Remedial Action Plan

CENTRAL SANITARY LANDFILL

21545 Cannonsville Road
Pierson, Michigan

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TABLE OF CONTENTS

1.0 INTRODUCTION *1*

1.1 PURPOSE AND SCOPE OF REMEDIAL ACTION PLAN *1*

1.2 HISTORICAL OVERVIEW *3*

2.0 GEOLOGIC AND HYDROGEOLOGIC SETTING ***9***

2.1 SITE GROUNDWATER *9*

2.2 SURFACE WATER *10*

2.3 RESIDENTIAL WATER WELLS ***11***

3.0 NATURE AND EXTENT OF GROUNDWATER IMPACT ***12***

3.1 EXPOSURE ROUTES *13*

3.2 GROUNDWATER QUALITY CHARACTERIZATION *14*

3.2.1 Metals and Inorganics *14*
3.2.1.1 Iron and Manganese
3.2.1.2 Total Dissolved Solids
3.2.1.3 Other Metals and Inorganics

3.2.2 Volatile Organic Compounds *20*
3.2.2.1 Diethyl Ether and Tetrahydrofuran
3.2.2.2 1,1-Dichloroethane
3.2.2.3 1,2-Dichloroethane
3.2.2.4 Chloroethane
3.2.2.5 1,1-Dichloroethene
3.2.2.6 cis-1,2-Dichloroethene
3.2.2.7 Vinyl Chloride
3.2.2.8 Trichloroethene
3.2.2.9 Benzene
3.2.2.10 Other VOCs

4.0 PROPOSED REMEDIAL ACTION ***32***

4.1 SOURCE CONTROL AND REMOVAL *34*

5.0 GROUNDWATER MONITORING AND SAMPLING PROGRAM ***35***

5.1 GROUNDWATER MONITORING NETWORK *35*

5.2 GROUNDWATER SAMPLING AND ANALYTICAL PROGRAM 37

5.3 CLEAN-UP REQUIREMENTS 37

5.4 CONTINGENCY IF SENTINEL WELLS EXCEED CLEAN-UP CRITERIA 38

5.5 CRITERIA FOR REDUCING GROUNDWATER MONITORING 39

6.0 OPERATION AND MAINTENANCE 42

7.0 SCHEDULE FOR REMEDIAL ACTION PLAN IMPLEMENTATION 44

8.0 FINANCIAL ASSURANCE 45

9.0 REFERENCES 46

TABLES

1 Estimated Financial Assurance to Fund 30 Years of Remedial Activities and Groundwater Monitoring

FIGURES

1 Location Map

2 Site Map

3 VOC Isoconcentration Contour Map – June 2010

4 Geologic Cross Section A-A′

5 Geologic Cross Section B-B′

6 Geologic Cross Section C-C′

7 Geologic Cross Section D-D′

8 Geologic Cross Section E-E′

9 Iron Isoconcentration Contour Map – April 2011

10 Manganese Isoconcentration Contour Map – August 2012

11 Total Dissolved Solids Isoconcentration Map – June 2010

12 VOC Isoconcentration Contour Map – June 2001

13 VOC Isoconcentration Contour Map – May 2002

14 VOC Isoconcentration Contour Map – May 2003

15 VOC Isoconcentration Contour Map – May 2004

APPENDICES

Appendix A - Agreement for a Limited Residential Remedial Action
Legal Description of Property
Declaration of Restrictive Covenant
Financial Assurance Mechanism
Permanent Marker Inscription
Appendix A1 – Correspondence

Appendix B – Historical Groundwater Analytical Data

Appendix C – Time/Concentration Graphs

Appendix D – Groundwater Modeling Report

Appendix E – Iron& Manganese Investigations

Appendix F - Transport Model

Appendix G – Well Logs

Appendix H – Operation and Maintenance Plan for the Groundwater Remediation System

1.0 INTRODUCTION

Engineering & Environmental Solutions, LLC presents in this report a Limited Residential Remedial Action Plan for Central Sanitary Landfill, Pierson, Michigan (Figure 1). The report was prepared on behalf of Central Sanitary Landfill and is consistent with Part 115 and Part 201 requirements. Remedial activities conducted for contaminated groundwater include removal of the contamination source (source removal) and installation and operation of a groundwater remediation system that is supplemented by natural biodegradation and long-term groundwater monitoring. All impacted groundwater is located on-site. Remedial actions conducted at the site since 1992 have significantly reduced the concentration of contaminants remaining in groundwater.

An agreement pursuant to Section 20120b(3) of Part 201, Environmental Remediation NREPA will be entered between Central Sanitary Landfill and the Michigan Department of Environment Quality (MDEQ), as part of MDEQ approval of this Remedial Action Plan. Consistent with past MDEQ protocol, the terms of the Agreement (Agreement to Implement a Limited Remedial Action; Appendix A) will be consistent with the terms of the Remedial Action Plan. With approval, the legally enforceable Agreement will be in-place to meet the terms of the Remedial Action Plan pursuant to Part 115 and Part 201 and replace the site's Consent Judgment dated October 18, 1990.

A review of historical developments leading to submittal of this Remedial Action Plan is presented in Section 1.2. A history of correspondence with the MDEQ for Remedial Action development is provided in Appendix A1. A letter to the MDEQ dated December 13, 1995, provides the status of requirements under the Consent Judgment. Since that time, the only remaining requirement has been the remediation groundwater and monitoring.

1.1 PURPOSE AND SCOPE OF REMDIAL ACTION PLAN

Central Sanitary Landfill is located in Pierson Township, Montcalm County, approximately 2 miles north of Pierson, Michigan (Figure 1). The purpose of the site's Remedial Action Plan is to provide a clean-up strategy for impacted groundwater. Groundwater is impacted by volatile organic compounds (VOCs) and contains iron, manganese, zinc, boron, sodium, and total dissolved solids above established background levels.

Groundwater analytical data collected at site monitoring wells during the past 18 years demonstrate that the on-going remedial actions taken by Central Sanitary

Landfill have made significant progress in containing and reducing contaminates. Removal of the Pierson Township Dump, completed in 1992, in combination with active remediation and natural attenuation of the VOC plume have substantially improved groundwater quality downgradient from the landfill. The former Pierson Township Dump shown on Figure 2, was the primary source for groundwater contamination at the site. Currently, all impacted groundwater is located on-site and there is no requirement or need to address other media.

The site intends to continue the current land use as a municipal solid waste disposal facility. The most practical and feasible groundwater remedial technology was selected and is presented in this report. This Remedial Action Plan addresses all areas of the site where groundwater protection standards (Section 5.3) are exceeded. The scope of the Remedial Action Plan includes:

- source control by removal of the former Pierson Township Dump (completed in 1992), no additional action for source control is needed or proposed;

- continued operation and maintenance of the existing groundwater pump and treat system, as needed, to remove VOCs from groundwater;

- on-site land-use restrictions (Appendix A) for areas where impacted groundwater exceeds groundwater protection standards;

- a contingency plan to install additional sentinel wells and expand the restricted area should VOCs migrate to sentinel wells;

- a contingency plan to install additional sentinel wells and expand the restricted area should inorganics associated with a release migrate to sentinel wells at levels above groundwater protection standards;

- continued long-term monitoring obligations consistent with the sampling and analytical plan contained in this report; and

- continued maintenance of the landfill cap, leachate collection system, and other engineering measures.

Volatile organic compounds are currently being removed from the aquifer downgradient from the landfill by mechanical means (pump and treat). An evaluation of the site's historical groundwater analytical data (Appendix B) indicates that VOCs have steadily decreased in the groundwater aquifer over the past 18 years. Based on downward trends observed at the perimeter of the VOC

plume, we believe that natural biodegradation has contributed to the remedial process at the site. An explanation of decreasing VOC levels within the plume is provided in Section 3 and illustrated in time series graphs provided in Appendix C and trend analyses provided on Figure 16. Groundwater monitoring at the perimeter of the site is used to confirm plume containment within an area designated for exposure control.

The current groundwater pump and treat system includes three active purge wells (PW-5R, PW-6 and PW-7R), a bag filter used to filter iron and particulates from purged groundwater, an air-stripper to treat purged groundwater, and an effluent infiltration pond located above the VOC plume. An isoconcentration map for total VOCs detected in June 2010 (Figure 3) shows the extent of the VOC plume at the site. The estimated extent of the groundwater capture zone under average pumping conditions is shown in Appendix D (Figure 13). In order to evaluate changes that would increase the capture zone, different combinations of pumping rates among existing purge wells and different locations of treated recharge basins were considered in the groundwater model provided in Appendix D. The optimum groundwater remedial action pumping scenario is presented in Appendix D (Figure 14). The scenario maximizes capture of the existing VOC plume while minimizing the potential for drawing contamination further from the known source. This scenario includes the use of three purge wells (PW-5R, PW-6, PW-7R; Figure 2) and relocating the infiltration basin (Appendix D, Figure 14) to assist as a hydraulic barrier to eastward migration of VOCs and still be within the VOC plume (Figure 3).

A historical overview of remediation activities conducted at Central Sanitary Landfill during the past 24 years is presented below.

1.2 HISTORICAL OVERVIEW

In 1989, VOCs were detected in groundwater at site monitoring wells. The source of the VOCs was from the unlined Pierson Township Dump (Figure 2). In 1992, waste materials in this old unlined disposal area were excavated and placed in an on-site double lined disposal area and capped consistent with the site's Consent Judgment.

A groundwater remediation system (pump and treat system) began operation at the site in April 1992 as required by the Consent Judgment. The system consisted of four purge wells (PW-1 through PW-4) and a temporary purge well (TPW-1). Purge well PW-1 is located north of the landfill and purge well PW-2 is located approximately 600 feet east of the landfill (Figure 2). Purge wells PW-1 and PW-2 were used to purge groundwater impacted with VOCs. Purge wells PW-3 and PW-4 are located near the eastern perimeter of the site and were

intended to create a barrier to groundwater flow by pumping clean groundwater relatively far from the source. Purge well PW-3 is located approximately 1,000 feet southeast of the VOC plume and is screened in a unit composed predominantly of silt and clay which inhibits the well's ability to produce groundwater. Purge well PW-3 was operated intermittently and shut down prior to 2003. Temporary purge well TPW-1 was located east of the former Pierson Township Dump and was abandoned prior to 1995 for construction of Phase V-A. Existing well locations are shown on Figure 2.

A groundwater flow model was prepared for the site in 1995 (*Ground Water Flow Modeling Report,* GRK&A, 1995). Based on the results of this model, three new purge wells (PW-5, PW-6, and PW-7) were installed in April 1997. The new purge wells are located immediately downgradient from the landfill (Figure 2) within the VOC plume. The new purge wells were intended to replace purge wells located at the perimeter of the site. Purge wells PW-5, PW-6, and PW-7 remained inactive until 2003.

A work plan to upgrade and modify the groundwater remediation system was presented to the MDEQ in February 2003. Between February 2003 and September 2004, a total of seven meetings were held with the MDEQ to review remediation system performance and to develop appropriate upgrades to the system. A work plan was approved by the MDEQ in April 2003, and purge wells PW-1 and PW-4 were "turned-off" in April 2003, following concurrence from the MDEQ. As part of the system upgrade, the groundwater treatment building and an infiltration pond were moved from the southwest side of the site to an area east of the closed landfill. The infiltration basin and secondary basin are located over the area of existing groundwater contaminant. The move was necessary to make room for the southern expansion of the landfill. The treatment building was relocated to the east side of the closed landfill to be closer to the purge wells and infiltration basins.

