSHA PELs and calculated indoor air screening criteria were considered when assessing indoor air concentrations directly. In addition calculated residential and non-residential indoor air screening criteria were used to calculate GWSLs and SGSLs which were then used to assess the potential for volatilization to indoor air, where indoor air samples were not collected.

5.4.6 Groundwater Screening Levels

Residential and non-residential GWSLs were calculated in accordance with the 2009 MDEQ Background Document and the 2002 USEPA Draft Guidance using both residential and non-residential exposure scenarios and the most recent chemical specific toxicity values accepted and/or published by the USEPA at that time (February 2010). Proposed GWSLs were accepted by the USEPA in a comment letter dated August 24, 2010. At the request of USEPA, GWSLs were updated in February 2012 to reflect more recent TCE toxicity data (published September 28, 2011). Calculations sheets are provided in Appendix H, and these screening levels are included on tables which present concentrations of VOCs in groundwater.

5.4.7 Soil Gas Screening Levels

As described above, the evaluation of the risk associated with the volatilization to indoor air migration pathway is a rapidly developing field. Recommendations provided in draft guidance documents are particularly variable with regards to soil gas:

- The 2008 MDEQ Draft Guidance uses a generic deep (>5 feet) soil gas attenuation factor of 0.002 and a generic sub-slab soil gas attenuation factor of 0.02.
- The 2002 USEPA Draft Guidance uses a generic deep (>5 feet) soil gas attenuation factor of 0.01 and a generic sub-slab soil gas attenuation factor of 0.1 for single family residential properties.

In addition to the published, draft, generic attenuation factors, guidance allows for the calculation of site specific attenuation factors. For the former TPC site, a site specific deep soil gas attenuation factor was calculated using the USEPA Johnson Ettinger Model Spreadsheet (v. 3.1). The site-specific soil gas attenuation factor of 0.003 was calculated using the most conservative site geologic conditions observed in the vicinity of affected groundwater.

Finally, TPC also considered SGSLs calculated using a generic attenuation factor of 0.1 as recommended by Project Manager Michelle Mullin of USEPA in a comment letter dated August 24, 2011.

During this period of uncertainty in state and federal policy, TPC has compared soil gas data to SGSLs calculated using a range of attenuation factors. Non-residential sub-slab SGSLs are calculated using an attenuation factor of 0.02. Non-residential deep SGSLs are calculated using a site-specific attenuation factor of 0.003. Residential sub-slab SGSLs are calculated using attenuation factors of 0.02 and 0.1. Residential deep SGSLs are calculated using attenuation factors of 0.003, 0.01, and 0.1. Calculations sheets are provided in Appendix H.

Section 6
Constituents of Concern

6.1 Introduction

In 2008, a Phase I Environmental Site Assessment (ESA) was conducted by Atwell-Hicks, LLC, as part of the potential sale of the Tecumseh Products Company (TPC) manufacturing site to Consolidated Biscuit Company (CBC). The Phase I ESA report recommended that a Phase II Subsurface Investigation be conducted to determine the nature and extent of the recognized environmental conditions. A Phase II ESA conducted by ATC Environmental Consultants (ATC) on behalf of CBC was performed between December 2008 and February 2009. Results of the Phase I ESA were used to identify sample locations and select parameters for sample analysis. Based on historic site operations ATC considered volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), metals and cyanide potential constituents of concern (COCs). ATC developed a sampling strategy based historical site usage. A table summarizing the rationale for each investigation location, as well as parameters analyzed is provided on Table C1 in Appendix C, and sample locations are shown on Figure 3.

The Phase II Investigation conducted by ATC found that VOCs are present in soil and groundwater throughout the former manufacturing area. Chlorinated solvents including trichloroethene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA) were found in soil and groundwater above risk-based screening levels. Because 1,4-dioxane is commonly used to stabilize 1,1,1-TCA, TRC Environmental Corporation (TRC) considered 1,4-dioxane a potential, previously unevaluated COC in the areas with 1,1,1-TCA in soil and groundwater. Therefore, a subset of the soil, groundwater and storm sewer samples collected during the April 2009 investigation activities conducted by TRC, were also analyzed for 1,4-dioxane.

An evaluation of potential COCs, and a rational for the selection of site-specific COCs is provided below.

6.2 Volatile Organic Compounds

Volatile organic compounds, particularly chlorinated VOCs (CVOCs), are the COCs for the site. VOCs are present in soils throughout the area beneath the 750,000-square-foot manufacturing building. VOCs found in soil above risk-based screening levels include ethylbenzene, xylenes, trimethylbenzenes (TMBs), n-butyl benzene, 2-methyl-naphthalene, naphthalene, n-propyl benzene, and CVOCs (tetrachloroethene [PCE], TCE, 1,2-cis-dichloroethene [cis-DCE], vinyl chloride, 1,1,1-TCA, and 1,1,2-trichloroethane [1,1,2-TCA]). VOCs are also present in both on-site and off-site groundwater above risk-based screening levels. VOCs found in groundwater above risk-based screening levels include acetone, 2-butanone, benzene, ethylbenzene, xylenes, TMBs, and CVOCs (PCE, TCE, 1,1-dichloroethene [1,1-DCE], cis-DCE, trans-1,2-dichloroethene [trans-DCE], vinyl chloride, 1,1,1-TCA, 1,1,2-TCA and 1,1-dichloroethane [1,1-DCA]). The nature and extent of VOCs are described in more detail in Sections 7 (Source Area), 8 (Soil), 9 (Groundwater), 10 (Surface Water), and 11 (Soil Gas and Indoor Air).

6.3 1,4-Dioxane

Because 1,4-dioxane is commonly used to stabilize 1,1,1-TCA, 1,4-dioxane was considered a potential COC in the areas with 1,1,1-TCA in soil and groundwater. Therefore, a subset of the soil, groundwater and storm sewer samples collected during the April 2009 investigation activities conducted by TRC, were also analyzed for 1,4-dioxane. The results of 1,4-dioxane sample analysis are provided in Appendix C. 1,4-dioxane was not detected in on-site soils (Table C2), and was detected at only 2 locations in on-site groundwater (Table C3). 1,4-dioxane was not detected at any off-site or perimeter groundwater sample locations, or storm sewer sample locations. Laboratory analytical data for 1,4-dioxane are provided in Appendix I. Given that 1,4-dioxane was not detected in either on-site soils or off-site groundwater, 1,4-dioxane is NOT a COC for the site.

6.4 Semi-Volatile Organic Compounds

The Phase II investigation conducted by ATC included the collection of 21 soil samples and 32 groundwater samples for SVOCs analysis. Laboratory analytical data are included in Appendix I.

SVOCs detected in on-site soils are summarized in Table C4. SVOCs were detected at 4 sample locations (GP-15, GP-16, GP-26, and HB-31). Sample results were compared to Part 201 criteria. Naphthalene was detected above the groundwater to surface water interface protection (GSIP) criteria (0.73 milligrams per kilogram [mg/kg]) at sample locations GP-15 and GP-16. Phenanthrene was detected above the GSIP criteria (2.1 mg/kg) at sample locations GP-15 (3.2 mg/kg) and HB-31 (5.7 mg/kg), and fluoranthene was detected above the GSIP criteria (5.5 mg/kg) at HB-31 (13 mg/kg). SVOCs were not detected above any other Part 201 criteria in on-site soil.

SVOCs detected in groundwater are summarized in Table C5. SVOCs were detected at a single sample location (GP-08). Sample results were compared to Part 201 criteria and Rule 57 values. Naphthalene and 2-methylnaphthalene were the only SVOCs detected in groundwater. Neither compound was detected above any of the Part 201 criteria or Rule 57 values. Given the limited extent of SVOCs detected on-site, and the fact that no SVOCs were detected above groundwater screening levels, SVOCs are NOT considered COCs for the site.

6.5 PCBs

The former TPC site in Tecumseh MI was part of TPC's compressor division. Historically, there were no die cast operations, large punch press operations, or other operations that would require heavy duty hydraulic oils that contained PCBs in past. Nonetheless, the Phase II investigation included the collection of on-site soils for PCBs analysis at 12 sample locations (GP-01, GP-04, GP-06, GP-07, GP-12, GP-14, GP-15, GP-16, GP-25, GP-26, GP-27, and HB-32). No PCBs were detected. Laboratory analytical data area included in Appendix I. PCBs are NOT COCs for the site.

6.6 Metals

The Phase II investigation conducted by ATC included the collection of 21 soil samples and 32 groundwater samples for metals analysis. Laboratory analytical data are included in Appendix I.

Metals detected in on-site soils are summarized in Table C6. Metals are naturally present in soil. Background soil concentrations can vary widely depending on soil type, deposition environment, etc. Nonetheless, the Michigan Department of Environmental Quality (MDEQ) has established statewide default background levels to assist in the evaluation of metals concentrations in soils. Arsenic, cadmium, chromium, copper, selenium, and zinc were found in soil above the Statewide Default Background concentration and Part 201 criteria for soil. Of the six metals detected above Statewide Default Background concentrations and one or more Part 201 criterion, only one (copper) was detected in groundwater. Metals detected in groundwater are summarized in Table C7. Exceedences are detailed below:

- Arsenic concentrations in soil ranged from 2.3 to 14 mg/kg. Arsenic concentrations in soil exceeded the Statewide Default Background concentration (5.8 mg/kg) and the drinking water protection (DWP) (4.6 mg/kg) and GSIP criteria (4.6 mg/kg) at four locations, and the direct contact (DC) criteria (7.6 mg/kg) at two locations. Note that the DC criterion for arsenic, although greater than the Statewide Default Background concentration, is well within the range of naturally occurring arsenic concentrations is soil. Furthermore samples with an arsenic concentration above the DC criterion (GP-16 and GP-27) were collected from below the building slab, preventing incidental direct contact. Arsenic was not detected in any groundwater samples. Given the natural variability of metals in soil and the lack of arsenic in groundwater, arsenic is NOT considered a COC for the site.
- Cadmium concentrations in soil ranged from 0.08 to 9.0 mg/kg. Cadmium concentrations exceeded the Statewide Default Background concentration (1.2 mg/kg), the GSIP criteria (3.0 mg/kg), and the DWP (6.0 mg/kg) criteria at 2 locations. Cadmium was not detected in any groundwater samples. Given the natural variability of metals in soil and the lack of cadmium in groundwater, cadmium is NOT considered a COC for the site.

