



2008 ANNUAL MONITORING REPORT

HIGHWAY 96 SITE WHITE BEAR TOWNSHIP, MINNESOTA

DISCLAIMER:

SOME FORMATTING CHANGES MAY HAVE OCCURRED WHEN
THE ORIGINAL DOCUMENT WAS PRINTED TO PDF; HOWEVER,
THE ORIGINAL CONTENT REMAINS UNCHANGED.

**REVISED JUNE 2009
REF. NO. 002012 (58)**

**Prepared by:
Conestoga-Rovers
& Associates**

1801 Old Highway 8 NW
Suite #114
Saint Paul, Minnesota 55112

Office: (651) 639-0913
Fax: (651) 639-0923

web: <http://www.CRAworld.com>

TABLE OF CONTENTS

| | <u>Page</u> |
|--|-------------|
| 1.0 INTRODUCTION | 1 |
| 1.1 SITE DESCRIPTION | 1 |
| 1.2 PROJECT BACKGROUND | 1 |
| 1.3 REMEDIAL ACTIONS | 2 |
| 1.3.1 SOURCE CONTROL OPERABLE UNIT | 3 |
| 1.3.2 RESIDENTIAL WATER SUPPLY OPERABLE UNIT | 4 |
| 1.3.3 GROUNDWATER OPERABLE UNIT | 4 |
| 1.3.3.1 GROUNDWATER EXTRACTION SYSTEM | 4 |
| 1.3.3.2 GROUNDWATER MONITORING PROGRAM | 5 |
| 1.4 RECENT ACTIVITIES | 6 |
| 2.0 SCOPE OF THE 2008 ANNUAL MONITORING REPORT | 9 |
| 3.0 HYDROGEOLOGIC UPDATE | 10 |
| 3.1 GEOLOGY | 10 |
| 3.2 HYDROGEOLOGY | 11 |
| 3.3 EW1A/EW2 PERFORMANCE ASSESSMENT | 13 |
| 3.4 DEWATERING SUMP PERFORMANCE ASSESSMENT | 15 |
| 3.5 ASSESSMENT OF POTENTIAL EFFECTS FROM ST. PAUL REGIONAL WATER SERVICE (SPRWS) SUPPLY WELLS | 15 |
| 4.0 GROUNDWATER ASSESSMENT | 18 |
| 4.1 HISTORICAL OVERVIEW OF GROUNDWATER DATA | 19 |
| 4.2 2008 DATA PRESENTATION | 21 |
| 4.2.1 PERCHED GROUNDWATER UNIT | 22 |
| 4.2.2 LOWER SAND AQUIFER | 22 |
| 4.2.3 ST. PETER SANDSTONE AQUIFER | 23 |
| 4.2.4 PRAIRIE DU CHIEN AQUIFER | 25 |
| 4.2.5 RESIDENTIAL WELLS | 25 |
| 4.2.5.1 STATUS OF MDH HRL RULE REVISION FOR VINYL CHLORIDE | 26 |
| 4.2.5.2 NEW RESIDENTIAL WELL INSTALLATIONS | 27 |
| 5.0 GAS PROBE MONITORING | 29 |
| 6.0 SOIL CAP INSPECTIONS | 31 |
| 7.0 CONCLUSIONS | 32 |
| 8.0 RECOMMENDATIONS | 33 |

LIST OF FIGURES
(Following Report)