To better delineate the vertical and horizontal extent of impacted groundwater, additional site wells were sampled for VOCs during the second quarter 2003 following correspondence with the MDEQ. Analytical results from this sampling event were used to update and modify groundwater remedial operations to allow capture of the most impacted groundwater at the site.

To determine purge system performance, monthly sampling for VOCs began in September 2003 and continued through August 2004. Groundwater samples were collected at purge wells PW-2, PW-5, PW-6, and PW-7. In August 2003, purge wells PW-5, PW-6, and PW-7 were "turned-on" and began pumping groundwater at approximately 15 to 25 gallons per minute (gpm) for a total of 50 to 60 gpm.

VOCs detected in groundwater monitoring wells north of the landfill (MW-13 and MW-14B) were thought to be due to the pumping at purge well PW-1, north of the landfill, while VOCs detected east of the landfill were thought to be due to the pumping at purge well PW-4 located northeast of the landfill. The influence from purging groundwater at these wells caused spreading of the impacted groundwater away from the source rather than removing impacted groundwater at the source. The redesigned capture system uses purge wells PW-5, PW-6, and PW-7 to remove VOC impacted groundwater at the source and prevented the spreading of the plume across the site.

Results of the purge system performance sampling indicated that purge wells PW-6, and PW-7 were effective in capturing impacted groundwater before it migrated to purge well PW-2. In addition, the performance sampling showed decreasing VOC trends at purge well PW-5. With MDEQ approval, purge well PW-2 was "turned-off" in November 2003 and purge well PW-5 was "turned-off" in June 2004.

As part of the site's on-going remedial action investigations, well pair MW-35s/ MW-35d was installed in October 2004 downgradient from the known VOC plume. Subsequent sampling events showed low levels of VOCs in deep well MW-35d. Step-out well pair MW-36s/MW-36d was installed in April 2005 at the site's eastern property boundary to characterize the lateral and vertical extent of groundwater impacts downgradient from the VOC plume. Subsequent sampling events showed very low levels of VOCs in deep well MW-36d. VOCs detected at this well were consistent with break-down products expected at the outer-most edge of a chlorinated VOC plume and are parameters-of-concern for the Remedial Action Plan. The shallow well (MW-36s) at this step-out well pair has been consistently clean; therefore, a clean line was established for VOCs in the shallow aquifer approximately 900 feet downgradient from the landfill between wells MW-35s and MW-36s.

In February 2006, downgradient water wells at 20959 Schoolfield Road, 2354 Amy School Road, and 2459 Amy School Road (Figure 2) were voluntarily sampled for VOCs by Central Sanitary Landfill with split samples collected by the MDEQ. These wells are located further downgradient from the landfill than monitoring well MW-36d and are no longer used to supply water for human consumption. At that time, the well at 20959 Schoolfield Road was on private property and the water wells at 2354 and 2459 Amy School Road were owned by Central Sanitary Landfill. The analytical results from repeat sampling at these wells between February 2006 and August 2009 indicate that all VOCs were below their detection limits. Based on these results, the known limit of the VOC plume

in the deep aquifer (zero line) was at some location between monitoring well MW-36d and the well at 20959 Schoolfield Road.

The MDEQ indicated that the water wells could not be used as clean line sampling points. Therefore, monitoring well MW-37 was installed in March 2007 along Schoolfield Road between monitoring well MW-36d and the well at 20959 Schoolfield Road (property now owned by Central Sanitary Landfill). Well MW-37 was installed to establish the clean-line for the eastern most limit of the VOC plume in the deep aquifer.

Diethyl ether was sampled at site groundwater monitoring wells for the first time during the third quarter 2007 as part of a split sampling event with the MDEQ. At that time, a very low level of diethyl ether was detected at monitoring well MW-37. Prior to that sampling event, VOCs had never been detected at monitoring well MW-37. Detectable levels of diethyl ether at well MW-37 were below the Part 201 aesthetic clean-up criteria of 10 ug/L and significantly below the health-based standard of 3,700 ug/L. Diethyl ether has been included as a parameter-of-concern for the site's Remedial Action Plan.

VOCs have never been detected above their detection limits in samples collected from the water well at 20959 Schoolfield Road which is screened in the same deep aquifer as monitoring wells MW-36d and MW-37. Based on these results, the detectable limit (clean-line) for diethyl ether and all other VOCs in the deep aquifer is at some location between monitoring well MW-37 and the former residential well (Figure 3).

Based on discussions with the MDEQ and in response to a MDEQ letter dated March 20, 2009, monitoring well MW-38 was installed as a clean-line step-out sentinel well approximately 1,300 feet downgradient from monitoring well MW-37. The well was installed in July 2009 on property owned by Central Sanitary Landfill. Monitoring well MW-38 is screened in the deep aquifer at the same depth as MW-37 and MW-36d. Monitoring well MW-38 is sampled quarterly for all parameters-of-concern and has been clean since it was installed in July 2009. Based on these results, the limits of the VOC plume in the deep aquifer (zero line) is at some location between monitoring well MW-37 and well MW-38. However, results for repeated sampling of the water well at 20959 Schoolfield Road demonstrate that the VOC clean-line is close to monitoring well MW-37. The intended purpose of monitoring well MW-38 is to show a clean-line beyond the known VOC plume downgradient from the landfill and allowed the water wells at 20959 Schoolfield Road and 2459 Amy School Road to be removed from the monitoring network. With MDEQ concurrence, the water wells were removed from the monitoring plan. Monitoring well MW-38 has been included

in the site's Remedial Action Plan monitoring program and sampled for the parameters-of-concern on a quarterly basis.

Based on discussions with the MDEQ, monitoring wells PW-4 and MW-39 were installed in July 2010 to better define the VOC clean-line northeast of the VOC plume in the deep aquifer. Monitoring well PW-4 is a 2-inch-diameter well constructed within the pre-existing, unused purge well PW-4. Monitoring wells PW-4 and MW-39 are screened across the same stratigraphic horizon and above the same clay layer encountered at deep wells MW-35d, MW-36d, and MW-37. Since June 2010, monitoring wells PW-4 and MW-39 have been sampled quarterly for the parameters-of-concern. VOCs have not been detected at these sentinel wells. VOCs have never been detected at purge well PW-4 since it was installed in 1992. Based on discussions with the MDEQ, monitoring wells PW-4 and MW-39 were the final wells needed to complete the VOC plume delineation.

VOCs have not been confirmed in the shallow aquifer during the past 8 years at shallow wells MW-35s and MW-36s. The clean-line in the shallow aquifer has been established between monitoring well MW-35s and monitoring MW-36s.

Purge well PW-7 was replaced with purge well PW-7R in July 2010 after it was found that fine sand from this well was being pumped into the remediation system air-stripper due to a failure of the well seal/screen. Purge well PW-7 was one of three purge wells proposed for pumping groundwater within the VOC plume east of the former Pierson Township Dump. This well was replaced with purge well PW-7R to maintain the proper groundwater capture for the site's remedial action.

The site's remediation system was updated in 2012 based on the optimum groundwater remedial action pumping scenario (Figure 14). The scenario maximizes capture of the existing VOC plume while minimizing the potential for drawing contamination further from the known source. This scenario includes the use of three existing purge wells (PW-5R, PW-6, PW-7R; Figure 2) and the new infiltration basin (Appendix D, Figure 14) to assist as a hydraulic barrier to eastward migration of VOCs (Figure 3). In 2012, purge well PW-5 was replaced with purge PW-5R to increase capture along the north edge of the VOC plume. In addition, a new air-stripper was installed at the site to treat the higher groundwater flow volume for the optimum pumping scenario.

In summary, the primary remedial activities conducted during the past 24 years included (1) the removal of the VOC source material (former Pierson Township Dump), (2) activation of purge wells within the VOC plume to remove and treat VOC impacted groundwater; (3) "shut-down" of perimeter purge wells to minimize spreading of the VOC plume; (4) determining the lateral and vertical

extent of groundwater contamination; (5) establishing an on-site VOC clean-line for the shallow and deep aquifers; and (6) upgrading the groundwater remedial system to maximize capture of the VOC plume.

The purpose of this Remedial Action Plan is to provide a clean-up strategy for parameters detected above groundwater protection standards. VOCs, iron, manganese, and total dissolved solids have been consistently detected above groundwater protection standards in the plume area and have been identified as parameters-of-concern for the remedial action. Zinc, boron, and sodium have been detected above their groundwater protection standards at two wells in the southeastern portion of the plume. As requested by the MDEQ, zinc, boron, and sodium have been included as parameters-of-concern for the remedial action. None of the parameters-of-concern have migrated off-site above their groundwater protection standards.

2.0 GEOLOGIC AND HYDROGEOLOGIC SETTING

The site geologic and hydrogeologic setting is described in the Hydrogeological Investigation Report (*SME; March 2000*) and summarized below.

The geological setting of the site consists of 350 to 390 feet of unconsolidated glacial sediments overlying either sandstone or limestone bedrock. The upper 100 feet of the glacial sediments consists of fine sand with interbedded silt and clay lenses. The subsurface distribution of the interbedded sand, silt, and clay units is illustrated in geologic cross sections A-A′, B-B′, C-C′, D-D′, and E-E′ (Figures 4 through 8).

2.1 SITE GROUNDWATER

The natural groundwater elevation of the site's uppermost aquifer was evaluated during a period when the purge well system was shut down. During the shut down period in August 1994, groundwater elevations ranged from approximately 896 feet above mean sea level (MSL) along the west side of the site to 893 feet above MSL along the east side of the site. At that time, a groundwater divide existed along the western perimeter of the site in the vicinity of Interstate U.S. 131. Groundwater west of U.S. 131 flowed west while groundwater beneath the site flowed east.

A groundwater model report prepared for the site using recent average pumping rates for the remediation system confirm groundwater flow direction and the location of the groundwater divide (Appendix D, Figure 13). A groundwater contour map was generated based on groundwater elevations measured at site wells in June 2010 (Appendix D, Figure 13). The contour map shows (1) the direction of groundwater beneath the site, (2) the groundwater divide west of the site, and (3) the deflection of groundwater contour lines downgradient from the operating purge wells east of the landfill.

Hydraulic Gradient and Flow Velocity

The average hydraulic gradient for the site was calculated using the head difference divided by the distance along the known flow direction downgradient from the purge wells in three locations using wells P-10 and P-12 (0.80 feet/490 feet), wells P-4 and P-25 (1.13 feet/750 feet), and wells P-20 and P-26 (1.51 feet/980 feet). Based on the August 2010 groundwater elevations, the average hydraulic gradient at the site was approximately 0.0015 foot per foot (ft/ft).

The groundwater flow velocity in the uppermost aquifer (sand unit) was determined using the groundwater gradients calculated for the site and

hydraulic conductivities derived from the pumping test conducted by Wenck in 1992. Transmissivities determined by the pumping tests ranged from 2,500 to 7,300 square feet per day (ft^2/day). Using an average saturated aquifer thickness of 60 feet, the hydraulic conductivity for the site was calculated to range from approximately 42 to 120 feet per day (ft/day).

The average flow velocity of groundwater in the sand unit was calculated from the following equation:

$$V = Ki/n_e$$

where V is the average flow velocity of groundwater, K is the hydraulic conductivity, i is the hydraulic gradient, and n_e is the effective porosity of the aquifer medium (sand unit).

A range of groundwater flow velocities for the site were calculated using an average hydraulic gradient of 0.0015 ft/ft measured between wells P-10 and P-12, wells P-4 and P-25, and wells P-20 and P-26 and hydraulic conductivities of 42 and 120 feet per day (ft/day) based on measurements used for the area east of the landfill in the modeling report (GRK&A, 1995). The water-bearing sand unit that contains the uppermost aquifer has an estimated effective porosity of 25 percent (Driscoll, 1986). The groundwater flow velocity in areas downgradient from the landfill ranges from approximately 92 to 263 feet per year.