- Chromium concentrations in soil ranged from 3.8 to 24 mg/kg. Total chromium concentrations in soil exceeded the Statewide Default Background concentration (18 mg/kg) and the GSIP criteria (3.3 mg/kg) at one location. Chromium was not detected in any groundwater samples. Given the natural variability of metals in soil and the lack of chromium in groundwater, chromium is NOT considered a COC for the site.
- Copper concentrations in soil ranged from 6.2 to 110 mg/kg. Copper concentrations exceeded the Statewide Default Background concentration (32 mg/kg) and the GSIP criteria (7.5 mg/kg) at four locations. Copper was not detected in groundwater above any Part 201 criterion or Rule 57 value. Given the natural variability of metals in soil and the low concentrations of copper in groundwater, copper is NOT considered a COC for the site.
- Lead concentrations in soil ranged from 5.7 to 170 mg/kg. Lead concentrations in soil did not exceed screening levels at any of the sample locations. However, the measured concentration of lead in groundwater did exceed the drinking water (DW) criterion (0.004 milligrams per liter [mg/L]) at one location (GP-10 at 0.005 mg/L). Lead concentrations in groundwater did not exceed any other Part 201 criterion or Rule 57 value. As described in footnote L of the Part 201 operational memoranda, the default DW criterion for lead was calculated using a biologically based model linked to the soil DC criterion (400 mg/kg). If soil concentrations are below 400 mg/kg, the site specific DW criteria may be increased to the state action level of 0.015 mg/L. All lead concentrations in soil are below the DC criterion, and all groundwater concentrations are below the state action level. Therefore lead is not considered a COC for the site.
- Selenium concentrations in soil ranged from 0.23 to 3.5 mg/kg. Selenium concentrations exceeded the Statewide Default Background concentration (0.41 mg/kg) and the GSIP criteria (0.40 mg/kg) at eight locations. Selenium was not detected in groundwater above any Part 201 criterion or Rule 57 value. Given the natural variability of metals in soil and the lack of selenium in groundwater, selenium is NOT considered a COC for the site.
- Zinc concentrations in soil ranged from 13 to 260 mg/kg. Zinc concentrations exceeded the Statewide Default Background concentration (47 mg/kg) and the GSIP criteria (170 mg/kg) at one location. Zinc was not detected in groundwater above any Part 201 criterion or Rule 57 value. Given the natural variability of metals in soil and the lack of zinc in groundwater, zinc is NOT considered a COC for the site.

6.7 Cyanide

The Phase II investigation conducted by ATC included the collection of 1 soil sample (at soil boring GP-16) and 18 groundwater samples for cyanide analysis. Laboratory analytical data are included in Appendix I. Cyanide was not detected in the soil sample. Groundwater samples were analyzed for total cyanide; however compliance with Part 201 criteria and Rule 57 values is based on amenable (*i.e.*, free) cyanide. Typically only a fraction of total cyanide is amenable. Sample results for cyanide detected in groundwater are summarized in Table C7. Cyanide was detected slightly above the groundwater/surface water interface (GSI) criterion (0.0052 mg/L) at sample location GP-17 (0.006 mg/L). Total cyanide was not detected above any other Part 201 criterion or Rule 57 value. Given that **total** cyanide was detected in groundwater at only two locations, and that the one criterion exceedence was only slightly above the **amenable** cyanide criterion, cyanide is NOT a COC for the site.

6.8 Summary

Based on review of historical site use and the Phase II ESA (ATC, 2009), VOCs, particularly CVOCs were identified as COCs at the site. In particular the solvents TCE and 1,1,1-TCA were used for degreasing operations. These compounds and their breakdown products: 1,1-DCA, 1,2-DCA, 1,1-DCE, cis-DCE, trans-DCE, and vinyl chloride have been identified as the primary COCs in on-site soil and/or groundwater. Laboratory data used to evaluate and eliminate other potential COCs, including SVOCs, 1,4-dioxane, PCBs, metals and cyanide are included in Appendix I. Tables which compare detected compounds to relevant Part 201 criteria and Rule 57 values are included in Appendix C.

Since May 2009, remedial investigation activities have focused on defining the nature and extent of VOCs in soil, groundwater, surface water, soil gas and indoor air. The results of these investigation activities are detailed in Sections 7 (Source Area), 8 (Soil), 9 (Groundwater), 10 (Surface Water), and 11 (Soil Gas and Indoor Air).

Section 7
Source Characterization

7.1 Introduction

Chlorinated VOCs (CVOCs), particularly trichloroethene (TCE), are present in soil and groundwater above applicable screening levels throughout the site. Using a risk-based approach, remedial investigation activities, described in more detail below, have identified two primary source areas: the northern source area and the southern source area.

7.1.1 Northern Source Area

The northern source area is the area upgradient of monitoring wells MW-04s and MW-03s. This area was used for machining and degreasing activities prior to unit assembly during the mid-1900s, when TCE was commonly used as a solvent. The area occupies approximately 250,000 square feet beneath the existing building, extending from Area K in the west through the original footprint of P-Building in the east (Figure 2). Letter designations, *i.e.*, Area K, Building Q, etc., for each building/building addition are shown on Figure 2. P-Building, constructed in 1908, was remodeled and expanded into the parking lot to the east and south in 1994. The P-Building expansion area is not considered a potential source area.

Despite extensive investigation efforts, no single point source has been identified in the northern source area. Rather CVOCs in soil and groundwater apparently originate from years of minor spills associated with daily operations at that time. Numerous potential point sources were identified in the 2008 Phase I Environmental Site Assessment (ESA). The Phase II investigation conducted by ATC Environmental Consultants (ATC) evaluated these known or suspected historic operations such as the former WWTP area (GP-16), former underground and above ground storage tank areas (GP-17 and GP-28), former hazardous waste storage areas (GP-11 and GP-23), and former used oil drum storage areas (GP-29). See Table C1 in Appendix C. Although concentrations of CVOCs in soil and groundwater are above risk-based screening levels at these locations, the highest concentrations of constituents of concern (COCs) are detected at locations with no known point source.

A passive soil gas (PSG) survey was conducted by TRC Environmental Corporation (TRC) and Beacon Environmental Services, Inc. (Beacon) to help identify point sources, if any, within the northern source area. A total of 150 PSG samplers were installed in a

40-foot grid pattern throughout the northern source area to qualitatively evaluate the distribution of CVOCs in soil gas throughout the northern source area. PSG sample locations are shown on Figure 17. Results of the PSG survey are included in Appendix J. Areas with the highest concentrations of TCE and its breakdown products (yellow to red) are illustrated on Figure 18. Results of the PSG survey and subsequent site reconnaissance identified a former chemical stockroom located in Area D (Figure 2). Subsequent investigation near the former chemical stockroom did not identify a point source, but rather two mechanisms by which minor TCE spills may have occurred throughout the northern source area: 1) frequent transport of degreasing solvents by machine operators to the workstations via small uncovered containers for equipment maintenance and cleaning, and 2) the historical use of above ground piping to distribute degreasing solvents through the facility.

– Communications with on-site Tecumseh Products Company (TPC) staff indicated that plant workers may have transported small quantities of degreasing solvents from the stockroom to their work stations to clean machining equipment. Historically small amounts of these solvents were likely spilled as they were transported by hand from the stockroom. PSG survey results, which indicate the presence of elevated concentrations of TCE throughout the corridor north and south of the stockroom support this explanation.

– TCE used in the chemical stockroom was stored and distributed locally from a small storage tank (such as a modified 55-gallon drum). The small storage tank was refilled using above ground chemical piping. Above ground chemical piping to and from this stockroom was traced to the points of termination. One line extended to the north into Building Area B (near soil boring NS-19). Two chemical lines extended to the south to the approximate location of sub-slab sample point SV-06. From there the piping turned to the west and followed the corridor into Area K. One of the pipes terminated near the southwest corner of Area K (near soil boring NS-17); the end was cut but not capped. The other pipe turned to the south and entered Area TD where several empty above ground chemical storage tanks remain. Subsequent investigation indicates that there may be a local soil source at sample location NS-17, but groundwater concentrations at this location are comparably low. Historically above ground piping may have extended to and through other portions of the building. That piping had the potential to leak at joints and connection points. Similarly as plant operations changed, piping may have been modified or abandoned without properly draining conveyance piping first (as evidenced by the cut pipe near the southwest corner Area K.

Remedial investigation activities indicate that chlorinated ethenes (TCE and the breakdown products cic-1,2-dichloroethene [cis-DCE] and vinyl chloride) have the potential to migrate off site above appropriate risk-based screening levels. TCE, cis-DCE, and/or vinyl chloride affected groundwater extends from the northern site perimeter at monitoring wells MW-04s and MW-03s to the northeast. Cross Section E-E' (Figure 10) depicts site geology and groundwater concentrations along the approximate groundwater flow path. In addition, soil gas investigation activities have identified TCE in soil gas north of the site well beyond (>100 feet) the extent of TCE in shallow groundwater, indicating that on-site soil gas, affected by CVOCs present in on site soil and groundwater, has the potential to migrate laterally through the vadose zone.

7.1.2 Southern Source Area

The southern source area is located in the vicinity of a former Distillation Solvent Recovery System (solid waste management unit 5 [SWMU 5]) in Area M. Remedial investigation activities indicate that TCE and 1,1,1-trichloroethane (1,1,1-TCA) which originate in the southern source area have migrated off site above appropriate risk-based screening levels. Relatively high concentrations of TCE and 1,1,1-TCA (>1,000 ug/L) which originate in the shallow groundwater originate near monitoring well MW-34s and extend downgradient to the east well beyond the site boundary. Geologic Cross Section D-D' (Figure 9) depicts site geology and groundwater concentrations along the approximate groundwater flow path through the southern source area to the River Raisin.

7.2 Source Characterization – Physical and Chemical Parameters

Remedial investigation activities included an evaluation of the physical and chemical characteristics of the source areas.

- **Vadose Zone Geology:** Soil samples were collected through the vadose zone at the majority of source area sample locations. Visual classification, as recorded on soil boring logs (Appendix E) found that the vadose zone is characterized by a layer of fill beneath the building slab, underlain by native highly permeable soils which become saturated at depth. In some areas the surficial native silty/sandy clay unit observed at off-site boring locations is observed between the fill and the permeable unit. Fill composition is highly variable ranging from clay to silty gravel, with multiple fill types observed at some locations. The depth of fill ranges from several inches to several feet. The permeable unit typically ranges in composition from sandy silt to sand with gravel. The permeable unsaturated zone has a thickness of 10 to 20 feet.
- **Depth to Groundwater:** The depth to groundwater beneath the main building varies from approximately 23 feet in the west to 20 feet in the east.

- **Aquifer Thickness:** Beneath the former TPC manufacturing building a clay confining unit has been encountered at depths ranging from 39.5 to 47.5 feet below ground surface (ft bgs) in the north and 49 to 54 ft bgs in the south, resulting in an aquifer thickness of approximately 20 to 30 feet.

- **Aquifer Homogeneity:** Soil samples were collected to the top of clay at five source area investigation locations (NS-18, NS-19, NS-20, SS-09, and SS-10) and one on-site location downgradient of the southern source area (MW-35d/B-68). Visual classification, as recorded on soil boring logs (Appendix E), found that the aquifer is composed of almost entirely of permeable soils ranging in composition from silty sand to gravel. Gamma logging was conducted at these locations to supplement visual classification. Gamma logging results are also included on soil boring logs. At each location the gamma response through the aquifer varied by approximately 400 counts per second (cps). Where clay was encountered, the response increased by 400 cps or more. No significant areas of low permeability soil were identified within the source area aquifer.