| | |
|-------------|---|
| FIGURE 1.1 | SITE LOCATION |
| FIGURE 1.2 | SITE PLAN |
| FIGURE 1.3 | GAS VENT LOCATIONS- NORTH DISPOSAL AREA |
| FIGURE 1.4 | MUNICIPAL WATER SYSTEM |
| FIGURE 1.5 | OFF-SITE GROUNDWATER MONITORING NETWORK |
| FIGURE 3.1 | LOCATION OF CROSS SECTIONS |
| FIGURE 3.2 | PERCHED GROUNDWATER ELEVATIONS (OCTOBER 2008) |
| FIGURE 3.3 | LOWER SAND/ ST. PETER SANDSTONE AQUIFER GROUNDWATER ELEVATIONS (OCTOBER 2008) |
| FIGURE 3.4 | UPPER ST. PETER SANDSTONE AQUIFER GROUNDWATER ELEVATIONS (OCTOBER 2008) |
| FIGURE 3.5 | BASAL ST. PETER SANDSTONE AQUIFER GROUNDWATER ELEVATIONS (OCTOBER 2008) |
| FIGURE 3.6 | POUNDS OF TOTAL VOCs (TVOCS) REMOVED |
| FIGURE 3.7 | VOC REMOVAL EFFICIENCY |
| FIGURE 3.8 | TOTAL VOC CONCENTRATIONS - EW1/EW1A/EW2 |
| FIGURE 3.9 | TOTAL VOC CONCENTRATIONS 7 ROBB FARM ROAD |
| FIGURE 3.10 | CROSS SECTION - GROUNDWATER EXTRACTION SYSTEM (OCTOBER 2008) |
| FIGURE 4.1 | TOTAL VOC CONCENTRATIONS - LW3 |
| FIGURE 4.2 | TOTAL VOC CONCENTRATIONS - MW4D |
| FIGURE 4.3 | TOTAL VOC CONCENTRATIONS - MW12D |
| FIGURE 4.4 | TOTAL VOC CONCENTRATIONS - MW8B |

LIST OF FIGURES (CONT'D)
(Following Report)

| | |
|-------------|---|
| FIGURE 4.5 | TOTAL VOC CONCENTRATIONS - MW12B |
| FIGURE 4.6 | TOTAL VOC CONCENTRATIONS - 11 ROBB FARM ROAD |
| FIGURE 4.7 | TOTAL VOC CONCENTRATIONS - 1 LILY POND ROAD |
| FIGURE 4.8 | TOTAL VOC CONCENTRATIONS - 11 LILY POND ROAD |
| FIGURE 4.9 | TOTAL VOC CONCENTRATIONS - 6 BLUE GOOSE ROAD |
| FIGURE 4.10 | TVOCS IN PERCHED GROUNDWATER (OCTOBER 2008) |
| FIGURE 4.11 | TVOCS IN LOWER SAND AQUIFER (OCTOBER 2008) |
| FIGURE 4.12 | TVOCS IN ST PETER SANDSTONE AQUIFER (OCTOBER 2008)- ON-SITE MONITORING WELL LOCATIONS |
| FIGURE 4.13 | TVOCS IN ST PETER SANDSTONE AQUIFER (OCTOBER 2008)- OFF-SITE MONITORING WELL LOCATIONS |
| FIGURE 4.14 | TVOCS IN PRAIRIE DU CHIEN AQUIFER (OCTOBER 2008)- OFF-SITE MONITORING WELL LOCATIONS |
| FIGURE 4.15 | MAXIMUM TVOC CONCENTRATIONS IN RESIDENTIAL WELLS (2008) |
| FIGURE 4.16 | MAXIMUM VINYL CHLORIDE CONCENTRATIONS IN RESIDENTIAL WELLS (2008) |
| FIGURE 5.1 | GAS PROBE LOCATIONS- NORTH DISPOSAL AREA |
| FIGURE 5.2 | % COMBUSTIBLE GAS CONCENTRATIONS - GP1 |
| FIGURE 5.3 | % COMBUSTIBLE GAS CONCENTRATIONS - GP2 |
| FIGURE 5.4 | % COMBUSTIBLE GAS CONCENTRATIONS - GP3 |
| FIGURE 5.5 | % COMBUSTIBLE GAS CONCENTRATIONS - GP4 |

LIST OF FIGURES (CONT'D)
(Following Report)

- FIGURE 5.6 % COMBUSTIBLE GAS CONCENTRATIONS - GP5
- FIGURE 5.7 % COMBUSTIBLE GAS CONCENTRATIONS - GP6
- FIGURE 5.8 MEH GAS MONITORING LOCATIONS -
NORTH DISPOSAL AREA