2.2 SURFACE WATER

Surface water at the site infiltrates into the ground and does not leave the site. Three small ponds are located in the northeast portion of the site (Figure 2). Shallow groundwater in this area is approximately 5 to 10 feet below ground surface. Surface water in the ponds is an expression of the water table.

The nearest off-site surface water bodies include Taylor Drain located approximately 2,200 feet east of the site, Wood Lake located approximately 2,900 feet northeast of the site, and Whitefish Lake located approximately 4,800 feet west of the site (Figure 1).

The site is not located within any floodplains. The nearest river with a floodplain is the Little Muskegon River located approximately 6.5 miles north of the site. Tamarack Creek is a tributary of the Little Muskegon River and is located approximately 3.5 miles north of the site.

2.3 RESIDENTIAL WATER WELLS

There are several domestic water wells within 800 feet of the site boundary and houses within 300 feet. However, domestic water wells and houses within 800 feet from the solid waste boundary are owned by Central Sanitary Landfill and the wells are no longer in use.

3.0 NATURE AND EXTENT OF GROUNDWATER IMPACT

Groundwater analytical data collected at site monitoring wells and purge wells were evaluated to determine the nature and extent of impacted groundwater. Data collected since 1995 were used to assess on-site and potential off-site groundwater impacts from the landfill. Analytical results are provided in Appendix B.

The parameters-of-concern identified for the site are:

> iron, manganese, and total dissolved solids (zinc, boron, and sodium at monitoring wells MW-18 and MW-30).
>
> diethyl ether, tetrahydrofuran, 1,1-dichloroethane, 1,2-dichloroethane, chloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, vinyl chloride, trichloroethene, and benzene.

Time series graphs showing historical trends for the parameters-of-concern are provided in Appendix C.

Inorganics

The inorganics are considered parameters-of-concern if levels are above site background and/or Part 201 clean-up criteria. The Part 201 residential clean-up criteria is used when levels are above site background or when site background cannot be established.

Zinc, boron, and sodium have been detected above their Part 201 clean-up criteria at monitoring wells MW-18 and MW-30 and will be monitored at sentinel wells downgradient from these wells. The sentinel wells include P-20, P-22, P-25/P-25d, and P-15/P-30.

Isoconcentration maps for iron, manganese, and total dissolved solids are provided in Figures 9, 10, and 11; respectively. The isoconcentration maps were generated based on groundwater analytical data collected between 2010 and 2012.

VOCs

VOCs are considered parameters-of-concern if they are detected above Part 201 residential clean-up criteria and they have been confirmed in at least two consecutive sampling events during the past 3 years.

The VOC plume at the site is stable or shrinking. Isoconcentration maps illustrate a progressively smaller VOC plume over the past 10 years and trend analyses indicate predominately downward trends or no significant trends within the VOC plume. A discussion of these finding in provided below.

Isoconcentration maps generated for total VOCs are provided in Figure 3 and Figures 12 through 15. The isoconcentration maps show total VOCs in groundwater for the years 2001, 2002, 2003, 2004 and 2010. The maps illustrate the overall decreasing levels of VOCs in the plume area. The highest concentration of VOCs has shifted from the area around monitoring well MW-30 to the area around monitoring well MW-10N. This was due to the shut-down of purge well PW-2 and activation of purge wells PW-6 and PW-7. This pumping scenario allows the remediation system to capture the VOC plume at its source. Please note that diethyl ether and tetrahydrofuran were sampled for the first time in 2007. The 2010 isoconcentration map for total VOCs appears to have a larger plume than pervious maps; however, this is from the addition of diethyl ether and Tetrahydrofuran after 2007.

VOC trends were evaluated at all site monitoring wells. No VOCs were detected in 17 of those monitoring wells. The Sen's Slope statistical analysis was used to evaluate the VOC trends in the remaining nine wells. A summary of the trend analyses is provided on Figure 16. For the VOCs detected in these nine wells there were four upward trends, 40 with no significant upward or downward trends, and 13 VOCs with downward trends (Figure 16).

The following sections discuss possible exposure routes downgradient from the landfill. In addition, these sections provide specific information regarding contaminate migration modeling, plume concentrations, and observed trends associated with the parameters-of-concern.

3.1 EXPOSURE ROUTES

Potential exposure routes include air, surface water, soil, and groundwater. Air, surface water, and soil are not expected to pose a risk of exposure since the landfill is lined and capped. Gas produced by the landfill, including methane, is properly collected and treated to prevent dangerous levels from accumulating and escaping uncontrollably. The source of VOCs in groundwater was from the former Pierson Township Dump. The location of the Pierson Township Dump is shown on Figure 2. In 1992, waste materials in this old unlined disposal area were excavated and placed in an on-site double lined disposal area and capped. The landfill cap prevents any potential leachate from entering surface drainage. Impacted soils and waste are properly contained under the landfill cap, eliminating the risk of direct contact exposure routes, erosion, volatilization to

ambient and indoor air, blowing dust, and other hazards associated with exposed waste and impacted soil. The cap also greatly reduces the leaching of waste and impacted soils to groundwater.

Groundwater is the only potential exposure route identified for the site. Current monitoring results indicate that impacted groundwater associated with the VOC plume has not migrated off-site. A groundwater flow model prepared as part of this Remedial Action Plan (Appendix D; Figure 14) shows impacted groundwater captured by three purge wells. This scenario includes the use of purge wells PW-6, and PW-7R along with the new water infiltration basin (Figure2). During 2012, purge well PW-5 was replaced by purge well PW-5R. The infiltration basin was constructed in 2011 and is located to serve as an additional hydraulic barrier to eastward migration of VOCs while remaining within the VOC plume. The proposed pumping scenario maximizes capture of the existing VOC plume while minimizing the potential for drawing contamination further from the known source.

Dermal contact with groundwater is not likely except during sampling and maintenance of the monitoring wells, purge wells, and treatment system. Workers conducting sampling and maintenance of the wells and treatment system will wear appropriate personal protective equipment to avoid dermal contact with groundwater. The water table is found at significant depth, approximately 40 feet below ground surface, and there is no use of groundwater in the plume area. There are no risks associated with this pathway.

The risks due to hazardous substances in groundwater as a result of volatilization of VOCs to indoor air are minimal. The only building located above impacted groundwater is the groundwater treatment building. This building is not occupied other than short durations during maintenance and sampling of the treatment system.

The closest surface water body is Taylor Drain which is located approximately 2,000 feet downgradient from the VOC clean-line east of monitoring well MW-37. The closest drinking water well is approximately 1,000 feet downgradient from the VOC clean-line. Impacted groundwater associated with the landfill is not known to discharge to surface water, and samples collected from water wells downgradient from the site show no evidence of impact.

3.2 GROUNDWATER QUALITY CHARACTERIZATION

As part of the remedial activities at the site, waste materials in the former Pierson Township Dump were excavated in 1992, and disposed of in an on-site double lined disposal area and capped. The unlined disposal area was the source for

VOC impacts to groundwater. The site's groundwater pump and treat system has been removing VOCs from groundwater since April 1992.

Groundwater downgradient from the former Pierson Township Dump is currently impacted by three inorganics (iron, manganese, total dissolved solids), and ten VOCs (diethyl ether, tetrahydrofuran, 1,1-dichloroethane, 1,2-dichloroethane, chloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, vinyl chloride, trichloroethene, and benzene). Time series graphs showing historical trends for these parameters are provided in Appendix C. In addition, elevated levels of zinc have been detected at monitoring well MW-18 and elevated levels of boron and sodium have been detected at monitoring well MW-30.

A discussion of these parameters includes (1) the most recent levels detected compared to groundwater protection standards; (2) their spatial distribution relative to the landfill, groundwater capture zone, and monitoring wells; (3) the natural degradation processes that influence the concentration of the parameters downgradient from the landfill; and (4) trend analysis.

3.2.1 Metals and Inorganics

Groundwater monitoring wells downgradient from the former Pierson Township Dump have levels of iron and total dissolved solids above site background. Monitoring results indicated that iron, manganese, and total dissolved solids are the only metals and inorganics that consistently exceed Part 201 residential clean-up criteria and site-specific background tolerance limits at more than one monitoring well. Site-specific tolerance limits are provided in Appendix A, Exhibit 3.

Site-specific tolerance limits have been developed for iron, manganese, and total dissolved solids based on historical groundwater analytical data collected at background wells that have not been influenced by landfill activities. The groundwater analytical data are provided in Appendix B.

The manganese tolerance limit was developed based on additional background sampling in areas of the site that have not been influenced by landfill activities. The naturally elevated levels were confirmed by multiple samples from the same wells. A non-parametric tolerance level was selected using the highest confirmed manganese level detected at the background wells. The MDEQ agreed to the site-specific tolerance limit for manganese in their letter dated November 30, 2012 (Appendix A, correspondence).

It is not technically practical to completely remediate iron, manganese, and total dissolved solids in groundwater because these parameters are naturally

occurring. As part of the site's remediation system, groundwater treated for VOCs is directed through a bag filter to remove iron and other particulates. Elevated levels of iron, manganese, and total dissolved solids associated with the VOC plume are not migrating off-site. Areas downgradient from the VOC plume are monitored for these inorganics by sentinel wells.

3.2.1.1 Iron and Manganese

Dissolved iron and manganese have been detected at site monitoring wells above the background tolerance limits and Part 201 clean-up criteria. Groundwater remedial investigations have included the sampling of 32 monitoring wells and 4 purge wells. The historic database for iron and manganese is provided in Appendix B. For comparison purposes, time series graphs were developed for the analytical data collected within the plume to show long-term trends. The graphs are presented in Appendix C. Iron and manganese isoconcentration maps (Figures 9 and 10) were developed to show concentrations at the site in April 2011 and August 2012, respectively.

Iron and manganese levels above background are, in part, the result of biodegradation of VOCs in groundwater. The spatial and analytical correlation between elevated levels of dissolved iron and manganese and the VOC plume are evidence of continued biodegradation processes and are common under anaerobic conditions. At the site, iron and manganese levels have been detected above background within the VOC plume. The site-specific tolerance limit for iron is 2.5 mg/L and the site-specific limit for manganese 0.8 mg/L. These limits were developed based on additional background groundwater investigations conducted at the request of the MDEQ in 2011 and 2012. Results of the iron and manganese background groundwater investigations are provide in Appendix E.

Iron levels within the VOC plume have been detected above background at wells MW-5, MW-10N, MW-14B, MW-30, P-38, PW-2, PW-5, PW-6, and PW-7 (Figure 9). Elevated iron levels outside of the VOC plume have been detected above background at wells MW-38, MW-39, and PW-4 (Figure 9). An investigation of elevated iron levels in the vicinity of wells MW-39 and PW-4 was completed in 2011 (Appendix E). Results of the iron investigation show that there is a separation between of the elevated iron levels in the vicinity of wells MW-39 and PW-4 and the elevated iron levels within the plume (Appendix E). Long-term trends for iron within the plume are generally stable (Appendix C). Manganese levels detected within the VOC plume follow these same trends (Figure 10); however, manganese levels above background are isolated to an area beneath the northwestern portion of the site.