- **Groundwater Flow and Gradient:** The horizontal gradient for groundwater flow is approximately 0.001 across the site. Flow from the northern source area is to the east/northeast, and flow from the southern source area is to the east. The vertical gradient, measured in nested well pairs immediately west of the building (MW-28s/d and MW-19s/d), is neutral with no significant upward or downward flow.

- **Field Indicator Parameters:** Reducing conditions favorable for the reductive dechlorination of CVOCs, are best measured by the redox potential (ORP) and the dissolved oxygen (DO) concentration in groundwater. A negative ORP and a low DO concentration generally indicate that the aquifer is under reducing conditions. Field measurements, including ORP and DO concentrations, are collected quarterly at source area compliance monitoring points (MW-32s, MW-33s, and MW-34s). Quarterly field measurements indicate that the shallow aquifer in the northern source area is under reducing conditions, with consistently negative ORP readings and low DO concentrations (<1.0 milligrams per liter [mg/L]) at both monitoring well MW-32s and monitoring well MW-33s. By contrast, field measurements collection at monitoring well MW-34s suggest that the aquifer in the southern source area has oxidative conditions (positive ORP and DO concentrations that are typically >4 mg/L). Measured field parameters are summarized in Table K1 (Appendix K).

- **Other Indicator Parameters – TOC:** Biologically supported reductive dechlorination requires both reducing conditions and a food source. Total organic carbon (TOC) concentrations were measured in soil and groundwater samples collected from the source area aquifer at sample locations (NS-18, NS-19, NS-20, SS-09, and SS-10). Measured TOC concentrations are summarized in Tables K2 and K3 for soil and groundwater respectively.

TOC data indicate that there is an abundant food source for reductive dechlorination in the shallow zone of the aquifer in the northern source area (1,100 to 6,700 mg/kg). However, with the exception of sample location NS-20, TOC was detected only in samples collected near the water table indicating that food source for reductive dechlorination in the solid phase is limited at depth. In the northern source area, TOC concentrations in groundwater decreased with depth ranging from 1.8 to 3.0 mg/L near the water table to 0.95 to 1.7 near the top of the clay confining unit. In the southern source area, TOC concentrations in groundwater were essentially the same throughout the aquifer ranging from 0.81 to 0.92 mg/L. Higher TOC concentrations detected in the shallow the aquifer matrix (*i.e.*, saturated soil) in northern source area aquifer are likely related to the petroleum hydrocarbons that have also been detected. These petroleum hydrocarbons provide a food source, helping to create conditions favorable for the reductive dechlorination of CVOCs.

- **Residual Non-Aqueous Phase Products:** Field personnel have not observed non-aqueous phase product during source area investigation activities. However concentrations of TCE and 1,1,1-TCA observed in soil gas and groundwater suggest that residual sorbed TCE and 1,1,1-TCA in the form of ganglia may be present in the vadose zone and upper aquifer. However, as described below, concentrations of TCE and 1,1,1-TCA decrease significantly with depth indicating that non-aqueous phase products have **NOT** accumulated at the interface of the clay confining unit.

7.3 Source Characterization – VOCs in On-Site Soil

Source area investigation activities included five sub-surface soil investigations/sample collection events:

- A Phase II ESA conducted by ATC on behalf of Consolidated Biscuit Company (CBC) was performed between December 2008 and February 2009. The Limited Phase II Investigation included the advancement of 30 on-site soil borings. Soil borings conducted by ATC are designated as GP-XX (installed with a Geoprobe®) or HB-XX (installed with a hand auger). A total of 21 soil samples were collected for volatile organic compounds (VOCs) analysis.
- In April 2009, TRC conducted an on-site sub-surface investigation to more completely define potential source areas. The investigation included the advancement of 18 soil borings (NS-01 through NS-10 and SS-01 through SS-08) using a Geoprobe®. One or more soil samples were collected at each investigation location, except NS-03 located outside the building footprint, for VOCs analysis (22 total samples).
- In September 2010, TRC conducted additional soil and groundwater investigation activities to further define and evaluate potential on-site source areas identified using a passive soil gas survey (described above) and subsequent site reconnaissance. This investigation

included the advancement of 10 additional soil borings (NS-11 through NS-17 and MW-32s through MW-34s). Two soil samples were collected at each boring location (20 total samples).

- In April 2012, 4 soil vapor extraction wells (SVE-01 through SVE-04) were installed along the northern perimeter of P-Building. The field technician observed an "organic" odor while logging soils at these locations. Consequently 2 soil samples were collected at each location for VOCs analysis.
- Between July 2012 and August 2012, additional source area investigation activities were conducted as outlined in the Workplan for Proposed Source Area Remedial Investigation Activities in order to address United States Environmental Protection Agency (USEPA) comments made during the March 2012 project meeting. This investigation included the advancement of 5 additional source area soil borings (NS-18, NS-19, NS-20, SS-9, and SS-10) to the top of the clay confining unit. Three soil samples were collected at each source area boring location for VOC and TOC analysis. Note that soil samples collected during this investigation were collected from the aquifer (rather than the vadose zone as is typical) at approximately the same depths that groundwater samples were collected so that VOC concentrations in co-located soil and groundwater samples could be compared.

Soil boring logs from source area investigation locations are included in Appendix E. Laboratory analytical results are included in Appendix I. Table 1 provides a summary of detected VOCs in on-site soil, including sample collection depth. VOCs found in soil above Part 201 criteria include:

- **Petroleum hydrocarbons:** ethylbenzene, xylenes, trimethylbenzenes (TMBs), n-butyl benzene, 2-methyl-naphthalene, naphthalene, and n-propyl benzene; and
- **CVOCs:** chlorinated ethenes and ethanes including the parent compounds (tetrachloroethene [PCE], TCE, 1,1,1-TCA, and 1,1,2-trichloroethane [1,1,2-TCA]), as well as their breakdown products (cis-DCE and vinyl chloride).

Petroleum hydrocarbons were detected only in the northern portion of the site. These compounds exceed the drinking water protection (DWP) criteria and/or the groundwater/ surface water interface protection (GSIP) criteria at seven locations (NS-06, NS-09, NS-10, GP-14, GP-15, GP-16, and MW-33s). These compounds have not been detected in off-site groundwater downgradient of the northern source area. As such the presence of petroleum hydrocarbons in northern source area soils is not a significant driver for risk-based corrective measures at the site. However, as discussed above, petroleum hydrocarbons in the northern source area do help create conditions favorable for the reductive dechlorination of CVOCs.

CVOCs are present in soils throughout the area beneath the 750,000-square-foot manufacturing building. The TCE concentration was above the DWP criterion (0.10 mg/kg) in 80 of the 90 soil samples collected, above the GSIP criterion (4.0 mg/kg) in 35 samples, and above the non-residential soil volatilization to indoor air inhalation (SVIAI) criterion (37 mg/kg) in 6 samples. The PCE concentration was above the DWP criterion (0.1 mg/kg) in 33 of 90 samples, and above the GSIP criterion (1.2 mg/kg) in 3 samples. The highest concentrations of TCE (100 mg/kg at NS-17) and PCE (5.9 mg/kg at GP-14) in soil were detected in the northern source area in Building Area K. 1,1,1-TCA was detected above the GSIP criterion (1.8 mg/kg) at 16 of 90 sample locations, and above the DWP criterion at 10 locations. The highest concentration of 1,1,1-TCA (17 mg/kg) was detected at SS-09 in the southern source area (Building Area M). 1,1,2-TCA was detected above the DWP criteria (0.10 mg/kg) at a single location, MW-33s (0.30 mg/kg). Breakdown byproducts are less prevalent in on-site soil. The cis-DCE concentration was above the DWP criterion (1.4 mg/kg) in 7 of 90 samples; the highest concentration of cis-DCE (9.6 mg/kg) was detected at NS-06. The vinyl chloride concentration was above the DWP criterion (0.040 mg/kg) in 6 of 90 samples, and above the GSIP criterion (0.26 mg/kg) at 4 sample locations. The highest concentration of vinyl chloride (0.55 mg/kg) was detected at NS-20. Figure 19 illustrates the distribution of parent compounds (PCE, TCE, and 1,1,1-TCA) in on-site soils.

See Section 8 for an evaluation of potential on-site receptors, relevant exposure pathways, and corrective measures.

7.4 Source Characterization – VOCs in Source Area Groundwater

Source area investigation activities included four groundwater investigations:

- A Phase II ESA conducted by ATC on behalf of CBC was performed between December 2008 and February 2009. The Limited Phase II Investigation included the advancement of 30 on-site soil borings. Soil borings conducted by ATC are designated as GP-XX (installed with a Geoprobe®) or HB-XX (installed with a hand auger). A total of 31 groundwater samples were collected for VOCs analysis.
- In April 2009, TRC conducted an on-site sub-surface investigation to more completely define potential source areas. The investigation included the advancement of 18 soil borings (NS-01 through NS-10 and SS-01 through SS-08) using a Geoprobe®. One or more groundwater samples were collected at each investigation location for VOCs analysis (22 total).
- In September 2010, TRC conducted additional soil and groundwater investigation activities to further define and evaluate potential on-site source areas identified using a passive soil gas survey (described above) and subsequent site reconnaissance. This investigation

included the advancement of 10 additional soil borings (NS-11 through NS-17 and MW-32s through MW-34s). One grab groundwater sample was collected at soil boring locations NS-11 through NS-17, and shallow water table monitoring wells were installed at sample locations MW-32s through MW-34s. These source area monitoring wells have been sampled during regular quarterly groundwater monitoring events since that time.

- Between July 2012 and August 2012, additional source area investigation activities were conducted as outlined in the Workplan for Proposed Source Area Remedial Investigation Activities in order to address USEPA comments made during the March 2012 project meeting. This investigation included the advancement of 5 additional source area soil borings (NS-18, NS-19, NS-20, SS-9, and SS-10) to the top of the clay confining unit. Three temporary wells (at the water table, in the intermediate aquifer and immediately above the clay) were installed at each source area boring location. Note that wells were developed prior to sample collection to help minimize the potential for inaccurate results due to the downward displacement of affected soils from the unsaturated zone and upper aquifer during well installation activities. Groundwater samples were analyzed for VOCs and TOC.

Soil boring logs from source area investigation locations are included in Appendix E. Laboratory analytical results are included in Appendix I. Table 2 provides a summary of detected VOCs in source area grab groundwater samples. Table 3 provides a summary of detected VOCs at compliance monitoring well locations including source area wells MW-32s, MW-33s and MW-34s. Tables 2 and 3 also provide sample collection depth and the screened interval. VOCs detected in source area groundwater above relevant or potentially relevant risk-based screening levels include:

- **Petroleum hydrocarbons:** benzene; and
- **CVOCs:** chlorinated ethenes and ethanes including the parent compounds (PCE, TCE, and 1,1,1-TCA), as well as their breakdown products (1,1,-dichloroethene [1,1-DCE], cis-DCE, trans-1,2-dichlorethene [trans-DCE], vinyl chloride, and 1,1-dichloroethane [1,1-DCA]).

Benzene was detected in shallow groundwater at soil boring location GP-16 (9 ug/L) above the drinking water (DW) criterion. No other petroleum hydrocarbons were detected in source area groundwater above relevant risk-based screening levels.