LIST OF TABLES
(Following Report)

| | |
|-----------|---|
| TABLE 3.1 | GROUNDWATER ELEVATIONS (JANUARY 2008 - DECEMBER 2008) |
| TABLE 3.2 | OPERATION AND MAINTENANCE ACTIVITY -GROUNDWATER EXTRACTION SYSTEM (JANUARY 2008 - DECEMBER 2008) |
| TABLE 3.3 | 2008 AVERAGE MONTHLY GROUNDWATER EXTRACTION RATES |
| TABLE 4.1 | HISTORICAL GROUNDWATER SAMPLING EVENT SUMMARY |
| TABLE 4.2 | 2008 GROUNDWATER DATA DETECTIONS- PERCHED GROUNDWATER UNIT |
| TABLE 4.3 | 2008 GROUNDWATER DATA DETECTIONS- LOWER SAND AQUIFER |
| TABLE 4.4 | 2008 GROUNDWATER DATA DETECTIONS- ST. PETER SANDSTONE AQUIFER |
| TABLE 4.5 | 2008 GROUNDWATER DATA DETECTIONS- PRAIRIE DU CHIEN AQUIFER |
| TABLE 4.6 | 2008 GROUNDWATER DATA DETECTIONS - RESIDENTIAL WELLS |
| TABLE 5.1 | HISTORICAL MSA GAS PROBE MONITORING RESULTS |
| TABLE 5.2 | LANDTEC GEM 500 GAS PROBE MONITORING RESULTS |

LIST OF APPENDICES

| | |
|------------|---|
| APPENDIX A | GEOLOGIC CROSS SECTIONS' |
| APPENDIX B | HISTORICAL SUMMARY OF GROUNDWATER ELEVATIONS |
| APPENDIX C | ANNUAL MONITORING WELL SAMPLING TECHNICAL MEMO |
| APPENDIX D | HISTORICAL DATA SUMMARY |
| APPENDIX E | LABORATORY ANALYTICAL REPORTS AND DATA QUALITY ASSESSMENT AND VALIDATION MEMOS |

1.0 INTRODUCTION

This report presents the results of the 2008 groundwater sampling program conducted at the Highway 96 Site (Site) pursuant to the requirements of the Response Action Plan (RAP), dated January 1994, as amended and referenced in the Consent Order.

This report covers the monitoring period from January 1, 2008 to December 31, 2008.

1.1 SITE DESCRIPTION

The Site is located in White Bear Township, Minnesota. The Site location is shown on Figure 1.1. The Site operated as a local disposal area from the 1920s until 1973. Primarily residential wastes were received and burned at the Site. Some drummed wastes were disposed at the Site in the late 1960s and early 1970s. The Site was comprised of two disposal areas, the North and South Disposal Areas, which encompassed 4.5 and 1.5 acres, respectively. A Site Plan is presented on Figure 1.2.

1.2 PROJECT BACKGROUND

In 1986, a study was conducted at the Site by the United States Environmental Protection Agency (USEPA), which identified groundwater contamination by volatile organic compounds (VOCs). The Minnesota Pollution Control Agency (MPCA) subsequently issued a Request for Response Action (RFRA) to three potentially responsible parties (PRPs): Whirlpool Corporation (Whirlpool), Reynolds Metals Company (Reynolds) and Red Arrow Waste Disposal Services. Conestoga-Rovers and Associates (CRA) was retained by Reynolds and Whirlpool in 1986 to assist with the implementation of the RFRA.

On behalf of Reynolds and Whirlpool, CRA conducted a Remedial Investigation and Feasibility Study (RI/FS). The RI involved a review of the waste disposal history, installation of monitoring wells, excavation of test pits within the waste and groundwater monitoring in monitoring wells and nearby residential wells. The results of the RI were submitted to the MPCA in March 1988 (Ref. 1).

In response to the confirmation of groundwater contamination at the Site, Whirlpool and Reynolds proposed an Interim Response Action Plan (IRAP) (Ref. 1) involving the removal of drums found during the investigation and the installation of a groundwater extraction system.

In May 1988, the MPCA approved the RI and IRAP.