Iron levels detected above background at wells MW-38 and MW-39 represent natural groundwater conditions in the deep aquifer and are not associated with the VOC plume. Iron levels detected above background at well PW-4 are believed to be a combination of natural groundwater conditions (Appendix E) and conditions associated with construction materials used for the groundwater purge well (steel casing and screen). The elevated iron levels detected in groundwater beneath the northeast portion of the site are not associated with the VOC plume. Before purge well PW-4 was converted to a monitoring well, it pumped clean groundwater from 1992 to 2003. VOCs have never been detected at this location.

According to The Central Michigan District Health Department *Environmental Health Fact Sheets* for iron posted on their website (www.cmdhd.org), iron "concentrations of 1 to 5 parts per million (ppm) is common in groundwater." This range is above the iron levels typically detected at site monitoring wells outside of the VOC plume area. During the second quarterly 2010 event, iron levels detected at wells inside the VOC plume area range from non-detect to 15 mg/L (Figure 9).

The Part 201 generic standard for iron was set based on the United States Environmental Protection Agency (EPA) Secondary Drinking Water Maximum Contaminant Level (SMCL). The SMCL for iron is based upon cosmetic and aesthetic effects (such as taste and staining of plumbing fixtures), unrelated to health effects. Because the SMCLs are not risk-based or enforceable, public drinking water facilities are able to distribute water to consumers that contains iron above the 0.3 mg/L SMCL. In many areas of the United States and Michigan, the public consumes drinking water containing iron above the SMCL without any defined health risks. The health based Part 201 standard for iron is 2 mg/L.

Based on the evaluation of the nature and extent of elevated iron and manganese, there is no significant risk to human health and environment in areas downgradient from the site. Site groundwater poses no risk to aquatic plants and animals.

A release from the former Pierson Township Dump may have contributed to the iron and manganese levels detected above background at site wells within the plume area. Groundwater impacted with iron and manganese associated with the VOC plume is restricted to the facility property. The area with iron and manganese levels above background is shown on Figures 9 and 10. Restricting on-site use of groundwater is intended to minimize potential exposure routes and risk to human health and the environment.

Aerobic to Anaerobic Conditions

In the site's aquifer system, where organic material is available, bacteria will utilize the organics for electron donors. As long as dissolved oxygen (O_2) is present, it will remain the electron receptor. This is the basis of aerobic bacterial activity. When subsurface oxygen is depleted, the aerobic bacteria are replaced by anaerobic bacteria which use mineral phase iron (Fe^{+3}) and manganese (Mn^{+4}) as well as any available NO^{-}_{3}, SO_4, and CO_2 as electron receptors. The addition of an electron to mineral phase Fe^{+3} and Mn^{+4} via anaerobic bacterial activity causes the reduced, and now soluble, Fe^{+2} and Mn^{+2} to be released into groundwater.

Natural Attenuation (Anaerobic Biodegradation)

In addition to the site's pump-and-treat system, natural attenuation processes (biodegradation, dispersion, sorption, and volatilization) can greatly influence the fate and transport of VOCs in groundwater downgradient from the landfill. Biodegradation of compounds into daughter compounds has been documented by the EPA (EPA, 1998) and evidence of this process has been observed at the site. Elevated concentrations of dissolved iron and manganese are commonly used as indicators for verifying biodegradation of VOCs in groundwater (EPA, 1998). The spatial and analytical correlation between high levels of dissolved iron and manganese and the VOC plume are evidence of biodegradation processes within the aquifer.

During the anaerobic biodegradation of VOCs, Fe^{+3} is often used as an electron acceptor for the breakdown of organic carbon (EPA, 1998). During this natural process, Fe^{+3} commonly found in the soils is reduced to Fe^{+2} and becomes soluble in groundwater (EPA, 1998). A similar process occurs with manganese. At the site, levels of dissolved iron have been detected above background at monitoring wells MW-5, MW-10N, MW-14B, MW-30, P-38, PW-2, PW-5, PW-6, and PW-7 (Figure 9). Manganese levels follow the same general trends within the VOC plume. The spatial and analytical correlation between iron and manganese levels detected above background, and the VOC plume are evidence of continued biodegradation processes within the aquifer.

3.2.1.2 Total Dissolved Solids

Total dissolved solids refer to the total amount of all inorganic and organic substances including minerals, salts, metals, cations or anions. The solids must be small enough to pass through a 2 micrometer filter. The concentrations in water are equal to the sum of positively charged ions (cations) and negatively charged ions (anions). Total dissolved solids are not considered a primary

pollutant. High levels of total dissolved solids typically indicate hard water and may lead to scale build-up in pipes, reduced efficiency of water filters, and aesthetic problems such as bitter or salty taste.

The Part 201 generic standard for total dissolved solids (500 mg/L) was set based on the EPA SMCL. The SMCL is based upon cosmetic and aesthetic effects (such as taste and staining of plumbing fixtures), unrelated to harmful health effects. In many areas of the United States and Michigan, the public consumes drinking water containing total dissolved solids above the SMCL without any defined health risks.

Total dissolved solids have been detected in groundwater above the Part 201 limit of 500 mg/L and above the site's background tolerance limit of 870 mg/L (Appendix A, Exhibit 3). Total dissolved solids have been detected above background at monitoring wells MW-10N, MW-14B, MW-18, and MW-30 (Figure 11). Levels of total dissolved solids detected at these wells are believed to be associated with the VOC plume. The historic database for total dissolved solids is provided in Appendix B. For comparison purposes, time series graphs were developed for the analytical data collected within the plume to show long-term trends. The graphs are presented in Appendix C. A total dissolved solids isoconcentration map (Figure 11) was developed to show concentrations at the site in June 2010. Total dissolved solids are below the background tolerance limit at all sentinel wells downgradient from the landfill (Appendix B). Exceedance of the tolerance limit is restricted to a small area adjacent to the landfill within the VOC plume (Figure 11).

Based on the evaluation of the nature and extent of total dissolved solids in groundwater, there is no significant risk to human health and environment for areas downgradient from the site. Site groundwater poses no risk to aquatic plants and animals.

3.2.1.3 Other Metals and Inorganics

Zinc, boron, sodium, and total inorganic nitrogen have been detected and confirmed above Part 201 clean-up criteria in two monitoring wells. A discussion of these parameters is provided below.

Zinc

Zinc levels have been detected above the Part 201 clean-up criteria (2.4 mg/L) at monitoring well MW-18 (Figure 2). Analytical results for Zinc (2003 through the first quarter 2011) are presented in Appendix B. Zinc levels detected at this older well are related to the galvanized steel riser pipe and screen used in the

construction of the monitoring well. The oxidation and degradation of the metals in the galvanized pipe have impacted groundwater samples collected at this well. It is recommended that all new monitoring wells and replacement wells be constructed with PVC riser pipe and screen. At the request of the MDEQ, Zinc is considered a parameter-of-concern for the Remedial Action Plan.

Boron and Sodium

Boron and sodium levels have been detected above Part 201 clean-up criteria (0.5 and 120 mg/L; respectively) at site monitoring well MW-30 (Figure 2). Analytical results for these parameters are provided in Appendix B. The boron and sodium levels at this well represent a local groundwater chemistry anomaly. These parameters have not been detected or confirmed above clean-up criteria at any other monitoring wells within the plume or outside of the plume. At the request of the MDEQ, boron and sodium are considered parameters-of-concern for the Remedial Action Plan.

Total Inorganic Nitrogen

Total inorganic nitrogen has been detected above Part 201 clean-up criteria (10 mg/L) at monitoring well MW-36d (Figure 2). Analytical results for this parameter are provided in Appendix B. Levels of total inorganic nitrogen above Part 201 criteria are believed to be associated with a previous residential septic system located near this monitoring well. Total inorganic nitrogen has not been confirmed above clean-up criteria at any other site monitoring wells and is not associated with the plume adjacent to the landfill. Total inorganic nitrogen is not considered a parameter-of-concern for the Remedial Action Plan.

3.2.2 Volatile Organic Compounds

Historical groundwater analytical for VOCs is provided in Appendix B. VOCs have been confirmed at eleven on-site monitoring wells (MW-5, MW-10N, MW-13, MW-14B, MW-30, MW-35d, MW-36d, MW-37, P-36, P-37, and P-38) and four purge wells (PW-2, PW-5, PW-6, and PW-7). The source area for VOC impacts to groundwater was the former Pierson Township Dump which was removed in 1992. The site's groundwater remediation system includes purge wells that capture and treated groundwater from the center of the VOC plume. Total VOC isoconcentration maps for data collected in June 2001, May 2002, May 2003, May 2004, and June 2010 and presented in Figures 12 through 15, and Figure 3; respectively. It should be noted that two additional VOCs (diethyl ether and tetrahydrofuran) were added to the monitoring program during the third quarter 2007 giving the appearance that the VOC plume has increased. However, total VOC levels detected across the site have shown a steady decline since routine

monitoring for VOCs began. To verify decreasing VOC levels, trend analyses were conducted at nine wells. Results of the trend tests are provided on Figure 16 and show 4 upward trends, 40 non-trends, and 13 downward trends.

The historical groundwater analytical data indicates that monitoring well MW-10N and purge well PW-6 have been the most contaminated wells and represent the center of the VOC plume. The primary remedial activity at the site is groundwater purging from the center of the plume supplemented by natural biodegradation and long-term monitoring at the perimeter of the plume.

Natural attenuation processes (biodegradation, dispersion, sorption, and volatilization) influences the fate and transport of VOCs in groundwater. Biodegradation of compounds into daughter compounds has been documented by the EPA (EPA, 1998) and evidence of this process has been observed at the site.

The model BIOCHLOR (version 1.0), available through the United States Environmental Protection Agency, was used for modeling the transport of chlorinated solvents in the aquifer with biotransformation modeled as a first-order decay process. The basic model assumptions are:

- uniform groundwater flow conditions with uniform hydrogeologic and environmental conditions over the entire model area;
- designed for simulating the sequential reductive dechlorination of chlorinated ethane's and ethene's;
- first-order decay; and
- a constant source that fully penetrates the aquifer.

The model assumes a no pumping scenario where groundwater is allowed to migrate freely downgradient from the source. The biotransformation results for select parameters-of-concern (ethane's and ethane's) are provided in Appendix F. Natural attenuation has been, and will continue to be a secondary remedial process at the site.

A discussion of the VOC parameters-of-concern is provided below.

3.2.2.1 Diethyl Ether and Tetrahydrofuran

Diethyl ether and Tetrahydrofuran were sampled for the first time during the third quarter 2007 as part of split sampling with the MDEQ. These parameters were added to the routine groundwater monitoring program in 2007. Since 2007,

diethyl ether has been detected in eight monitoring wells (MW-5, MW-10N, MW-14B, MW-30, MW-36d, MW-37, P-37, and P-38; Appendix B) and tetrahydrofuran has been detected in six monitoring wells (MW-5, MW-10N, MW-30, P-36, P-37, and P-38; Appendix B). In 2008, diethyl ether and tetrahydrofuran were included as parameters-of-concern for the site's Remedial Action Plan. Time series graphs provided in Appendix C indicate that levels of diethyl ether and tetrahydrofuran have been stable or decreasing since 2007. During the third quarter 2010 sampling event, diethyl ether was detected above the aesthetic Part 201 clean-up criteria (10 ug/L) at three on-site monitoring wells (MW-5, MW-30, and MW-36d). The highest level of diethyl ether (175 ug/L) was detected at monitoring well MW-5 which is located adjacent to the northeast edge of the closed landfill and upgradient from purge well PW-5 (Figure 2). Before the purge wells PW-5, PW-6, and PW-7 began operation (August 2003), it is believed that diethyl ether migrated to the east of the landfill due in part to long-term pumping at purge well PW-4. Purge well PW-4 was shut down in April 2003. The highest levels of diethyl ether detected at the site are significantly below the residential health based drinking water value of 3,700 μg/L.