Figure 20 illustrates the horizontal extent of VOCs above Part 201 Criteria in groundwater. In addition, groundwater isoconcentration maps were prepared for the four most ubiquitous compounds in groundwater: TCE (Figure 21), cis-DCE (Figure 22), vinyl chloride (Figure 23), and 1,1,1-TCA (Figure 24). Concentrations of VOCs detected at source area sample locations (Table 2), compliance monitoring well locations (Table 3), perimeter and off-site grab groundwater sample locations (Table 4), and permeable reactive barrier (PRB) performance monitoring well locations (Table 5) were used to prepare the isoconcentration maps.

As illustrated on Figure 21, the highest concentrations of TCE in groundwater (>1000 ug/L) are found in three areas:

- The first originates near the northern perimeter of the site in the vicinity of soil boring NS-11 and extends downgradient to sample locations NS-05, NS-06, NS-02 and beyond (northern source area);
- The second occurs in the vicinity of the former chemical stockroom (NS-14 and MW-32s) (northern source area); and
- The third originates in Area M near the location of SWMU 5, a former Distillation Solvent Recovery System. The highest concentrations extend from source area sample locations GP-21, SS-01, SS-04, SS-05, SS-06, SS-08, and MW-34s downgradient to sample locations GP-22, SS-07 and beyond (southern source area).

Figures 22 and 23 illustrate the distribution of TCE degradation byproducts (cis-DCE and vinyl chloride, respectively). As illustrated on these isoconcentration maps, the source area highest concentrations of degradation products in source areas (>1,000 ug/L cis-DCE and >100 ug/L vinyl chloride) are found in the northern portion of the site in the vicinity of sample location NS-15.

As illustrated on Figure 24, the highest concentrations of 1,1,1-TCA in groundwater (>1000 ug/L) originate in Area M. The highest concentrations extend from source area sample locations GP-21, SS-01, SS-02, SS-04, SS-05, SS-06, SS-08, and MW-34s downgradient to sample locations GP-22, SS-07 and beyond.

Groundwater samples were collected from multiple depths at 13 locations throughout the facility to evaluate the vertical concentration profile. Including:

- Sample locations NS-18, NS-19 and NS-20 in the northern source area;
- Sample locations NS-03, NS-04 east of the northern source area;
- Sample locations GP-23 and GP-28 in the central portion of the facility; and
- Sample locations GP-22, SS-01, SS-02, SS-09, and SS-10 in the southern source area),

In general, the concentrations of parent compounds decrease with depth, with concentrations significantly lower in the deep aquifer immediately above the clay confining unit (Table 3). In the northern source area, TCE concentrations ranged from 900 to 2,600 ug/L at the water table, and from 27 to 59 ug/L immediately above the top of the clay confining unit. Similarly TCE concentrations in the southern source area ranged from 560 to 1,600 ug/L at the water table, and from less than 1.0 to 5.8 ug/L immediately above the top of the clay confining unit. In the northern source area, 1,1,1-TCA was only detected in the shallowest (water table) samples at concentrations ranging from 11 to 830 ug/L. In the southern source area, 1,1,1-TCA concentrations ranged from 160 to 3,500 ug/L near the water table, and from less than 1 to 4.5 ug/L immediately above the top of the clay confining unit. While residual sorbed TCE and 1,1,1-TCA in the form of ganglia may be present in the vadose zone and upper aquifer, the concentrations in groundwater suggest that dense non-aqueous phase liquid (DNAPL) is NOT present below the water table, *i.e.*, the groundwater concentration does not exceed approximately 1-percent of saturation or 11,000 ug/L for TCE (Pankow and Cherry, 1996).

See Section 9 for an evaluation of potential groundwater receptors, relevant exposure pathways, and corrective measures.

Section 8
Soil

8.1 Summary of Soil Investigation Activities

As discussed earlier in this Report, a Phase II Environmental Site Assessment (ESA) was conducted by ATC Environmental Consultants (ATC) between December 2008 and February 2009. Results of the Phase I ESA were used to identify sample locations and select parameters for analysis. Based on historic site operations ATC identified volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), metals and cyanide as parameters for further evaluation. ATC developed a sampling strategy based on historical site usage. Based on review of historical site use and the Phase II ESA (ATC, 2009), VOCs, particularly chlorinated VOCs (CVOCs), were identified as constituents of concern (COCs) at the site, in particular, the solvents trichloroethene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA) which were historically used for degreasing operations. These compounds and their breakdown products: 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-DCE), trans-1,2-dichloroethene (trans-DCE), and vinyl chloride have been identified as the primary COCs in on-site soil and/or groundwater. Laboratory data used to evaluate and eliminate other potential COCs, including semi-volatile organic compounds (SVOCs), 1,4-dioxane, polychlorinated biphenyls (PCBs), metals and cyanide are included in Appendix I. Tables which compare detected compounds to relevant Part 201 criteria and Rule 57 values are included in Appendix C. Since April 2009, remedial investigation activities have focused on defining the nature and extent of VOCs in soil, groundwater, surface water, soil gas and indoor air. The results of source area soil investigation activities are detailed in Section 7.

8.2 Relevant Exposure Pathways and Corrective Measures

As described Section 7, data show that CVOCs, particularly TCE, are present in source area soils throughout the area beneath the 750,000 square foot manufacturing building above risk-based screening levels. However, there is no reasonable transport mechanism by which off-site soils (excluding those below the water table and within the capillary fringe) could be affected by source area soil and groundwater contamination above appropriate risk-based screening levels. Therefore, remedial investigation activities did not include the collection of off-site soils from VOCs analysis.

VOCs were detected in on-site soil above Part 201 drinking water protection (DWP) criteria, Part 201 groundwater surface water interface protection (GSIP) criteria, and soil volatilization to indoor air inhalation (SVIAI) criteria. VOCs were not detected in soil above direct contact criteria. Potential exposure pathways were evaluated in the context of risk-based screening levels exceedences.

- Exceedences of residential and non-residential DWP criteria indicate that the groundwater may be affected above risk-based screening levels. Groundwater is evaluated further in Section 9.
- Exceedences of GSIP criteria indicate that surface water has the potential to be affected above risk-based screening levels. Surface water is evaluated further in Section 10.
- Exceedences of SVIAI criteria indicate that soil gas and indoor air have the potential to be affected above risk-based screening levels. Soil gas and indoor air are evaluated further in Section 11.
- Direct contact criteria were not exceeded. Therefore contact with affected soil is NOT a relevant exposure pathway.

Note that exposure pathways are only relevant if the applicable screening levels for that pathway are exceeded, *e.g.*, the ingestion of groundwater migration pathway is relevant only if drinking water criteria are exceeded. Pathways that are not relevant are not considered further.

A Declaration of Restrictive Covenant (RC) for the former Tecumseh Products Company (TPC) property has been filed with the Lenawee County registers of deeds. This RC limits future property use to commercial/ industrial use and prohibits the installation of wells, other than those required for groundwater monitoring purposes.

Section 9
Groundwater

9.1 Source Area Groundwater Investigation Activities

As discussed earlier in this Report, a Phase II Environmental Site Assessment (ESA) was conducted by ATC Environmental Consultants (ATC) between December 2008 and February 2009. Results of the Phase I ESA were used to identify sample locations and select parameters for analysis. Based on historic site operations, ATC selected volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), metals and cyanide for further evaluation. ATC developed a sampling strategy based on historical site usage. Based on review of historical site use and the Phase II ESA (ATC, 2009), VOCs, particularly chlorinated VOCs (CVOCs), were identified as constituents of concern (COCs) at the site. In particular, the solvents trichloroethene (TCE) and 1,1,1-trichloroethane (1,1,1-TCA) which were historically used for degreasing operations. These compounds and their breakdown products: 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-DCE), trans-1,2-dichloroethene (trans-DCE), and vinyl chloride have been identified as the primary COCs in on-site soil and/or groundwater. Laboratory data used to evaluate and eliminate other potential COCs, including semi-volatile organic compounds (SVOCs), 1,4-dioxane, polychlorinated biphenyls (PCBs), metals and cyanide are included in Appendix I. Tables which compare detected compounds to relevant Part 201 criteria and Rule 57 values are included in Appendix C. Since April 2009, remedial investigation activities have focused on defining the nature and extent of VOCs in soil, groundwater, surface water, soil gas and indoor air. The results of source area soil investigation activities are detailed in Section 7.

9.2 Perimeter and Off-Site Investigation Activities

In March 2009, TRC Environmental Corporation (TRC) initiated a phased series of investigations to define the horizontal extent of COCs in groundwater above risk-based screening. A chronology of remedial investigation activities is provided in Appendix D. Perimeter and off-site groundwater investigation activities have included:

- The collection of a grab groundwater samples from the backfill around utility corridors at seven locations around the perimeter of the site, to evaluate potential preferential migration pathways. Utility corridor sample locations are designated B-XXb, where XX is the sample location number. Table 4 provides a summary of detected VOCs at perimeter and off-site grab groundwater sample locations, including utility corridor sample locations. Laboratory analytical data are included in Appendix I.

- The collection of one or more grab groundwater samples at the majority of perimeter and off-site boring locations. Perimeter and off-site boring locations are designated B-XX, where XX is the sample location number. Table 4 provides a summary of detected VOCs at perimeter and off-site grab groundwater sample locations. Laboratory analytical data are included in Appendix I.
- Data from groundwater samples collected at these soil boring locations were used to support the development of the compliance monitoring network and to support the design of the permeable reactive barrier (PRB).
- Installation of a compliance monitoring well network that includes source area, perimeter, and downgradient sentinel wells. Compliance monitoring wells are designated MW-XXs or MW-XXd, where XX is the sample location number. The "s" designates a shallow water table well and the "d" designates a deep well installed near the interface of the clay confining unit. In areas where the saturated thickness is less than 10 feet, no "s" or "d" designation is made.
- A total of 39 compliance monitoring wells are sampled quarterly in accordance with the quarterly sampling plan. Each quarter, groundwater elevations are collected, field parameters (pH, conductivity, redox potential, dissolved oxygen, turbidity and temperature) are measured, and samples are collected for VOCs analysis. Semi-annually, a subset of the compliance monitoring wells is also sampled for monitored natural attenuation (MNA) parameters (ferrous iron, chloride, nitrate and sulfate). A summary of detected VOCs at compliance monitoring well locations is provided in Table 3, and laboratory analytical data are included in Appendix I. Groundwater elevations are tabulated in Appendix F. Field parameters and concentrations of monitored natural attenuation parameters are tabulated in Appendix K.
- Installation of a performance monitoring well network for the PRB that includes up gradient, side gradient, in barrier, downgradient shallow and downgradient deep wells. PRB performance monitoring wells are designated PRB-XXs or PRB-XXd, where XX is the sample location number. The "s" designates a shallow, water table, well and the "d" designates a deep well installed below the bottom of the PRB in the intermediate aquifer.
- A total of 19 PRB performance monitoring wells (including one installed in August 2012) are sampled quarterly. Each quarter, groundwater elevations are collected, field parameters (pH, conductivity, redox potential, dissolved oxygen, turbidity and temperature) are measured, and samples are collected for VOCs analysis. Samples may also be monitored for other indicator parameters (MNA parameters and dissolved gases) as

appropriate. A summary of detected VOCs at PRB performance monitoring well locations is provided in Table 5. Other data collected during PRB performance monitoring activities are summarized in the September 2012 Performance Monitoring Report which is included as Appendix L.