The FS involved the evaluation of remedial alternatives, which were presented in the Alternatives Analysis Report (Ref. 2), and were submitted to the MPCA in October 1988. The MPCA approved the Alternative Analysis Report in February 1989. Whirlpool and Reynolds continued with the FS by evaluating potential remedial alternatives. A Detailed Analysis Report (DAR) was submitted to the MPCA in April 1989 (Ref. 3). This evaluation included a proposed remedial plan for the Site. The MPCA did not comment on the DAR until June 1992, and approved the DAR with modifications in June 1994.

In 1993, Reynolds and Whirlpool conducted a groundwater investigation in North Oaks, Minnesota. The groundwater investigation provided a general definition of the groundwater flow system in the vicinity of the Site and the southeast portion of North Oaks. This investigation also delineated the extent of a remnant VOC plume. Vinyl chloride was the only VOC to exceed the Recommended Allowable Limit (RAL). The North Oaks Southeast Groundwater Investigation report was submitted to the MPCA in October 1993 (Ref. 4).

In January 1994, Whirlpool and Reynolds submitted the Phase I Response Action Plan (Ref. 5) to the MPCA. The Phase I Response Action Plan (Phase I RAP) outlined the activities required for the implementation of the final remedy at the Site. The MPCA approved the Phase I RAP with modifications by letter, dated March 1, 1994.

In May 1994, Whirlpool and Reynolds submitted the Phase II Response Action Plan (Ref. 6) to the MPCA. The Phase II Response Action Plan (Phase II RAP) provided additional construction details on the Phase I RAP and provided details on the installation of a dewatering sump and gas probes. The MPCA approved the Phase II RAP, with modifications by letter, dated October 3, 1994.

1.3 REMEDIAL ACTIONS

As a parallel activity to the RI/FS, interim remedial actions have been implemented by Whirlpool and Reynolds. These actions have included drum removal, groundwater extraction system installation, North Oaks groundwater investigation, and South Disposal Area investigation. The final remedy for the Site is divided into three operable units: Source Control Operable Unit, Residential Water Supply Operable Unit, and Groundwater Operable Unit.

1.3.1 SOURCE CONTROL OPERABLE UNIT

During 1987 and 1988, contractors for the responsible parties removed drums containing hazardous substances from the North Disposal Area (NDA). In 1993, additional drums were removed from the South Disposal Area (SDA). In 1994, waste from the NDA and SDA were screened using a backhoe to look for any remaining drums. Drums and drum-related waste identified during the screening process were removed and transported off-site for disposal. The contractors also drained the pond located within the NDA. All the pond water was discharged to the sanitary sewer, the sediment and material from the pond bottom were screened, and drums of waste were removed. The drums were disposed at licensed facilities in the fall of 1995.

After screening the NDA and the pond, the contractors transferred all waste material from the SDA to the NDA. Tests of the soils underlying the SDA showed no residual contamination, and the SDA was backfilled with clean soil. The results of the SDA investigation were submitted to MPCA in January 1994 (Ref. 7). All waste material at the NDA, including the waste material transferred from the SDA, was compacted, graded, and capped with two feet (ft.) of clean soil and remains on the property. Since the waste areas were combined, the NDA has been referred to as the Consolidated Waste Area (CWA).

In the spring of 1995, a total of six gas probes were installed in the CWA for methane monitoring, in accordance with the Post Closure Operation and Maintenance Plan (O&M Plan) (Ref. 8). The installation and gas probe monitoring conducted in 1995 are discussed in further detail in the Remedial Action Final Report (Ref. 9).

The Source Control Operable Unit remedy was completed in the fall of 1995 and is discussed in further detail in the Remedial Action Final Report (Ref. 9).

In response to the MPCA's comments to the Remedial Action Final Report, three passive methane vents were installed in the North Disposal Area in November of 1996 as shown in Figure 1.3. The vents were screened across the entire thickness of the unsaturated waste to allow for future drawdown due to the operation of the dewatering sump.

1.3.2 RESIDENTIAL WATER SUPPLY OPERABLE UNIT

In 1993, the MDH issued drinking water well advisories to 12 homes in North Oaks between the Site and Gilfillan Lake, because vinyl chloride had been detected in their wells at levels exceeding the health-based risk level that was in place in 1993. Reynolds and Whirlpool chose to address this off-site contamination by connecting all 60 homes with private wells on the east side of the lake to the White Bear Township municipal water system. These connections were completed in 1994. Figure 1.4 shows the area serviced by municipal water.