The highest levels of tetrahydrofuran (130 ug/L) were detected at monitoring wells MW-5 and MW-30 in April and November 2008. Tetrahydrofuran has not been detected above its Part 201 clean-up criteria (95 ug/L) since the second quarter 2009.

Diethyl ether and tetrahydrofuran have not been detected in any of the sentinel wells and groundwater impacted by these VOCs does not appear to be migrating further downgradient in the regional aquifer. For example, detectable levels of diethyl ether have remained between 5 and 9 ug/L at the edge of the VOC plume (monitoring well MW-37) since monitoring began in 2007. As part of this Remedial Action Plan, groundwater purge wells PW-6, and PW-7R and a replacement well for purge well PW-5 will capture groundwater in areas impacted by the highest concentrations of these VOCs.

3.2.2.2 1,1-Dichloroethane

Low levels of 1,1-dichloroethane (1,1-DCA) have been detected at monitoring wells MW-5, MW-10N, MW-13, MW-30, and MW-36d and purge wells PW-2, PW-6, and PW-7 (Appendix B); however, the concentrations detected at these wells have been below the Part 201 clean-up criteria of 880 ug/L since 1999. The highest levels of 1,1-DCA were detected in monitoring wells MW-10N and MW-30 (Appendix B). During the past twelve years, concentrations detected in monitoring well MW-10N have decreased from 1,100 ug/L (May 1998) to 70 ug/L (November 2007) (Appendix B). Levels of 1,1-DCA have since increased to 210 ug/L.

Levels of 1,1-DCA detected in monitoring well MW-30 have shown a steady decline from 2,000 ug/L in May 1998 to a low of 39 ug/L in June 2010 (Figure 16). Time series graphs showing the decreasing levels of 1,1-DCA in the groundwater aquifer are presented in Appendix C.

Very low levels of 1,1-DCA have also been detected at the downgradient edge of the VOC plume in monitoring well MW-36d. At this well, levels of 1,1-DCA show a decreasing trend since 2005(Appendix C) (Figure 16), ranging from non-detect to approximately 3.0 ug/L.

Concentrations of 1,1-DCA detected at all site monitoring wells and purge wells have been below the Part 201 clean-up criteria since 1999.

There is no indication that 1,1-DCA is migrating off-site. Groundwater samples collected at sentinel wells along the downgradient perimeter of the site have been consistently clean. Based on the following observations, 1,1-DCA does not pose a risk to human health and the environment at locations downgradient from the site.

- decreasing levels of 1,1-DCA have been observed within the plume area, specifically at monitoring wells MW-10N and MW-30,
- the original source area for VOCs has been removed,
- the remediation system will continue to capture and treat impacted groundwater within the VOC plume,
- very low levels of 1,1-DCA have remained stable at the downgradient edge of the plume, and
- 1,1-DCA has never been detected at the sentinel wells.

3.2.2.3 1,2-Dichloroethane

Levels of 1,2-Dichloroethane (1,2-DCA) have been detected above the Part 201 clean-up criteria at monitoring wells MW-10N and MW-30, and at purge well PW-2 (Appendix B). Levels of 1,2-DCA at all other site monitoring wells and purge wells have been below the Part 201 clean-up criteria of 5 ug/l. Levels of 1,2-DCA are currently below Part 201 clean-up criteria (5 ug/L) at all monitoring locations except well MW-30.

The highest level of 1,2-DCA detected at the site was observed at monitoring well MW-10N. During the past 13 years, levels of 1-2, DCA detected in well MW-10N have shown a steady decline from 89 ug/L (November 1997) to 1.8

ug/L (June 2010) (Figure 16)(Appendix B). Decreasing levels observed adjacent to the original source (area beneath the landfill) was anticipated because the source area was removed and the area was capped greatly reducing the potential leaching of VOCs to groundwater beneath the landfill.

As part of the on-going remediation system improvements at the site, purge well PW-6 was turned on in August 2003 and PW-2 was shut-down in November 2003. The purge wells were sampled for VOCs between August 2003 and February 2006. Levels of 1,2-DCA detected at purge well PW-2 and adjacent monitoring well MW-30 show an increasing trend between May 2005 and May 2006. The highest level detected at purge well PW-2 was 63 ug/L (August 2005) and the highest level detected at monitoring well MW-30 was 33 ug/L (May 2006). Since these peak concentrations, 1,2-DCA has shown a steady decrease at both of these locations.

Levels of 1,2-DCA have been increasing at purge well PW-6 (Appendix B) since it was "turned-on" in August 2003. It is anticipated that concentrations will continue to rise or level off at this purge well as it captures groundwater from the source area adjacent to the landfill and from areas between purge well PW-6 and PW-2. Time series graphs show the observed trends at monitoring wells MW-5, MW-10N, MW-30, and purge wells PW-2 and PW-6 (Appendix C).

There is no indication that 1,2-DCA is migrating off-site. VOCs have never been detected in groundwater samples collected at the sentinel wells along the downgradient perimeter of the site. Based on the following observations, 1,2-DCA does not pose a risk to human health and the environment at locations downgradient from the site.

- decreasing levels of 1,2-DCA have been observed within the plume area,
- the source area for VOCs has been removed,
- the remediation system will continue to operate if VOC levels remain above groundwater protection standards at site monitoring wells,
- very low levels of 1,2-DCA have remained stable at the downgradient edge of the plume, and
- 1,2-DCA has never been detected at the sentinel wells.

3.2.2.4 Chloroethane

Low levels of chloroethane have been detected at monitoring well MW-10N and purge wells PW-2, PW-6, and PW-7 (Appendix B). Historical groundwater analytical data indicated that chloroethane has not exceeded Part 201 clean-up criteria (430 ug/L) at these monitoring locations since 1999. Chloroethane levels detected at monitoring well MW-30 have historically been above the Part 201 clean-up criteria with the highest level reported at 780 ug/L in March 2005 (Appendix B). Since then, the levels have steadily declined to 86 ug/L in June 2010 (Appendix C).

Chloroethane is a first order decay parameter produced by the breakdown of 1,1-dichloroethane (1,1-DCA). Decreasing levels of 1,1-DCA detected at monitoring well MW-30 indicate that the source is being reduced by natural degradation and the purging of groundwater at wells PW-5R, PW-6 and PW-7R.

The biotransformation of chloroethane was evaluated using the BIOCHLOR model. A concentration of 370 ug/L observed at monitoring well MW-30 was used as the source concentration for the model (Appendix B). The model assumes a no pumping scenario where groundwater is allowed to migrate freely downgradient from the source. The distance from monitoring well MW-30 to the site's eastern property boundary, along the downgradient flow path, is approximately 2,200 feet. Results of the model (Appendix F) indicate that chloroethane will degrade to below its detection limit along the downgradient flow path from the well to the property boundary.

Chloroethane has never been detected at sentinel wells P-25, P-25d, and MW-38 located downgradient from well MW-30. There is no indication that chloroethane is migrating off-site. VOCs have never been detected at any of the on-site sentinel wells along the downgradient perimeter of the site. Based on the following observations, chloroethane does not pose a risk to human health and the environment at locations downgradient from the site.

- decreasing levels of chloroethane have been observed within the plume area,
- the original source area for VOCs has been removed,
- the BIOCHLOR model indicates rapid biodegradation of chloroethane downgradient from the existing source, and
- chloroethane has never been detected in the eastern portion of the VOC plume or at the sentinel wells.

The groundwater pump and treat system will continue to operate if VOC levels remain above Part 201 clean-up criteria at site monitoring wells.

3.2.2.5 1,1-Dichloroethene

Levels of 1,1-Dichloroethene (1,1-DCE) have been detected in monitoring well MW-10N and purge well PW-6 (Appendix B). In September 2003, levels of 1,1-DCE were detected above the Part 201 clean-up criteria at purge well PW-6 when the well was "turned-on" as part of upgrades to the remediation system. Prior to the well being "turned-on", 1,1-DCE had not been detected in the purge well. Since then, 1,1-DCE levels increased to a maximum of 20 ug/L in October 2003 then show an overall downward trend through February 2006 (Appendix C). The increase was expected as contaminated groundwater was captured by the purge well. The decreasing levels 1,1-DCE observed at purge well PW-6 since October 2003, indicate this VOC and other VOCs are being removed from the aquifer by the groundwater pump and treat system.

The highest levels of 1,1-DCE detected at the site have been observed at monitoring well MW-10N. The highest level was 100 ug/L detected during the June 2010 sampling event. The spike in 1,1-DCE levels at monitoring well MW-10N followed a eight year period of non-detects and levels below the Part 201 clean-up criteria (7.0 ug/L). Levels of 1,1-DCE at all other site monitoring wells and purge wells have been below the detection limit since monitoring for VOCs began.

There is no indication that 1,1-DCE is migrating off-site. This VOC has never been detected at the sentinel wells along the downgradient perimeter of the site. Purge well PW-6 captures groundwater in the area around MW-10N (Appendix D) where elevated levels of 1,1-DCE have recently been detected. Based on continued operation of the groundwater remediation system and on-going monitoring at the sentinel wells, 1,1-DCE does not pose a risk to human health and the environment at locations downgradient from the site.

3.2.2.6 cis-1,2-Dichloroethene

Low levels of cis-1,2-dichloroethene (1,2-DCE) have been detected in monitoring wells MW-14B, MW-30, MW-35, MW-36d, and P-38, and in purge wells PW-2, PW-5, and PW-7 (Appendix B). Levels of 1,2-DCE at these wells have been below the Part 201 clean-up criteria of 70 ug/L. Levels of 1,2-DCE detected in monitoring wells MW-5 and MW-10N, and in purge well PW-6 have been above the Part 201 clean-up criteria. The highest levels detected at the site have been at monitoring well MW-10N. Between 1997 and May 2002, the levels fluctuated between 59 ug/L and 710 ug/L (Appendix C). Since then, concentrations have

decreased to below the detection limit (<1 ug/L) in April 2008 followed by an increase to 310 ug/L in October 2009 (Appendix C). An increase in 1,2-DCE concentrations have also been observed during this time at monitoring well MW-5. Both of these wells are located within the remediation system groundwater capture zone (Appendix D).

Levels of 1,2-DCE detected at purge well PW-6 increased from 1.9 ug/L in May 2003 to 92 ug/L in September 2003, when the well was "turned-on" and began purging groundwater for the remediation system. The concentrations in purge well PW-6 showed a steady decline to a low of 31 ug/L in February 2006. Purge well PW-6 is located adjacent to monitoring well MW-10N and is expected to have elevated levels of 1,2-DCE.

Very low levels of 1,2-DCE have also been detected at the downgradient edge of the VOC plume in monitoring well MW-36d. At this well, detectable levels of 1,2-DCE have remained stable since 2005, ranging from non-detect to 2.8 ug/L.

There is no indication that 1,2-DCE is migrating off-site. VOCs have never been detected in groundwater samples collected at on-site sentinel wells along the downgradient perimeter of the site. Based on the following observations, 1,2-DCE does not pose a risk to human health and the environment at locations downgradient from the site.

- decreasing levels of 1,2-DCE have been observed within the plume area,
- the original source area for VOCs has been removed,
- very low levels of 1,2-DCE have remained stable at the downgradient edge of the plume, and
- 1,2-DCE has never been detected at the sentinel wells.

The groundwater pump and treat system will continue to operate if VOC levels remain above Part 201 clean-up criteria at site monitoring wells.