9.3 Geochemical Properties of the Perimeter and Off-Site Groundwater

Remedial investigation activities included an evaluation of the physical and geochemical characteristics of the off-site aquifer. These parameters are used to evaluate how groundwater geochemistry may affect the fate and transport of COCs. These parameters provide an indication of the likelihood of continued biodegradation of the CVOCs as the plume moves to the perimeter and off site. The physical flow characteristics of the aquifer are summarized in Section 4.4.

- **Field Indicator Parameters:** Reducing conditions favorable for the reductive dechlorination of CVOCs are best measured by the redox potential (ORP) and the dissolved oxygen (DO) concentration in groundwater. A negative ORP and a low DO concentration generally indicate that the aquifer is under reducing conditions. Field measurements, including ORP and DO concentrations, are collected quarterly at compliance monitoring wells as well as PRB performance monitoring wells. Quarterly field measurements indicate that downgradient from the northern source area and coincident with the CVOC plume, the DO is generally low, and the ORP is generally negative (*i.e.*, MW-3s, MW-4s, MW-10s, MW-23, and MW-30s/d). This indicates that the geochemical conditions are favorable for continued reductive dechlorination. At other well nests, sidegradient to the plume, the shallow unconfined aquifer is typically under oxidative conditions, while the deeper aquifer is typically under reducing conditions, *i.e.*, a negative ORP and DO concentrations less than 1 milligrams per liter (mg/L) (*e.g.*, MW-12s/d, and MW-24s/d).

  Downgradient from the southern source area, along the site perimeter, geochemical parameters are controlled by the installation of the PRB. The PRB has been effective in creating geochemical conditions highly favorable to reductive dechlorination, as documented in the PRB performance monitoring report (Appendix L). Further downgradient from the PRB (*e.g.*, MW-21 and MW-31), the DO ranges between 3 and 7 ppm and the ORP is generally positive. This indicates that the southern plume at a distance downgradient from the PRB is aerobic and does not favor reductive dechlorination. (Note that influence from the PRB should propagate downgradient, but only as the groundwater flow and geochemistry will allow.)

  Measured field parameters at compliance monitoring well locations are summarized in Table K1 (Appendix K).

- **Other Indicator Parameters – TOC:** Biologically supported reductive dechlorination requires both reducing conditions and a food source. Total organic carbon (TOC) concentrations were measured in perimeter and off-site groundwater at six locations (Table K3). Background and southern source areas have similar TOC concentrations of approximately 1 mg/L. The northern source area, extending to monitoring well MW-04s has concentrations two to four times greater than background. This is consistent with the abundant evidence of natural reductive dechlorination occurring in the northern source area. In the southern source area, the lack of natural reductive dechlorination is likely attributable to the lack of electron donors (*i.e.,* a food source).
- **Monitored Natural Attenuation Parameters:** Concentrations of ferrous iron, chloride, nitrate and sulfate are monitored semi-annually at a subset of compliance monitoring locations. MNA parameter results are summarized in Table K4. The MNA parameters do not show strong evidence of conditions supporting reductive dechlorination in the downgradient monitoring wells, however; these data are not significantly different than the concentrations observed in two source area wells (*i.e.*, MW-32s and MW-33s), where active reductive dechlorination is evident based on the presence of breakdown products, cis-DCE and vinyl chloride.

Note that the PRB is designed to enhance natural reductive dechlorination by creating geochemical conditions favorable for reductive dechlorination. See the PRB Performance Monitoring Report included as Appendix L, for an evaluation of geochemical parameters in and around the PRB.

9.4 Summary of VOCs in Perimeter and Off-Site Groundwater

Groundwater samples have been collected at soil boring locations and monitoring well locations to determine the horizontal and vertical extent of VOCs in groundwater. Sample locations are shown on Figure 3. Perimeter and off-site groundwater data collected to date are summarized in Tables 3 through 5. Table 3 provides a summary of detected volatile organic compounds at compliance monitoring wells, Table 4 provides a summary of detected volatile organic compounds at perimeter and off-site grab groundwater sample locations, and Table 5 provides a summary of detected volatile organic compounds in PRB performance monitoring wells.

The VOCs that have been found in groundwater above Part 201 drinking water (DW) criteria, groundwater/surface water interface (GSI) criteria and/or groundwater screening levels for vapor intrusion (GWSLs) include:

- **CVOCs:** chlorinated ethenes and ethanes including the parent compounds (tetrachloroethene [PCE], TCE, 1,1,1-TCA, and 1,1,2-trichloroethane [1,1,2-TCA]), as well as their breakdown products (1,1-DCE, cis-DCE, trans-DCE, vinyl chloride, and 1,1-DCA). CVOCs, particularly TCE, cis-DCE, vinyl chloride and 1,1,1-TCA, are distributed throughout the study area.

- **Petroleum hydrocarbons:** ethylbenzene, toluene and xylenes. Petroleum hydrocarbons detected above screening levels appear to be limited to the area near the southeast perimeter of the site as described in the Technical Memorandum titled Summary of the Limited Aromatic Petroleum Hydrocarbon Investigation – April 2011.
- **Acetone and 2-Butanone:** These compounds are associated with the breakdown of the food source provided by the PRB, and are only detected above screening levels at in-barrier PRB performance monitoring locations.

Figure 20 illustrates the horizontal extent of VOCs above Part 201 Criteria in groundwater. In addition, groundwater isoconcentration maps were prepared for the four most ubiquitous compounds in groundwater: TCE (Figure 21), cis-DCE (Figure 22), vinyl chloride (Figure 23), and 1,1,1-TCA (Figure 24). Concentrations of VOCs detected at source area groundwater sample locations (Table 2), compliance monitoring well locations (Table 3), perimeter and off-site grab groundwater sample locations (Table 4), and PRB performance monitoring well locations (Table 5) were all used to prepare these isoconcentration maps.

As illustrated on Figure 21, the highest concentrations of TCE in perimeter and off-site groundwater (>1000 ug/L) are found in two areas.

- Along the northern perimeter of the site in the vicinity of monitoring well MW-04s and soil boring B-23. TCE has not been detected in any groundwater samples collected north of the Patterson Site right-of-way; and
- Downgradient of the southern source area, extending from the eastern perimeter of the site to monitoring well MW-21. Note that the PRB has resulted in in a reduction in TCE concentrations along the eastern perimeter of the site adjacent to Maumee Street, but a reduction in TCE concentrations at downgradient compliance wells has not yet been observed.

Figures 22 and 23 illustrate the distribution of TCE degradation byproducts (cis-DCE and vinyl chloride, respectively). As illustrated on Figure 22, the highest concentrations of cis-DCE (>1,000 ug/L) in perimeter and off-site groundwater were observed downgradient of the northern source area along the northern perimeter of the site in the vicinity of monitoring wells MW-03s and MW-04s, and immediately downgradient of the blended portion of the PRB at performance monitoring locations PRB-02s and PRB-04s. Similarly the highest concentrations of vinyl chloride (>100 ug/L) were also observed in the vicinity of the blended portion of the PRB and downgradient of the northern source area.

The highest concentrations of 1,1,1-TCA originate in the southern source area and extend downgradient (east) to Maumee Street (Figure 24).

Isoconcentration maps illustrate the horizontal distribution of COCs, regardless of sample depth. Samples have been collected at multiple depths in many locations, in order to evaluate the vertical distribution of COCs in the aquifer. The vertical distribution of COCs is illustrated in a series of cross sections through the entire study area. Figure 5 is a cross section location map, and Figures 6 through 11 are the cross sections.

As described above, the highest concentrations of CVOCs in source area groundwater are observed near the water table. In general, the highest CVOCs concentrations remain in the upper portion of the aquifer around the perimeter of the site. Note that at several boring locations with closely spaced, and narrow (2-foot) screen intervals in the upper aquifer (such as PRB design investigation locations B-49 through B-51) the highest groundwater concentration is observed in the upper aquifer several feet below the water table rather than at the water table. This downward displacement of the CVOC plume is an expected result of recharge, and is not indicative of a source at depth.

Along the eastern perimeter of the site, concentrations of COCs in groundwater are much lower in the deep aquifer immediately above the clay confining unit (Cross-Section F-F' on Figure 11). Downgradient of the southern source area the aquifer thickness decreases from approximately 30 feet along the site perimeter to less than five feet at monitoring wells MW-21 and MW-31. Due to this dewatering of the aquifer there is no observed vertical concentration profiles; in fact monitoring wells MW-21 and MW-31 are screened over the entire saturated interval (Cross-Section D-D' on Figure 9).

Along the northern site perimeter (Cross-Section C-C' on Figure 8) and downgradient of the northern source area (Cross-Section E-E' on Figure 10), CVOC concentrations, particularly concentrations of parent compounds (*i.e.*, TCE) are highest in the upper aquifer. However, observed concentrations of CVOCs, particularly degradation products are also high at grab samples collected near the top of the clay (B-23 and B-32) along the northern site perimeter. As illustrated in Cross-Section E-E' (Figure 10), concentrations of COCs in the upper aquifer decrease rapidly downgradient of the northern source area. This phenomenon is a function of the natural degradation process. The dominant degradation process of TCE and cis-DCE is reductive dechlorination. Conditions in the aquifer near the northern source area favor the reductive dechlorination of TCE and cis-DCE (negative ORP and a carbon source). However, vinyl chloride is reductively dechlorinated only in highly reducing (methanogenic) conditions. Vinyl chloride also degrades readily in oxidative conditions, such as those observed near the water table.

Cross section E-E' (Figure 10) provides a near textbook illustration of the reductive dechlorination of TCE along a groundwater flowline. Concentrations of TCE are elevated in the source area with significant concentrations of breakdown products cis-DCE and vinyl chloride. Moving downgradient and deeper in the aquifer, the proportion of cis-DCE increases relative to TCE, *e.g.*, soil boring location B-23. As groundwater flows off-site, the TCE is completely degraded, leaving only cis-1,2 DCE and vinyl chloride, *e.g.*, shallow groundwater at soil boring B-35. Finally, only vinyl chloride is present, which ultimately degrades through aerobic processes at the fringe of the plume. This degradation process is facilitated by the co-deposition of petroleum compounds with the chlorinated solvents in the northern source area.

In the southern plume, there is no evidence of co-deposition of petroleum compounds at the source. Therefore reductive dechlorination proceeds with only the benefit of lower levels of native (background) organic carbon. The persistence of parent compounds in this area is illustrated in Cross Section D-D' (Figure 9). However, Figures 21 through 24 illustrate the positive effects the PRB has had in enhancing the nature reductive dechlorination processes, which should ultimately reduce concentrations at monitoring wells further downgradient (MW-21 and MW-31).