1.3.3 GROUNDWATER OPERABLE UNIT

The Groundwater Operable Unit began as an interim remedial action and consists of continued operation of the groundwater extraction system and groundwater monitoring.

1.3.3.1 GROUNDWATER EXTRACTION SYSTEM

Groundwater contamination is present beneath the CWA and has migrated to the west, in the direction of groundwater flow. Since June 1989, a groundwater extraction system has been in operation at the site. The extraction system collects groundwater from Lower Sand aquifer and St. Peter Sandstone aquifer, and it has been effective in limiting the spread of contamination and in removing contaminants from the groundwater since its inception. The contaminated groundwater is discharged to the sanitary sewer for treatment.

In late 1994, after the consolidation of the NDA and SDA, a dewatering sump was installed directly into and under the CWA. Its purpose is to collect the leachate and to discharge the leachate to the sanitary sewer. Leachate is produced when rain and melting snow filter through the waste and dissolve chemicals from the waste. The responsible parties will continue to operate the dewatering sump to reduce the potential for degradation of the groundwater in the deeper, drinking-water aquifers.

1.3.3.2 GROUNDWATER MONITORING PROGRAM

Monitoring at the Highway 96 Site

The on-site groundwater-monitoring network includes 13 monitoring wells and 3 extraction wells screened in the perched groundwater, the unconsolidated glacial drift aquifer (Lower Sand aquifer), and the St. Peter Sandstone aquifer.

Groundwater samples are collected from on-site extraction wells on a monthly basis and from monitoring wells on an annual basis. Six of the 16 on-site monitoring wells are designated as compliance wells and are used to evaluate the effectiveness of the groundwater extraction system.

Monitoring in North Oaks - East of Gilfillan Lake

The off-Site groundwater-monitoring network east of Gilfillan Lake includes residential wells, former residential wells that have been converted into monitoring wells, and other monitoring wells that have been installed by the responsible parties. The off-Site groundwater monitoring network east of Gilfillan Lake is shown on Figure 1.5.

Twenty residential wells located outside the municipal water service area, east of Gilfillan Lake, have been monitored by Whirlpool/Reynolds and the MPCA on a regular basis since 1993. These residential well locations continue to be monitored on a routine basis.

Five former residential wells located east of Gilfillan Lake were converted to monitoring wells following installation of the municipal water system in 1994. The five converted residential monitoring wells are located at 6 Blue Goose Road, 1 Lily Pond Road, 11 Lily Pond Road, 11 Robb Farm Road, and 6 Wren Lane. The converted residential monitoring well at 6 Wren Lane was abandoned in May 2000, at the request of the property owner (and under MPCA approval). The other four converted residential monitoring wells remain in place and are monitored on an annual basis.

Nine monitoring wells have been installed east of Gilfillan Lake to monitor groundwater conditions downgradient from the Highway 96 Site in the Glacial Drift/Lower Sand, St. Peter Sandstone, and Prairie du Chien aquifers. Groundwater samples are collected from these monitoring wells on an annual basis. Six of these monitoring wells are also designated as compliance wells and are used to evaluate the effectiveness of the groundwater extraction system.

Monitoring in North Oaks - West of Gilfillan Lake

The off-Site groundwater-monitoring network west of Gilfillan Lake includes residential wells and other monitoring wells that have been installed by the responsible parties. The off-Site groundwater monitoring network west of Gilfillan Lake is shown on Figure 1.5.

From 1993 to 2004, Whirlpool/Reynolds and the MPCA monitored 31 residential wells located west of Gilfillan Lake on a regular basis. In 2005, the residential well monitoring network west of Gilfillan Lake was expanded to include an additional 31 residential well locations. The current residential well monitoring network west of Gilfillan Lake includes 62 residential wells. These residential well locations continue to be monitored on a routine basis.

Eight monitoring wells and one test extraction well have been installed west of Gilfillan Lake to monitor groundwater conditions downgradient from the Highway 96 Site in the St. Peter Sandstone and Prairie du Chien aquifers. Groundwater samples are collected from these monitoring wells on an annual basis.