3.2.2.7 Vinyl Chloride

Vinyl chloride has been detected above the Part 201 clean-up criteria at monitoring wells MW-5, MW-10N, MW-35d, P-37, and P-38 and purge wells PW-2 and PW-6 (Appendix B). Beginning in 2004, vinyl chloride levels at purge well PW-2 declined due to the influence of pumping groundwater for the remediation system. In August 2003, purge wells PW-6 and PW-7 were "turned-on",

intercepting the plume before it migrated to purge well PW-2. Pumping ceased in purge well PW-2 in November 2003.

Levels of vinyl chloride detected at monitoring well MW-10N show a significant decrease since June 2001 (Appendix C). The levels decreased from 230 ug/L in May 2000 to non-detect (<1.0 ug/L) in April 2008 followed by fluctuations of 30 to 40 ug/L (Appendix C). The most recent concentration was 10 ug/L detected in November 2010.

The production and biotransformation of vinyl chloride were evaluated using the BIOCHLOR model. Vinyl chloride is a direct degradation product of 1,2-DCE. The highest level of vinyl chloride (230 ug/L) observed at monitoring well MW-10N (May 2000, Appendix B) was used as the source concentration for the model. The model assumes a no pumping scenario where groundwater is allowed to migrate freely downgradient from the source area. Results of the model (Appendix F) indicate that levels of vinyl chloride slowly decrease as vinyl chloride degrades to ethane, CO2, and water. The model shows levels degrading to below Part 201 clean-up criteria at a distance of approximately 900 feet downgradient from the source. Time-of-travel in the aquifer is calculated to be approximately 92 to 263 feet per year (Section 2.1). The site property boundary is approximately 2,600 feet downgradient from monitoring well MW-10N. Vinyl chloride has never been detected beyond monitoring well MW-35d which is approximately 700 feet downgradient from monitoring well MW-10N.

There is no indication that vinyl chloride is migrating off-site. Groundwater samples collected at sentinel wells along the downgradient perimeter of the site have been consistently clean. Based on the following observations, vinyl chloride does not pose a risk to human health and the environment at locations downgradient from the site.

- decreasing levels of vinyl chloride have been observed within the plume area, most notably at monitoring well MW-10N,
- the original source area for VOCs has been removed,
- vinyl chloride has never been detected beyond monitoring well MW-35d which supports the BIOCHLOR model for biodegradation of vinyl chloride downgradient from the existing source area, and
- vinyl chloride has never been detected at the sentinel wells .

The groundwater pump and treat system will continue to operate if VOC levels remain above Part 201 clean-up criteria at site monitoring wells.

3.2.2.8 Trichloroethene

Trichloroethene (TCE) has been detected at monitoring well MW-10N and purge well PW-6 (Appendix B). Monitoring wells MW-14B and MW-30 have had sporadic detects at or slightly above the detection limit of 1.0 ug/L. The Part 201 clean-up criteria for TCE is 5.0 ug/L. Levels of TCE detected at monitoring well MW-10N showed a significant decrease from May 1998 to non-detects in May and November 2007. Since 2007, the concentrations increased to 67 ug/L (Appendix C). The most recent results were 1,800 ug/L reported in June 2010 and 2,200 ug/L reported in November 2010.

After purge well PW-6 was "turned-on" in August 2003, TCE levels increased from below the detection limit to 110 ug/L and have since stabilized between 47 and 99 ug/L, indicating that groundwater impacted by TCE is being captured and removed by the site's remediation system.

TCE has not been detected in the eastern portion of the VOC plume and is believed to degrade rapidly to daughter compounds as it migrates to the east. There is no indication that TCE is migrating off-site. Groundwater samples collected at downgradient monitoring wells and sentinel wells along the downgradient perimeter of the site have been consistently clean. Based on the following observations, TCE does not pose a risk to human health and the environment at locations downgradient from the site.

- decreasing levels of TCE have been observed within the plume area,
- the original source area for VOCs has been removed,
- TCE has never been detected in the eastern portion of the VOC plume, and
- TCE has never been detected at the sentinel wells.

The groundwater pump and treat system will continue to operate if VOC levels remain above Part 201 clean-up criteria at site monitoring wells.

3.2.2.9 Benzene

Benzene has been detected in monitoring wells MW-5, MW-10N, MW-13, MW-14B and MW-30 and purge wells PW-2 and PW-7 (Appendix B). During the June and November 2010 monitoring events, benzene concentrations were below the Part 201 clean-up criteria (5.0 ug/L) at all site monitoring wells.

The highest levels of Benzene detected at the site were at monitoring well MW-10N. Benzene levels detected at monitoring well MW-10N have decreased from 40 ug/L in November 1998 to less than 3 ug/L in June and November 2010 (Appendix C). Benzene levels detected at monitoring well MW-30 have decreased from 29 ug/L in May 2005 to less than 4 ug/L in June and November 2010. Prior to December 2003, groundwater impacted with benzene in the vicinity of monitoring well MW-30 was captured by purge well PW-2. When purge well PW-7 was "turned-on" and PW-2 was "turned-off", the flow direction changed as groundwater was drawn toward purge well PW-7. Decreasing levels of benzene observed at monitoring well MW-30 are due to the changes in flow direction. As purge wells PW-6 and PW-7R draw groundwater from the vicinity of monitoring well MW-30 and capture groundwater from the source area, benzene concentrations have decrease to levels below Part 201 criteria.

Low levels of benzene detected in monitoring wells MW-13 and MW-14B (1.0 to 2.1 ug/L) were likely due to pumping groundwater at purge well PW-1, north of the landfill, while levels detected in monitoring well MW-30 were likely due to pumping groundwater at purge well PW-2 located east of the landfill. The influence of purging groundwater at these wells caused spreading of the impacted groundwater away from the source rather than removing impacted groundwater at the source. The new purge well configuration where groundwater is pumped at purge wells PW-5R, PW-6, and PW-7R will remove VOC impacted groundwater at the source and prevent the spread of VOCs across the site.

There is no indication that Benzene is migrating off-site. Groundwater samples collected at the on-site sentinel wells along the downgradient perimeter of the site have been consistently clean. Based on the following observations, benzene does not pose a risk to human health and the environment at locations downgradient from the site.

- decreasing levels of benzene have been observed within the plume area at monitoring well MW-10N,
- the original source area for VOCs has been removed,
- benzene has never been detected in the eastern portion of the VOC plume, and
- benzene has never been detected at the sentinel wells.

The groundwater pump and treat system will continue to operate if VOC levels remain above Part 201 clean-up criteria at site monitoring wells.

3.2.2.10 Other VOCs

Other VOCs detected at the site monitoring and purge wells include trans-1,2,-dichloroethene, tetrachloroethene, methylene chloride, 1,2-dichloropropane, toluene, methyl ethyl keytone, 4-methyl-pentanone, 1,1,1-trichloroethane, xylenes, and acetone. During the past 3 years, all of these VOCs have been detected below their respective Part 201 residential clean-up criteria. The highest concentrations of these VOCs have been detected in areas adjacent to the active groundwater purge wells.

Groundwater samples collected from the RAP compliance monitoring wells will continue to be monitored for VOCs on a semi-annual basis. The perimeter sentinel wells will continue to be monitored for the VOCs on a quarterly basis. Based on the known extent of VOCs and proposed on-site deed restrictions for groundwater use, VOCs do not pose a significant risk to human health and the environment at locations outside of the proposed deed restriction area.

Based on the evaluation of the nature and extent of groundwater contaminants listed in Section 3.2, there is no significant risk to human health and environment for areas outside of the proposed on-site deed restriction area.

4.0 PROPOSED REMEDIAL ACTION

The proposed remedial action is based on the results of groundwater remedial investigations and technologies that meet the remedial action objectives. The final remedial action provides for:

- source control by removal of the former Pierson Township Dump (completed in 1992), no additional action for source control is needed or proposed;
- continued operation and maintenance of the existing groundwater pump and treat system, as needed, to remove VOCs from groundwater;
- on-site land-use restrictions for areas where impacted groundwater exceeds groundwater protection standards;
- a contingency plan to install additional sentinel wells and expand the restricted area should VOCs migrate to sentinel wells;
- a contingency plan to install additional sentinel wells and expand the restricted area should inorganics associated with a release migrate to sentinel wells at levels above groundwater protection standards;
- continued long-term monitoring obligations consistent with the sampling and analytical plan contained in this report; and
- continued maintenance of the landfill cap, leachate collection system, and other engineering measures.

Consistent with Section 20118(6)(d)(i), information has been provided in Section 3 demonstrating that there will be no adverse impact on the environment as a result of migration of contaminants during the remedial action, except for that part of the aquifer located on-site and within the VOC contamination plume. Consistent with Section 20118(6)(d)(ii), the remedial action includes an enforceable land-use restriction for the facility property to prevent unacceptable risk from exposure to VOCs, iron, manganese, zinc, boron, sodium, and total dissolved solids in groundwater as defined by the clean-up criteria provided in Section 5.3. The proposed on-site restricted area includes all areas impacted by the VOC plume and associated metals and inorganics.

The only exposure route of concern identified is through groundwater consumption. Therefore, remedial activities have been proposed to prevent consumption of groundwater. On-site groundwater is not and will not be used

within the restricted area for drinking water, and, therefore, does not pose a risk to human health. Groundwater samples collected from the perimeter sentinel wells show no VOCs above groundwater protection standards (Appendix B). Monitoring of the sentinel wells and active remediation of the VOC plume will provide adequate control to ensure potential groundwater impacts are addressed in a timely fashion. Long-term groundwater monitoring will be continued as required by the Remedial Action Plan and the MDEQ.

The proposed Remedial Action Plan as presented in this report complies with R299.5705(5) and (6) of Part 201, as amended, because VOCs associated with the release that are above the established clean-up criteria will be actively removed from the aquifer and not be allowed to migrate off-site. Therefore, consistent with the requirements of Section 20118 of Act 451, as specified in Rule 118(5), this report demonstrates that the proposed remedial action is protective of the public health, safety, and welfare, and the environment. Consistent with Rule 118(6)(d)(i), information has been provided in Section 3 demonstrating that there will be no adverse impact on the environment as a result of migration of contaminants during the remedial action, except for that part of the aquifer beneath the site.

Designated sentinel wells will monitor the on-site restricted area and verify that VOC contaminants do not migrate off-site at concentrations above groundwater protection standards. Monitoring the restricted area will provide adequate control to ensure that off-site impacts are addressed in a timely fashion. A contingency plan is provided in Section 5 to address potential off-site migration of VOCs.

The landfill cap is highly effective in reducing the amount of surface water infiltration through the waste; thus, minimizing the possibility of contaminants leaching to groundwater. Central Sanitary Landfill will maintain the cap and has provided Financial Assurance for the cap maintenance under Part 115 of Act 451. The previous removal of the former Pierson Township Dump and the addition of the existing landfill cap along with double composite liner systems for all new cells provide a reduction in toxicity, mobility, and volume of impacted groundwater downgradient from the site. No additional action for source control is needed or proposed.

Other elements of this Limited Residential Remedial Action include an operation and maintenance plan and permanent markers (Section 6), a schedule for implementation (Section 7), and a financial assurance mechanism (Section 8) acceptable to the MDEQ to fund long-term monitoring, operation and maintenance, and oversight, as applicable, to assure the effectiveness of the remedy. The remedy is subject to public notice and public comment.

4.1 SOURCE CONTROL AND REMOVAL

In 1989, VOCs were detected in groundwater collected at site monitoring wells. According to the Interim Revised Remedial Action Plan, the source of the VOCs was from an unlined disposal area referred to as the "Pierson Township Dump." Consistent with the site's consent judgment and part of the initial remedial actions, waste materials in this old unlined disposal area were excavated and placed in an on-site double lined disposal area and capped. Source control and removal operations were completed in 1992.