9.5 Evaluation of Groundwater Plume Stability

Groundwater chemistry data collected between March 2009 and April 2012 from compliance monitoring well locations were used to prepare a statistical evaluation of groundwater stability to support completion of the Contaminated Groundwater Under Control Environmental Indicator (EI) Determination as required under the Administrative Order on Consent (AOC). This statistical evaluation of groundwater stability was documented in a report titled "Statistical Evaluation of Groundwater Chemistry" (Evaluation) which was submitted to United States Environmental Protection Agency (USEPA) in June 2012. This Evaluation includes:

- A description of the monitoring well network;
- An explanation of the COCs used to evaluate groundwater stability;
- A description of the statistical methods used to evaluate groundwater stability including methodology, equations and example calculations;
- The results of the statistical evaluation including trend plots for each parameter-well combination and model output; and

- A summary of the results of the statistical evaluation including an explanation of the significance of any upward or downward trends identified.

A copy of this Evaluation is provided in Appendix M. No significant upward trends were observed. The Evaluation shows that concentrations within the groundwater plume are generally stable, and that the plume is not expanding.

9.6 Relevant Exposure Pathways

Exposure pathways were evaluated in the context of risk-based screening levels exceedences. Exposure pathways are only relevant if the applicable screening levels for that pathway are exceeded, *e.g.*, the ingestion of groundwater migration pathway is relevant only if drinking water criteria are exceeded. Pathways that are not relevant are not considered further.

VOCs were detected in groundwater above Part 201 drinking water criteria, Part 201 groundwater surface water interface (GSI) criteria, and site-specific GWSLs for vapor intrusion. VOCs were not detected in groundwater above groundwater contact criteria. Exposure pathways were evaluated in the context of risk-based screening levels exceedences:

- Exceedences of residential and non-residential DW criteria indicate that the ingestion of affected groundwater is a relevant pathway for groundwater. Tecumseh Products Company (TPC) evaluated the completeness of this pathway as described in Section 9.7 below.
- Exceedences of GSI criteria indicate that surface water has the potential to be affected above risk-based screening levels. Surface water is evaluated further in Section 10.
- Exceedences of GWSLs indicate that soil gas and indoor air have the potential to be affected above risk-based screening levels. Soil gas and indoor air are evaluated Section 11.
- Groundwater contact criteria were not exceeded. Therefore **contact with affected groundwater is NOT a relevant exposure pathway**.

9.7 Evaluation of Drinking Water Pathway and Corrective Measures

VOCs were detected in groundwater above screening levels for ingestion, but not above screening levels for contact. Therefore the ingestion of affected groundwater is the only relevant pathway for direct exposure to affected groundwater (Potential impacts to surface water and indoor air are considered separately). As described below, all private wells in the vicinity of affected groundwater have been decommissioned. Furthermore, institutional controls, to prevent the installation of new wells within the horizontal extent of affected groundwater, have been put in place, including:

- A Declaration of Restrictive Covenant (RC) for the former TPC property which has been filed with the Lenawee County registers of deeds. This RC limits future property use to commercial/ industrial use and prohibits the installation of wells, other than those required for groundwater monitoring purposes.
- A Groundwater Use Ordinance to prevent the installation of new wells within the horizontal extent of affected groundwater which was passed by the City of Tecumseh in June 2011.

Although the ingestion of affected groundwater is a relevant migration pathway, it is not complete, nor is it reasonably expected to be complete in the future. Investigation activities and corrective measures to evaluate and eliminate the off-site ingestion of potentially affected groundwater are described in detail below.

9.7.1 Public Water Supply Well Survey

The City of Tecumseh owns and operates two municipal well fields. One well field is located north of the City of Tecumseh, and is on the north (opposite) side of the River Raisin relative to the TPC site. The second well field (south) is located approximately one-half mile west of the site, west of South Union Street (Figure 1). This well field is hydraulically upgradient of the site, and analytical data from water quality testing routinely performed by the City of Tecumseh indicate that these wells are unaffected by COCs (RMT, 2009). Furthermore, a monitoring well (MW-11s) was installed approximately halfway between the well field and the site and near the edge of the wellhead protection area. No VOCs have been detected in samples collected from monitoring well MW-11s (Table 3). Groundwater elevation data does not indicate that drawdown associated with the municipal well field has affected the horizontal groundwater flow direction (Table F1 and Figures 13 through 16).

9.7.2 2009 Private Well Survey

In 2009, TRC conducted a private well survey to determine whether potentially affected off-site groundwater was used as a potable water supply or for any other uses. The survey area extended from Pearl Street west of the site to the River Raisin in the east, and from Russell Road south of the site to Pottawatamie Street north of the site. The survey included a search of publicly available water well logs through the Michigan Department of Environmental Quality (MDEQ) website (Well Logic System and historical well logs database) and through a Freedom of Information Act request to the Lenawee County Health Department (LCHD). Well logs obtained from the MDEQ and the LCHD for the area described above are included in the Current Conditions Report

(RMT, 2009). TRC also worked with the City of Tecumseh to identify properties that do not use municipal water (*i.e.*, are occupied, but are not receiving a water bill from the City of Tecumseh).

In 2009 and 2010, Notices of Off-Site Migration (NOMs) were sent to potentially affected property owners (Figure 25). Each NOM requested that property owners with private wells contact TPC to arrange for their well to be tested at no cost to them. A representative from TPC and TRC hand delivered NOMs to the owners of the properties not connected to city water in order to personally verify the presence of a private well (or not) and to request permission to collect a sample for analysis. Of the properties receiving NOMs, one non-potable (irrigation) supply well and five potable water supply wells were identified. The non-potable (irrigation) well (507 S. Maumee Street) and one of the five potable water supply wells (610 Mohawk Street) were determined to be relatively shallow (*e.g.*, less than 25 feet bgs). The four remaining potable wells were deeper (*e.g.*, greater than 50 feet). No well logs were available for the two shallow wells or for one of the deeper wells (307 Kilbuck Street). Well logs for the other three deeper wells are included in Current Conditions Report (RMT 2009).

9.7.3 Private Water Supply Well Testing

During the 2009 private well survey, described above, six private water supply wells were identified in the vicinity of affected groundwater (one irrigation and five potable). In order to verify whether or not these wells were affected by off-site migration of affected groundwater, TPC collected water samples from each well to be analyzed for VOCs by USEPA Method 524.2. Laboratory reports are provided in Appendix I.

Results indicated that two shallow water wells, located at 610 Mohawk Street and at 507 S. Maumee Street, were affected by VOCs (RMT, 2009). The well at 610 Mohawk Street (reportedly approximately 18 feet deep) was used as a potable water supply well. No well log was available for this well. The property owner was notified immediately after the data were received from the analytical laboratory and was supplied with bottled water. Additionally, TPC made arrangements with the property owner to connect him to the municipal water supply. In May 2009, the property at 610 Mohawk was connected to the municipal water supply and the shallow water well at the property was decommissioned. The property at 507 S. Maumee Street was connected to the municipal water supply prior to the 2009 well survey; the private supply well was used as a non-potable supply well for on-site irrigation. The property owner was notified by TPC on August 25, 2009. TPC worked with the property owner to convert outdoor irrigation operations to municipal water. The well at 507 S. Maumee Street was decommissioned in November 2010.

Well logs from the potable wells within the horizontal extent of affected groundwater indicate that the wells are screened in a deeper water bearing unit, underneath a sufficiently thick low permeability clay, and are not withdrawing groundwater from the affected aquifer. These wells were included in the water monitoring program through 2010.

9.7.4 Groundwater Use Ordinance, 2011 Private Well Survey, and Well Decommissioning

In 2010 and 2011, the City of Tecumseh worked with the MDEQ and TPC to prepare a Groundwater Use Ordinance. The City of Tecumseh passed the Groundwater Use Ordinance on June 6, 2011. This ordinance restricts groundwater use in the area near the site. Specifically, the restricted area includes the area of affected groundwater, as well as an approximately one block buffer zone around the area of affected groundwater (Figure 25). A total of 272 parcels are included in the restricted zone. Groundwater use is restricted as follows:

- The installation, development, maintenance, and use of private water wells is prohibited;
- Connection to the municipal water supply is required; and
- Existing private water wells must be abandoned.

A copy of the Groundwater Use Ordinance is included in Appendix N.

In conjunction with preparation of the Groundwater Use Ordinance, TPC agreed to identify and abandon, with owner consent, private wells within the restricted zone. On March 25, 2011, RMT, Inc. (RMT), on behalf of TPC, mailed a letter to each of the property owners affected by the Ordinance. The letters included a well survey card. On May 12, 2011, June 30, 2011, and August 8, 2011 follow-up letters with additional copies of the well survey cards were sent to property owners which had not yet responded. During August and September 2011, TPC also conducted a telephone survey and a door-to-door survey to obtain responses from owners that did not respond to the letter survey.

In December 2011, TPC met with property owners to confirm the presence/potential presence of a well at the properties identified as having a private well and to obtain permission to decommission the wells. Well decommissioning activities were completed in June 2012; all private wells with the restricted zone have been decommissioned. A letter documenting well abandonment activities was sent to the City of Tecumseh in August 2012. A copy of this letter is included in Appendix N. Figure 25 illustrates the location of the 12 wells that were abandoned by TPC to ensure compliance with the Groundwater Use Ordinance.

Section 10
Surface Water

10.1 Summary of Surface Water Investigation Activities

There are no surface water bodies located at the former Tecumseh Products Company (TPC) site. The nearest surface water body is the River Raisin which is located approximately 1,500 to 2,500 feet downgradient of the site. The River Raisin and associated wetland area is a regional discharge feature. There are two potential mechanisms for volatile organic compounds (VOCs) migrating from the site to reach the River Raisin:

- The storm sewer along the perimeter of the site discharges at storm water sample location STW-01 (Figure 3) into the river basin; and
- The River Raisin is a regional discharge feature for the groundwater beneath the TPC site as illustrated on Cross Section D-D' (Figure 8).

Storm water samples were collected from around the site. Sample results are presented in Table 6; sample locations are shown on Figure 3. The concentration of vinyl chloride at storm sewer sample location STW-02 on April 13, 2009 (23 ug/L) was above the groundwater/surface water interface (GSI) criterion (13 ug/L) and the Rule 57 human non-cancer value (HCV) (13 ug/L). Five subsequent sample events at this location have not confirmed this exceedence, nor were any VOCs detected above screening levels at the storm water discharge point (STW-01) during any of six sample events. Surface water is not affected above risk-based screening levels due to storm water discharge.

Surface water concentrations have been measured directly in the wetland area east of monitoring well MW-22, at sample location WL-01, and at a seep located adjacent to the former Blood Road Bridge (SEEP). No VOCs have been detected at these locations (Table 6).