1.4 RECENT ACTIVITIES

In October 2004, during routine monitoring of residential wells in North Oaks, low levels of vinyl chloride were detected in water samples collected from two residential well locations (12 West Shore Road and 13 West Shore Road). Subsequent residential well sampling during the period from January 2005 through October 2008 of over 80 residential wells located in the southeast portion of North Oaks has shown that vinyl chloride contamination in North Oaks is limited to four residential wells (12 West Shore Road, 13 West Shore Road, 15 West Shore Road, and 2 Hummingbird Hill) located near the west shore of Gilfillan Lake.

Since October 2004, Reynolds and Whirlpool have conducted extensive studies, under the supervision of the Minnesota Pollution Control Agency (MPCA), to investigate the nature and extent of volatile organic compound (VOC) contamination in residential wells located west of Gilfillan Lake. These studies included:

- 15 rounds of residential well sampling;
- installation of 13 new monitoring wells in North Oaks;
- vertical aquifer profiling (VAP) to provide vertical delineation of groundwater quality;

- installation of a test extraction well west of Gilfillan Lake in the Ski Lane Ravine;
- a subsurface geophysical survey of Gilfillan Lake; and
- continued monitoring at existing wells in North Oaks and at the Highway 96 Site in White Bear Township.

CRA has submitted various reports to MPCA, which present the results of the studies listed above (Ref. 10, Ref. 11, Ref. 12, and Ref. 13).

During this reporting period, two new upper St. Peter Sandstone aquifer monitoring wells (MW-19A and MW-21A) were installed in the Ski Lane Ravine (August 2008). Monitoring well installation was conducted in accordance with CRA's Work Plan dated September 25, 2007, which was approved by the Minnesota Pollution Control Agency (MPCA), with modifications, on October 11, 2007. A Completion Report associated with the August 2008 monitoring well installation activities was submitted to MPCA on December 30, 2008 (Ref. 14)

In June 2007, the MPCA requested that Reynolds and Whirlpool complete a Feasibility Study (FS) to evaluate potential response actions for vinyl chloride contaminated groundwater on the west side of Gilfillan Lake. The MPCA requested that Reynolds and Whirlpool evaluate the following remedial alternatives, under the following two scenarios:

MPCA Scenario A *(where there are no HRL exceedances at any residential well):*

- Alternative A1 - No further action
- Alternative A2 - Long term monitoring
- Alternative A3 - Groundwater extraction and monitoring

MPCA Scenario B *(where there are HRL exceedances at residential wells):*

- Alternative B1 - No further action
- Alternative B2 - Residential carbon filter and monitoring
- Alternative B3 - New/Deeper residential well and monitoring
- Alternative B4 - Municipal water and monitoring

In July 2007, on behalf of Reynolds and Whirlpool, CRA submitted the FS Report (Ref. 15) to MPCA. In September 2007, MPCA provided comments on the FS Report to

CRA. In October 2007, CRA provided responses to MPCA's comments on the FS Report. MPCA approved the FS Report, with modifications, in November 2007.

The MPCA used the FS Report to develop a Proposed Plan for an amendment to the Minnesota Decision Document (MDD) for the Highway 96 Site. The Proposed Plan outlined the preferred remedial alternative(s) for the area west of Gilfillan Lake (Operable Unit 4). The Proposed Plan was issued by MPCA on February 15, 2008. MPCA held a public meeting on February 26, 2008 and public comments on the Proposed Plan were accepted until March 21, 2008.

The MPCA reviewed the public comments on the Proposed Plan and prepared an amendment to the MDD and a Responsiveness Summary Document. The MDD amendment, which includes the Responsiveness Summary, was signed by MPCA on August 26, 2008. As outlined in the MDD amendment, the final MPCA-selected remedy for homes located within Operable Unit 4 of the Site includes:

- provision of a new/deeper residential well in the Prairie du Chien Aquifer for homes that are issued a well advisory due to Site-related VOCs;
- long term groundwater monitoring; and
- conditional installation and operation of a pumpout system in the Ski Lane Ravine (in the event that vinyl chloride or another Site-related VOC exceeds its respective HRL in any of the Ski Lane Ravine monitoring wells).