5.0 GROUNDWATER MONITORING AND SAMPLING PROGRAM

A remedial action groundwater monitoring and sampling program is provided in the following sections.

5.1 GROUNDWATER MONITORING NETWORK

The groundwater monitoring network includes eleven Remedial Action Plan sentinel wells, seven Remedial Action Plan compliance wells, and eight detection monitoring wells. Site monitoring wells are shown on Figure 2, and cross-sections A-A′, B-B′, C-C′, D-D′, and E-E′ (Figures 4 through 8).

Sentinel Wells	*Deep*	*Shallow*
	P-30	P-15
	P-25d	P-25
	MW-37	P-22
	MW-38	P-20
	MW-39	MW-36s
	PW-4	

Compliance wells	*Deep*	*Shallow*
	MW-30	MW-10N
	MW-36d	MW-14B
	P-38	MW-18
	MW-5	

Detection Monitoring Wells	*Downgradient*	*Upgradient*
	P-12	P-16
	P-23	P-35
	P-37	P-36
	P-21	MW-34

Details of the monitoring program are provided in the site's approved Hydrogeological Monitoring Plan (HMP). Well construction details and installation records for newly installed wells are provided in Appendix G.

The compliance wells are intended to evaluate long-term trends within the VOC plume and clean-up performance of the groundwater remediation system. The compliance wells are located within the VOC plume and are sampled semi-annually for the parameters-of-concern.

The sentinel wells are intended to confirm on-site containment of the VOC plume within an area designated for exposure control. The wells are located outside of

the VOC plume along the downgradient perimeter of the site and sampled quarterly for the parameters-of-concern. At the request of the MDEQ, monitoring well MW-37 has been included with the sentinel wells. Sentinel well MW-37 is located within the known VOC plume. The contingency plan addresses evaluation of future monitoring data at this well consistent with Section 5.4 of this report. Please note that sentinel and compliance wells P-15, P-20, P-22, P-25, P-25d, P-30, MW-18, and MW-30 are sampled for the zinc, boron, and sodium in addition to the other parameters-of-concern.

The sentinel wells include five wells screened in the shallow aquifer and six wells screened in the deep aquifer. All deep wells are screened across the same stratigraphic horizon known to be impacted by VOCs. The deep sentinel wells monitor the clean-line downgradient from the VOC plume in the deep aquifer. Similarly, the shallow wells monitor the clean-line downgradient from the VOC plume in the shallow aquifer. VOC contaminants in the deep aquifer have not been detected north or east of deep wells MW-36d and MW-37. The VOC clean line in the shallow aquifer is approximately 900 feet downgradient from the landfill between well MW-35s and MW-36s. VOC contaminants have never been confirmed in the shallow aquifer at monitoring well MW-36s. Monitoring well MW-36s is a sentinel well for the Remedial Action Plan monitoring program.

An on-site restricted area for groundwater use is proposed for the area impacted by the VOC plume. Conditions within the VOC plume will be monitored by the compliance wells and conditions along the downgradient perimeter of the site, outside of the VOC plume, will be monitored by sentinel wells. Monitoring data collected at the sentinel wells will identify potential VOC impacts before they migrate off-site and confirm that impacted groundwater located beneath the on-site restricted area does not present any future risk to public health, safety, or welfare, or the environment.

All monitoring wells at the site will remain visible throughout the year. The MDEQ will be notified prior to undertaking well repair, replacement, plugging or abandonment.

Upon the conclusion of all response activities requiring the use of groundwater wells detailed in this Remedial Action Plan, including operation and maintenance and long-term monitoring, Central Sanitary Landfill will provide notice to and obtain approval from the MDEQ for the proper plugging and abandonment or removal of all remaining wells and other remedial activity related devices at or related to the site. Upon receipt of MDEQ's approval, Central Sanitary Landfill will use the proper well abandonment procedures as described in ASTM Standard 5299-92 (Standard Guide for Decommissioning Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other

Devices for Environmental Activities), or other relevant or applicable standards that are in effect at the time the wells or devices are abandoned or removed.

5.2 GROUNDWATER SAMPLING AND ANALYTICAL PROGRAM

The sampling and analytical program was prepared consistent with the requirements of Part 115 and is provided in the site's HMP. In addition to the detection monitoring sampling program, the Remedial Action Plan compliance wells will be sampled semi-annually for the parameters-of-concern and the sentinel wells will be sampled quarterly for the parameters-of-concern. The parameters-of-concern are listed in Section 3.

During each sampling event, one independent sample will be collected from each of the designated monitoring wells. Well purging and groundwater sampling will be conducted using a submersible sampling pump, peristaltic pump, or disposable polyethylene bailers. Prior to initiation of groundwater purging and sampling activities, depth to water and water level elevation (feet above mean sea level) will be recorded to the nearest hundredth of a foot. The water level measurements will be used to prepare a groundwater contour map, determine groundwater flow direction, and calculate groundwater gradient at the site. The groundwater flow rate calculation and flow direction determined for each sampling event will be provided with the sampling report.

Laboratory methods used to generate all groundwater analytical data, including detection limits, are provided in the HMP. Analytical results for groundwater monitoring will be submitted to the MDEQ not more than 30 days after the end of the calendar quarter. An annual summary report for the Remedial Action Plan will be submitted with the fourth quarter monitoring results. The annual report will include a summary of the analytical results, observed trends associated with the parameters-of-concern, isoconcentration maps for the parameters-of-concern, and contaminant migration estimates. The following laboratory has been responsible for providing the groundwater analytical results for the landfill monitoring program and remedial investigation.

Heritage Environmental Services, LLC
7901 West Morris Street
Indianapolis, Indiana 46231

The groundwater analytical results for the quarterly monitoring program will be submitted to the MDEQ within 30 days after the end of each quarter.

5.3 CLEAN-UP REQUIREMENTS

The groundwater protection standards (GWPS) are as follows:

- For constituents that have a maximum contaminant level (MCL) promulgated under Section 1412 of the Safe Drinking Act under 40 CFR part 141; the lowest of the following:
    - the MCL for that constituent,
    - the generic residential clean-up criteria developed pursuant to Part 201 of the Natural Resources Environmental Protection, P.A. 451 of 1994, as amended (Part 201).
- For constituents for which MCLs have not been promulgated, the Part 201 clean-up criteria; and
- For constituents for which the background level is higher than the MCL or the Part 201 clean-up criteria, or for constituents for which MCLs and Part 201 clean-up criteria do not exist; the background concentration.

5.4 CONTINGENCY IF SENTINEL WELLS EXCEED CLEAN-UP CRITERIA

Sentinel wells are not expected to be impacted, however the following contingency plan has been developed in the event that GWPS for inorganics or VOCs are exceeded at a sentinel well.

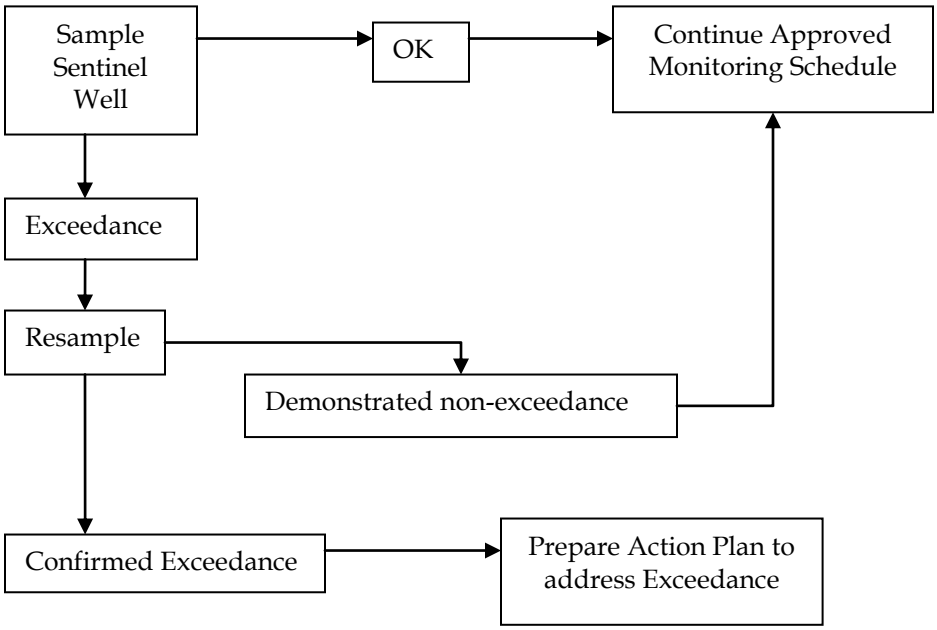
The U.S. EPA Unified Statistical Guidance (March 2009) recommends the use of confidence limits to compare site data to GWPS (see Chapter 21). In addition, the U.S. EPA recommends the use of Lower Confidence Limits (LCLs) in compliance monitoring (sentinel) wells. If the LCL exceeds the GWPS, a clear exceedance can be identified. Data from each sampling event will be compared to the GWPS. If groundwater analytical results indicate concentrations of inorganics or VOCs above the GWPS in a sentinel well, the MDEQ will be notified in the quarterly report and the LCL will be calculated using the eight most recent data points for that well/parameter. If the resample confirms the LCL exceedance after two consecutive quarterly events (initial event and resample event), the MDEQ will be notified to discuss possible additional actions and the Remedial Action Plan will be re-evaluated for compliance with Part 201.

In addition, the quarterly reports will identify possible significant increasing or decreasing trends for inorganics detected at the sentinel wells. Time series plots

will be generated to illustrate concentrations trends if there are data above the detection limit.

A plan of action will be provided to the MDEQ following an exceedance confirmation. Possible actions include sampling nearby existing monitoring wells or purge wells, drilling additional borings and collecting groundwater samples to refine the extent of exceedances of standards. The necessity of additional wells will be determined after collecting and reviewing data. If necessary, a replacement well will be installed or an additional sentinel well will be installed downgradient from the impacted well. Monitoring of the new well would occur on a schedule similar to that proposed for the existing sentinel wells to verify groundwater conditions. The area designated for exposure control will be extended, as needed, to keep impacted groundwater within an area covered by restricted groundwater use. A flow chart illustrating this sequence of events is provided below.