GSI criteria are exceeded in groundwater, indicating that groundwater has the potential to vent to the River Raisin and the associated wetland area above risk-based screening levels. Concentrations of VOCs at monitoring wells located along the downgradient edge of the area of affected groundwater were evaluated to determine the area over which groundwater may discharge to the river over generic risk-based screening levels. Monitoring wells in proximately to the River Raisin include MW-13s, MW-29s, MW-29d, MW-30s, MW-30d, MW-10s, MW-22, MW-17s, MW-31, MW-14s, and MW-14d. VOCs detected at compliance monitoring wells, including these locations, are summarized in Table 3. One exceedence of GSI criteria was found at these monitoring wells.

The observed concentrations of trichloroethene (TCE) at monitoring well MW-31 (180 to 310 ug/L over 10 sample events) have exceeded the generic GSI criterion (200 ug/L), prompting further evaluation of the groundwater to discharge to the River Raisin as described below.

10.2 Evaluation of Surface Water Exposure Pathways

Potential human surface water receptors include residents, workers and recreational users. Exposure pathways were evaluated to determine if they are relevant and complete.

10.2.1 Ingestion (Potable Water Supply)

Groundwater, not surface water, is used to supply drinking water in the City of Tecumseh and in other communities downstream of potential discharges to the River Raisin. Therefore the routine ingestion of affected surface water by residents or workers is **not a complete migration pathway**.

10.2.2 Incidental Ingestion and Other Exposures

The observed concentrations of TCE (180 to 310 ug/L) at monitoring MW-31 have exceeded the GSI criterion and the Rule 57 final chronic value (200 ug/L), warranting further evaluation. These generic screening levels do not consider the size of the receiving water body. As allowed under Michigan Part 201, a request was submitted to Michigan Department of Environmental Quality (MDEQ) for determination of a mixing-zone based GSI criterion for TCE in June 2012. MDEQ has not yet responded to this request.

The calculated surface water to groundwater mixing ratio is more the 2000:1, even when the lowest monthly 95-percent exceedence low flow for the discharge location used (Appendix O). Given the high mixing ratio, the final acute value (FAV) (3,500 ug/L) is considered an appropriate site specific risk-based screening level for human exposure. Concentrations of TCE at monitoring well MW-31 are more than an order of magnitude below the FAV; therefore incidental exposure to/ingestion of affected surface water by recreational users or workers is **not a relevant exposure pathway**, and current groundwater discharge to the River Raisin is acceptable for human use.

10.3 Environmental Risk Evaluation

Pursuant to Paragraph 13(b) of the Agreed Order on Consent (AOC), an environmental risk evaluation was prepared for groundwater venting to the River Raisin and adjoining wetland area. The AOC requires a qualitative assessment of environmental risk. However as discussed below, quantitative surface water and groundwater data were used to support this evaluation.

As discussed in Section 10.1, water samples have been collected from the wetland at sample location WL-01 and from the seep that discharges to the River Raison near the Blood Road Bridge (SEEP on Figure 3). Constituents of concern (COCs) have not been detected at these locations, providing direct evidence that at these locations the groundwater discharge does not pose a risk to the river.

The axis of highest concentrations in the chlorinated VOC (CVOC) plume is located approximately 200 feet to the north of the seep discharge and 800 feet south of the wetland sample location, therefore the surface water samples may not represent the maximum concentration of CVOCs in groundwater discharging to the River Raisin and adjoining wetlands. Monitoring well MW-31 is located in the center of the plume, approximately 200 feet upgradient from the wetlands. Conservatively assuming that the groundwater discharging to the wetlands has CVOC concentrations equivalent to those observed at MW-31, environmental risk may be evaluated by comparing the concentration of CVOCs at monitoring well MW-31 to Rule 57 Aquatic Maximum Values. Concentrations of CVOCs at monitoring well MW-31 do not exceed aquatic maximum values (AMVs) for any of the detected parameters, including TCE (AMV of 1,800 ug/L).

While the site hydrologic setting is one where the groundwater will discharge to the wetlands and the River Raison, groundwater will not discharge without being affected by flow through the wetland system. CVOCs are likely to be treated as they pass through the wetland system. CVOCs can be taken up through the roots of the wetland vegetation and degraded or transpired by the plants (USEPA 2005). Reductive dechlorination of the CVOCs can also occur as groundwater passes through the zones of pore water under reducing conditions (Waldron 2007). Both of these processes will degrade CVOCs before they accumulate in the soil or discharge to the surface, further reducing any potential environmental risk.

As illustrated in Figure 20, CVOCs may discharge to surface water above drinking water criteria. However, conservatively estimated discharge concentrations are well below environmental risk-based screening levels. Therefore exposure of ecological receptors to affected surface water is **not a relevant exposure pathway**, and current groundwater discharge to the River Raisin and the adjoining wetland is acceptable from an environmental risk perspective for the purposes of this Report and the groundwater stability EI Determination.

Section 11
Soil Gas and Indoor Air

11.1 Summary of On-Site Investigation Activities

As described in Section 7, source area soil and groundwater concentrations exceed applicable risk-based screening levels for vapor intrusion. These exceedences prompted further evaluation of the volatilization to indoor air migration pathway.

11.1.1 Evaluation of On-Site Sub-Slab Soil Gas Data

Sub-slab soil gas concentrations were evaluated at 18 sample locations within the main manufacturing building. Sample locations are designated SV-XX, where XX is the sample location number, as shown on Figure 3. Sample results are summarized in Table 7. Concentrations of tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA) and 1,2-dichloroethane (1,2-DCA) where detected above sub-slab non-residential soil gas screening levels (SGSLs) calculated using an attenuation factor of 0.02 at one or more locations. TCE was detected above sub-slab non-residential SGSLs at all sample locations except SV-05. SV-05 is located in Area H which has been used historically as office and research space. The maximum TCE concentration measured in sub-slab soil gas was 118,000 parts per billion by volume (ppbv) compared to a sub-slab SGSL of 84 ppbv. These data indicated that the on-site volatilization to indoor air migration pathway was likely complete, prompting an evaluation of chlorinated volatile organic compounds (CVOCs) in indoor air as described in below.

11.1.2 VOCs in On-Site Indoor Air

Given the elevated concentrations of constituents of concern (COCs) in soil, groundwater and sub-slab soil gas, indoor air samples were collected to evaluate risk directly. Indoor sample results are provided in Table 8 (Note: Samples dated February 2, 2010 were collected during a ventilation test. Sample conditions are not representative of current stagnant indoor air conditions). The following provides an assessment of indoor air concentrations relative to indoor air screening levels:

- No CVOCs are present at a concentration greater than 1 percent of their respective United States Department of Labor, Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs).

– TCE was detected above the long-term non-residential indoor air criterion (1.7 ppbv). The highest detected concentration of TCE in indoor air was 19.8 ppbv (IA-02).

– 1,1-DCA was detected above the non-residential indoor air criterion (1.2 ppbv) at one sample location (IA-15, 1.5 ppbv).

11.1.3 Potential On-Site Receptors

– **Residents:** The site is not used for residential purposes. The inhalation of affected indoor air by on-site residents is **not a complete exposure pathway**.

– **Workers:** For current and short-term exposure, indoor sample results indicate that CVOCs are not present in indoor air at concentrations greater than 1-percent of their respective OSHA PELs. However, sample results indicate that TCE and 1,1-DCA are present in indoor air above non-residential indoor air screening criteria.

  The site is currently occupied by the Tecumseh Food Machinery & Engineering, LLC (TFME) site manager who works out of an office located in the old security area (S-Building), and several temporary TFME employees who are in the process of scrapping the equipment TFME has stored on site. The inhalation of affected indoor air by on-site workers is a complete migration pathway.

  However, corrective measures, described in Section 11.5 below have been implemented to control the on-site volatilization migration pathway, and reduce indoor air concentrations to levels below long-term non-residential indoor air criteria in portions of the building that are not targeted for demolition (*i.e.,* S-Building and P-Building). TFME plans to separate P-Building and S-Building from the remainder of the plant, so that P-Building can be leased or sold as a separate parcel, and to demolish the remainder of the facility.

11.2 Summary of Perimeter and Off-Site Soil Gas Investigation Activities

Concentrations of CVOCs in perimeter and off-site groundwater have exceeded applicable risk-based screening levels for vapor intrusion. These exceedences prompted further evaluation of the volatilization to indoor air migration pathway. In April 2010, 14 soil gas sample points, SG-01 through SG-14 were installed to further evaluate the off-site volatilization to indoor air migration pathway. Comments from the United States Environmental Protection Agency (USEPA) prompted the installation of two additional soil gas sample points in September 2010 (SG-15 and SG-16). Soil gas sample locations are sampled quarterly.

As described in the September 2011 Environmental Indicator Report for Human Exposures, screening levels for the volatilization to indoor air migration pathway were developed in accordance with both current regulation and state and federal guidance. An evaluation of soil gas data available at that time found that:

- COCs were present at soil gas sample locations along the eastern perimeter of the site above non-residential SGSLs. Indicating that the volatilization to indoor air migration pathway is potentially complete at non-residential properties east of the southern source area. As described in more detail below, a permeable reactive barrier (PRB) was installed along the eastern site perimeter to control the potential volatilization to non-residential indoor air migration pathway east of the site.
- COCs were present at soil gas sample locations east of the site above residential SGSLs. As described in more detail below, crawl space sampling was initiated at 4 of the 5 residential properties east of the site and a sub-slab depressurization and ventilation (SSDV) system was installed at the remaining residential property. In addition, a PRB was installed along the eastern site perimeter to control the potential volatilization to residential indoor air migration pathway east of the site.
- Concentrations of COCs were below all potentially applicable SGSLs at all residential sample locations north of the site.
- An intermediate clay layer and associated perched groundwater in the area northeast of the site provide a natural barrier to vapor intrusion.

In January 2012, at the request of USEPA, soil gas screening levels were re-calculated to reflect updated toxicity data. Specifically, the USEPA Integrated Risk Information System (IRIS) published updated TCE toxicity data on September 28, 2011. Revised SGSL calculations, along with the associated revised indoor air criteria and groundwater screening level (GWSL) calculations were submitted to USEPA on February 1, 2012. Updated TCE toxicity data resulted in a reduction in the most restrictive residential SGSL for TCE from 23 ppbv to 4.0 ppbv. TCE has been detected above the revised residential SGSLs at sample locations in the residential area north of the site. However as illustrated on Figure 21, observed TCE concentrations in groundwater are below GWSLs in this area, indicating that affected source area soil gas may be migrating laterally away from the site.

During the March 2012 project meeting, USEPA and Tecumseh Products Company (TPC) discussed the exceedence of applicable TCE SGSLs at sample locations north of the site. TPC and USEPA agreed to the following measures to address the potential for volatilization to indoor air in residential areas near the site:

- Installation of a soil vapor extraction (SVE) system beneath P-Building (a portion of the former TPC site building located along the northern perimeter of the site) to control the on-site volatilization-to-indoor air migration pathway for future occupants of the facility; to reduce or eliminate the potential for lateral migration of affected soil gas from the site; and to extract residual CVOCs from the on-site soil matrix reducing the long-term potential for migration of CVOCs into soil gas and groundwater, *i.e.*, source control.
- Installation of additional soil gas sample points to verify the extent of CVOCs in soil gas.
- Preparation of a figure illustrating the location of major utilities relative to the water table; and
- Further demonstration that the intermediate clay layer and/or perched water in the area northeast of the site is an effective vapor barrier, specifically: installation of additional soil gas sample points, and preparation of a figure illustrating the areal extent of the clay layer and perched aquifer.

In June 2012, six new soil gas sample locations were installed north and west of the site (SG-17 through SG-21, and TVP-02s). Additionally, three replacement soil gas sample points (SG-12R, SG-14R and SG-15R) were installed near existing sample points where water in the sample port often prevented sample collection.

At present, 22 sample locations are included in the sampling program. Sample results are summarized in Table 9. These sample locations are distributed throughout the area of affected shallow groundwater, specifically along the downgradient perimeter of the site and in residential areas that may be affected by the off-site migration of CVOCs. Laboratory analytical reports are provided in Appendix I.

11.3 Evaluation of Clay Layer and Perched Groundwater

As requested by USEPA, a figure was prepared illustrating the approximate areal extent of the intermediate clay layer and the perched groundwater (Figure 12). This intermediate clay layer and the associated perched groundwater are a natural barrier to vapor intrusion. During the March 2012 meeting with USEPA, TPC agreed to further investigate/document the protectiveness of this natural vapor barrier. The results of this were submitted to USEPA on August 24, 2012. Soil gas samples were collected from all three replacement soil gas sample point locations (SG-12R, SG-14R and SG-15R), as well as two additional locations in the vicinity of the perched groundwater (SG-11 and SG-13). No COCs were detected above SGSLs at any of the sample locations north/northeast of the site in the vicinity of the intermediate clay layer and the perched groundwater. **The volatilization to indoor air migration pathway is not complete north/northeast of the site in the vicinity of the intermediate clay layer.**

11.4 Evaluation of Utility Corridors as Potential Preferential Pathways

As requested by USEPA, a figure illustrating major underground utilities in the area near the former TPC site was prepared. This figure was provided to USEPA on August 24, 2012. Figure 4 illustrates the approximate locations of sanitary sewer lines, storm sewers, and water lines. Figure 4 was developed from utility maps provided by the City of Tecumseh. Manholes depths were compared to boring logs from TPC investigation activities (specifically measured depth to groundwater) to determine which portions of these utilities are below the water table. Blue highlighting is used to identify the submerged portions of the major utilities. In general, utility corridors are saturated in the area with perched water and the area where the true water table is at or near the bottom of an overlying clay unit (Figure 12). Saturated utility corridors are NOT a potential lateral migration pathway for affected soil gas.

In most cases, city utilities were installed as the city developed. As such the majority of these utilities were installed more than 25 years ago. Given their age, TRC expects that these utilities were typically bedded and backfilled with soil from the native sand and gravel unit. Because backfill material is likely dominated by native materials which have had years to settle and compact, even unsaturated utility corridors in the vicinity of the site are unlikely to be significant lateral migration pathways for affected soil gas.

Other underground utilities (fiber optic, cable and gas lines) are also present in the vicinity of the former TPC site. However, those utilities are smaller and are typically installed at depths less than 5 feet. Because of their shallow depth, other underground utilities are expected to be unsaturated and significantly influenced by ambient air. Because of their relative connectedness to ambient air and their smaller size, other underground utilities are not expected to be significant lateral migration pathways for affected soil gas.

11.5 Corrective Measures

11.5.1 Installation of a SSDV at the Residence located at 704 Mohawk Street East of Site

In October 2011, a SSDV system was installed at the residence located at 704 Mohawk Street. Installation and performance verification activities have been conducted as described in the Workplan for the Installation of a Sub-Slab Depressurization/ Ventilation System: 704 Mohawk Street, dated May 2011 and revised September 2011. Pressure readings (collected during quarterly system inspections) show that the SDDV system has created a negative pressure gradient across the entire building footprint, indicating that the SSDV system has controlled the potential volatilization to indoor air migration pathway at 704 Mohawk Street. An exhaust sample and/or basement indoor air sample were collected in October 2011, November 2011 and May 2012 to further verify system performance. Sample results are summarized in Tables P1 and P2 (Appendix P). The laboratory analytical reports are included in Appendix I. Concentrations of COCs in indoor air have not been detected above residential indoor air criteria. The volatilization to indoor air migration pathway has been controlled at 704 Mohawk Street. One additional sample event will be conducted to address USEPA comments related to the Current Human Exposures Environmental Indicator (EI) Determination. Data will be submitted to the USEPA in December 2012.

11.5.2 Crawl Space Sampling at Residences East of Site

Four additional residential properties are located east of the site. In 2011, TRC conducted site inspections these properties (610 Mohawk Street, 502 Mohawk Street, 505 South Maumee, and 507 South Maumee Street) to support the design of a proposed SSDV system. Two significant features which affect the design, installation and functionality of a SSDV were observed:

- Houses at all four properties were constructed over a crawlspace with a dirt floor composed of low permeability soil (based on nearby soil boring data).
- At the three houses (502 Mohawk Street, 505 South Maumee, and 507 South Maumee Street), the crawl spaces frequently hold surface water, regularly flood during storm events, and likely have saturated conditions throughout the year.

Low permeability soils, particularly saturated low permeability soils are expected to create a natural vapor barrier through which volatile organic compounds (VOCs) from groundwater do not readily migrate. Consequently, crawl space sampling was conducted to more directly assess the volatilization to indoor air migration pathway.

Crawl space samples were collected in October 2011 and May 2012. Sample results are summarized in Tables P3 and P4 (Appendix P). The laboratory analytical reports are included in Appendix I. Site-specific COCs have not been detected above residential indoor air criteria in any of the samples collected. **The volatilization to indoor air migration pathway is not complete at these properties.** One additional sample event will be conducted to address USEPA comments related to the Current Human Exposures EI Determination. Data will be submitted to the USEPA in December 2012.

11.5.3 Permeable Reactive Barrier

In May 2011 a PRB was installed to reduce the potential for vapor intrusion downgradient of the southern source area by treating shallow CVOC-affected groundwater along the eastern (downgradient) property line before it migrates off site.

PRB design and construction is documented in the Construction Documentation Report for the Permeable Reactive Barrier Downgradient of the Southern Source Area, dated February 2012. The PRB performance monitoring network was installed in July and August 2011 in accordance with the Workplan Addendum to Install Additional PRB Performance Monitoring Wells at the Former Tecumseh Products Site in Tecumseh, Michigan. Quarterly groundwater monitoring was initiated in August 2011 in order to monitor the performance of the PRB. As described in the September 2012 Performance Monitoring Report (Appendix L), PRB Section 1, located along the eastern perimeter of the site adjacent to Maumee Street, is having a significant effect on the off-site migration of CVOCs, particularly TCE and 1,1,1-TCA. Geochemical parameters and indicators of food sources show that the PRB is creating conditions which enable the native bacteria to reductively dechlorinate TCE and 1,1,1-TCA, *i.e.*, lowering the redox potential (ORP) and releasing sources of food (dissolved organic carbon) into the aquifer. Groundwater data collected in the vicinity of PRB Section 2, indicate that the injected portion of the PRB has not duplicated the strong reducing conditions and abundant food source provided by the blended portion of the PRB. However, the VOC data do show that there is reductive dechlorination occurring in PRB Section 2.

11.5.4 Installation of a SSDV at S-Building On-Site

In October 2011, a SSDV system was installed on-site at S-Building, which at the time was occupied by on-site security, and is now occupied as office space by the TFME site manager. Installation and performance verification activities have been conducted as described in the Workplan for the Installation of a Sub-Slab Depressurization/ Ventilation System: S-Building at 100 East Patterson Street, including collection of indoor air samples to verify system performance in October 2011 and February 2012. Sample results are summarized in Table Q1 (Appendix Q). The laboratory analytical reports are included in Appendix I. Concentrations of COCs in indoor air have not been detected above non-residential indoor air criteria. The volatilization to indoor air migration pathway has been controlled at S-Building.

11.5.5 Installation of an On-Site SVE System

On March 30, 2012, TRC began installation of the on-site SVE system. Pilot SVE system construction, as described in the April 2012 Workplan to Conduct a Pilot Study to Facilitate the Design and Installation of a Full-Scale Soil Vapor Extraction System (Pilot SVE Workplan), was completed on April 13, 2012. As described in the Pilot SVE Workplan, stepped-rate tests and system balancing were completed between April 16, 2012 and April 20, 2012. Constant rate operation of the pilot SVE system began on April 23, 2012. The pilot SVE system included four soil gas extraction points along the northern perimeter of P-Building (SVE-01 through SVE-04). Those points became part of the full-scale SVE system design (Line 1). Constant rate operation of the pilot system continued until the full-scale SVE system was installed. Field activities associated with the construction and operation of the pilot SVE system are described in more detail in the Full-Scale Soil Vapor Extraction System Design and Installation Workplan (Full-Scale SVE Workplan) dated May 2012.

On May 29, 2012, TRC began installation of the full-scale SVE system as described in the Full-Scale SVE Workplan. Construction of three additional extraction wells (SVE-05 through SVE-07) and associated SVE piping (Line 2) was completed on June 1, 2012. Stepped-rate tests and full-scale system start-up were completed between June 4, 2012 and June 5, 2012. As described in the Full-Scale SVE Workplan, operation of the full-scale SVE system was initiated using a rented SVE system blower capable of extracting approximately 500 cubic feet per minute (CFM). A permanent SVE blower skid is under construction; when the permanent blower is installed, the soil vapor extraction rate is expected to be approximately 900 CFM. Following the installation of the permanent blower skid, field activities associated with the construction and start-up of the full-scale SVE system will be described in detail in a construction documentation report.

Exhaust samples were collected to evaluate system performance of both the pilot and full scale system. Exhaust concentrations increased substantially following the installation of Line 2, indicating that soil gas concentrations are much higher in the vicinity of one or more of the Line 2 extraction wells (SVE-05 through SVE-07). Given the soil gas extraction rate of approximately 500 CFM, exhaust concentrations may be indicative of a sustained source in the vadose zone in the vicinity of one or more of the Line 2 extraction points (SVE-05 through SVE-07). Prior to SVE system installation, soil gas with high concentrations of COCs, particularly TCE, had the potential to migrate laterally outside the area of shallow affected groundwater. Exhaust sample results are summarized in Table Q2 (Appendix Q). The laboratory analytical reports are included in Appendix I.

Note: The SVE system was operational prior to the collection of the second quarter 2012 soil gas sample event. However due to the short period of operation, the SVE system is not expected to have much, if any effect on soil gas concentration at locations more than 100 feet from the nearest extraction well. The SVE system is designed to reduce off-site soil gas concentrations by reducing/eliminating additional off-site migration. The radius of vacuum influence does not extend to the residential areas north and west of the site. However, because the source has been contained by the SVE system, TCE concentrations to the north should gradually decline once the source has been eliminated. TRC anticipates that there will be a reduction in soil gas concentrations in future soil gas sample events. Result from the next sample event (scheduled for early October 2012) will be submitted to the USEPA no later than December 2012 to address USEPA comments related to the Current Human Exposures EI Determination.

Section 12
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