Sentinel Well Sampling Flow Chart

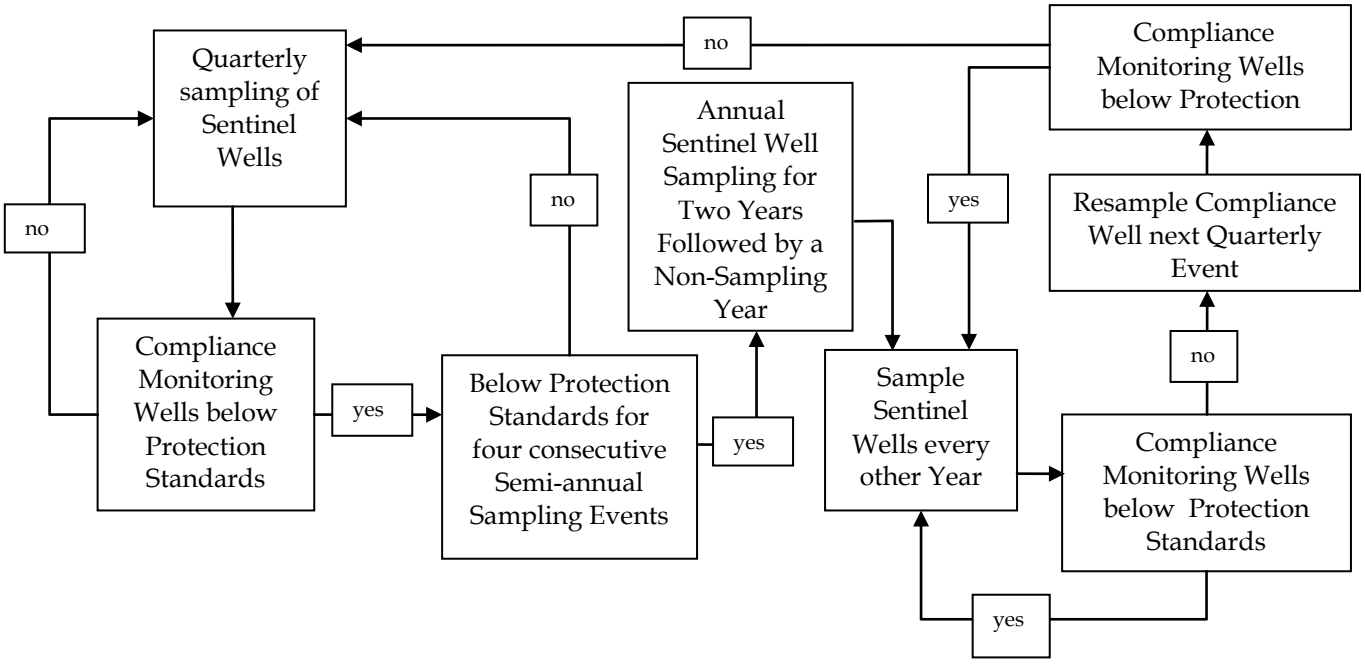


5.5 CRITERIA FOR REDUCING GROUNDWATER MONITORING

Groundwater monitoring will continue at the detection monitoring wells identified in Section 5.1 as required by Part 115 regulations and the site's approved Hydrogeological Monitoring Program. Consistent with similar Remedial Action Plans approved by the MDEQ, the sentinel wells will continue to be sampled quarterly until VOC levels in all on-site compliance wells remain

below groundwater protection standards for four consecutive semi-annual sampling events. Groundwater sampling at the sentinel wells will then be sampled annually for two consecutive years and then biannually (once every other year starting with the non-sampling year). If following a reduction in frequency for the sentinel wells, a parameter-of-concern exceeds its groundwater protection standard at a compliance monitoring well, the compliance well will be resampled during the next quarterly event. If the exceedance is not confirmed at the compliance well, the sentinel wells will continue to be sampled at the reduced frequency (biannually). If the exceedance is confirmed at the compliance monitoring well, the sentinel wells will return to quarterly sampling until contaminant concentrations again remain below the groundwater protection standards for four consecutive semi-annual sampling events at the compliance monitoring wells.

Sentinel Well Sampling Flow Chart for Reduced Monitoring



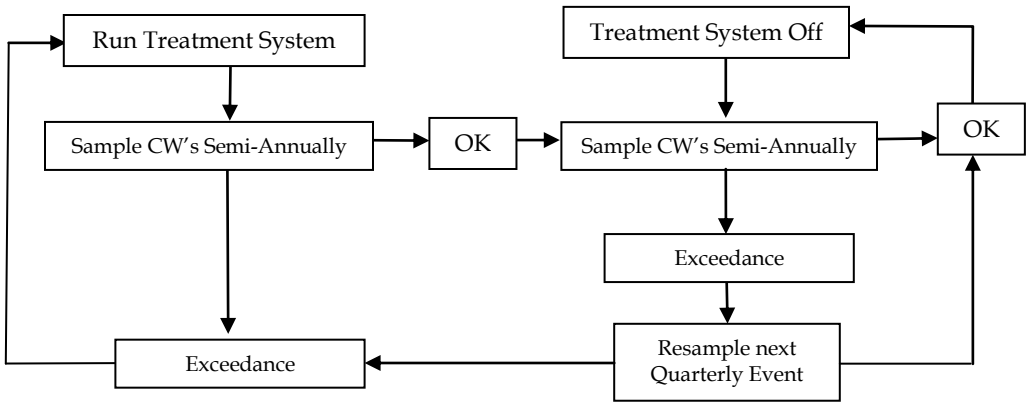
Groundwater remedial activities include pumping groundwater at purge wells PW-5, PW-6, and PW-7R and treatment with an air-stripper. Groundwater conditions within the VOC plume will be monitored on a semi-annually basis by compliance wells MW-30, MW-5, MW-36d, MW-10N, MW-37, MW-14B, and MW-18.

Remedial operations will continue until groundwater analytical results indicate concentrations of VOCs are below the groundwater protection standard (Section

5.3) at all compliance wells for two consecutive semi-annual sampling events. After two consecutive semi-annual sampling events where all VOCs are below their groundwater protection standards in all compliance wells, the system will be "turned-off". Please note that the perimeter sentinel wells will continue to be sampled for the parameters-of-concern.

The compliance wells will be sampled on a semi-annual basis when the groundwater pumping/treatment system is "off" unless an exceedance of the groundwater protection standards occurs. In the event of an exceedance, the well will be resampled for the VOC exceeding the limit during the next quarterly event. If the resample results are below the protection standards, the system will remain "off" and all the compliance wells will continue to be sampled on a semi-annual basis. If the resample confirms a VOC exceedance, the system will be "turned-on" and all the compliance monitoring wells will continue to be sampled on a semi-annual basis. The system will remain "on" until detectable levels of all VOCs are below the groundwater protection standards at all compliance wells for two consecutive sampling events. A flow chart illustrating this sequence of events is provided below.

Remedial Action Plan – System Operation Flow Chart



As illustrated above, well sampling and treatment system operations will continue as required until all the obligations of the Remedial Action Plan are met. The MDEQ will be notified of all confirmed exceedences and changes to the treatment system operating status.

6.0 OPERATION AND MAINTENANCE

The VOC plume is contained and treated by the groundwater remediation system which is considered the primary remedial activity at the site. In addition, natural biodegradation has contributed to the remedial process. A primary component of the Remedial Action Plan is long-term groundwater monitoring. Groundwater conditions are monitored by compliance wells, sentinel wells, and detection monitoring wells. An on-site restricted area for groundwater use is proposed for the area impacted by the VOC plume (Appendix A). Conditions within the VOC plume will be monitored by the compliance wells and conditions along the downgradient perimeter of the site, outside of the VOC plume, will be monitored by sentinel wells. The area designated for restricted groundwater use will be monitored consistent with the sampling and analytical plan contained in Section 5.0. Long-term monitoring and maintenance of the existing and future landfill liners and caps will be conducted consistent with Part 115 requirements as specified in the site's Operations Plan and Post-Closure Plan. Maintenance activities for the closed landfill areas will continue for as long as the Remedial Action Plan is effective.

Operation and maintenance of the remediation equipment will be required to assure efficient groundwater purging and VOC removal. Existing purge wells PW-5R, PW-6, and PW-7R are recommended to operate at between 20 and 30 gpm. See Figure 14 of the Groundwater Model Report (Appendix D). As requested by the MDEQ, groundwater levels will be measured at the purge wells on a schedule to verify proper drawdown. All groundwater measurements will be presented in the quarterly monitoring reports and included with the groundwater contour map. The primary means of determining groundwater capture will be through maintaining specific pumping rates at the purge wells. The pumping rate will be monitored weekly to assure proper flow is being maintained. A schedule for operating and maintaining the purge wells is provided in the Operation and Maintenance Plan (Appendix H).

The groundwater treatment system will be maintained in accordance with the Operation and Maintenance Manual (Appendix H). All components of the groundwater remediation system and monitoring program are in-place or will be upgraded to meet the requirements of the RAP.

The use of surface water and groundwater for drinking water is restricted at the site. As part of the remedial action, permanent markers will be placed at the site to show the area of restricted groundwater use. The markers are intended as a notice to prevent drinking contaminated or aesthetically affected groundwater. One permanent marker will be placed at the site's primary vehicle entrance (21545 Cannonsville Road, Pierson, Michigan) at a clear point of entry for a

person who might undertake prohibited activities. A second will be placed along Schoolfield Drive at the intersection of Amy School Road at a clear point of entry. The markers will be inspected and maintained, as needed, to keep them free of vegetation and clearly visible. The markers will be a rock monolith or similar structure with text and a line drawing presented on an attached weather resistant plaque. The inscription will describe the restricted area and the nature of the restrictions. The proposed inscription is provided in Appendix A. These restrictions prohibit excavation, filling, grading, drilling, or other activities that could affect the integrity of any final cover or leachate removal and gas collection systems within the restricted area. The marker will show the property boundary, engineered containment structures (landfill), scale, adjacent roads, and reader's location relative to the site.

A financial assurance mechanism presented in this report (Section 8), guarantees the continued operation and maintenance of the groundwater remediation system and Remedial Action Plan monitoring program. The financial assurance mechanism also includes the one time cost of abandoning the Remedial Action Plan monitoring wells.

7.0 SCHEDULE FOR REMEDIAL ACTION PLAN IMPLEMENTATION

In accordance with Act 451 Part 201 Rule 299.5605, and prior to implementation of this Remedial Action Plan, Central Sanitary Landfill will cooperate with the MDEQ to provide the required public notices, review and comment period, as necessary. The approved Remedial Action Plan is intended to replace the Consent Judgment dated October 18, 1990, and the Interim Remedial Action Plan dated March 15, 1996.

The primary components of the Remedial Action Plan are source removal (completed), active groundwater remediation, on-site deed restrictions for groundwater use, and long-term groundwater monitoring. The source area of groundwater contamination (Pierson Township Dump) was removed and capped in 1992. All components of the groundwater remediation system and monitoring network have been installed or will be installed as part of this Remedial Action Plan. The Remedial Action Plan monitoring program was implemented in 2003 and has been updated during the on-going remedial investigations.

Central Sanitary Landfill may request that the MDEQ consider a modification to the Remedial Action Plan by submitting a request for modification that provides sufficient detail as to the modification requested and provides justification for the modification to the MDEQ for review and approval. Any request for modification will be forwarded to the MDEQ 30 days prior to the date that the performance of any affected response activity is due. Upon MDEQ approval, Central Sanitary Landfill will perform the remedial activities that are provided for in the modification in accordance with MDEQ-approved implementation schedule.

The Remedial Action Plan will only be modified by written agreement between Central Sanitary Landfill and the MDEQ.

8.0 FINANCIAL ASSURANCE

Central Sanitary Landfill will provide and maintain a financial assurance mechanism (FAM) (Appendix A) acceptable to the MDEQ to assure the performance of long-term Remedial Action Plan costs. The long-term Remedial Action Plan costs have been documented (Table 1) based on an annual estimated maximum cost for remedial activities as if they were to be conducted by a person under contract to the State. Long-term Remedial Action Plan costs were not based on remedial activities being conducted by employees of Central Sanitary Landfill.

The FAM is intended to be in an amount sufficient to cover long-term Remedial Action Plan costs at the landfill site for a 30-year period and will be in a form that allows the MDEQ to immediately contract for the response activities for which financial assurance is required in the event Central Sanitary Landfill fails to implement the required tasks. The existing estimated financial assurance to fund 30 years of groundwater remedial activities is provided in Appendix A. An estimated financial assurance consistent with the remedial activities proposed under this Remedial Action Plan is provided in Table 1. The existing FAM is intended to be modified to meet the financial requirements of the remedial activities proposed in this Remedial Action Plan.

9.0 REFERENCES

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