2.0 SCOPE OF THE 2008 ANNUAL MONITORING REPORT

The Annual Monitoring Report is established to report on required activities at the Site as described in the RAP, which includes:

- A summary of groundwater elevation data;
- A plot of the groundwater elevations for the perched groundwater system;
- Groundwater contours for the elevations of the Lower Sand/St. Peter Sandstone Aquifer;
- A plot of total volatile organic compounds (TVOCs) with respect to time for selected wells;
- A figure for each groundwater medium monitored showing TVOCs at each monitoring station; and
- An assessment of the monitoring parameters and sampling frequencies and recommendations for the addition or deletion of monitoring stations.

3.0 HYDROGEOLOGIC UPDATE

This section provides a hydrogeologic summary for the Site, which includes 2008 groundwater elevation data and performance assessments of the extraction wells and the perched groundwater dewatering sump.

3.1 GEOLOGY

The near surface geology of the Site consists of unconsolidated glacial deposits overlying Paleozoic sedimentary bedrock. The topography of the Site is undulating, which is typical of a glacial terrain. The ground surface elevation ranges from 930 to 970 feet above mean sea level (AMSL).

The unconsolidated sediment is highly variable, ranging from clay to gravel size particles. This area has been defined as a complex intermixed deposit of glacial till with sandy loam and sandy clay loam (Ref. 16). The glacial deposit ranges in thickness from 50 to 150 feet.

The glacial deposits are typically underlain by the St. Peter Sandstone. However, erosional remnants of the younger Platteville Limestone and Glenwood Shale exist. The St. Peter Sandstone is classified as a white, fine to medium grained, well-sorted, silica sandstone. The St. Peter Sandstone ranges in thickness from 0 to 150 feet. A 13- to 20-foot thick shale layer typically separates the upper St. Peter Sandstone aquifer from the basal portion of the St. Peter Sandstone aquifer.

The St. Peter Sandstone is underlain by the Prairie du Chien Group. The Prairie du Chien Group consists of interbedded dolomitic limestone and sandstone. Regionally, the Prairie du Chien ranges in thickness from 0 to 250 feet.

Geologic cross-sections have been constructed west and northwest from the Site, through North Oaks. The cross-sections are located on Figure 3.1 and presented in Appendix A. Geologic cross section A-A' extends from the Highway 96 Site westward across Gilfillan Lake through the Ski Lane Ravine area to the North Oaks Golf Course. Geologic cross-section B-B' extends from the Highway 96 Site northwest along Duck Pass Road on the northern shore of Gilfillan Lake.

3.2 HYDROGEOLOGY

There are four significant hydrostratigraphic units: the perched groundwater, the unconsolidated glacial drift aquifer (Lower Sand aquifer), the St. Peter Sandstone aquifer, and the Prairie du Chien aquifer.

Groundwater elevations have been monitored at the Site since July 1987. A historical summary of groundwater elevations is presented in Appendix B. A summary of recent groundwater elevations (January 2008 to December 2008) is presented in Table 3.1.

The perched groundwater system is the uppermost water-bearing unit at the Site. Perched groundwater units are topographically restricted and are typically associated with closed basins that collect surface runoff. Perched groundwater is observed at the North Disposal Area and the former South Disposal Area. The perched groundwater at the North Disposal Area is of greater areal extent and is likely influenced by the wetland area located immediately to the east. Perched groundwater at the former South Disposal Area is smaller in areal extent and is not associated with the perched groundwater in the North Disposal Area.

Perched groundwater elevations historically have ranged from 909 feet to 945 feet AMSL. Groundwater flow within this unit is primarily downward to the Lower Sand aquifer. However, horizontal migration does occur. October 2008 perched groundwater elevations are presented on Figure 3.2. Perched groundwater elevations were not contoured due to their limited areal extent and variable groundwater elevation. Perched groundwater elevations have fluctuated up to 17 feet, but the average seasonal fluctuation is approximately 3 feet. The variable elevations are typical for a perched groundwater system that is dependent on infiltration and rainfall events.

The Lower Sand aquifer is the uppermost aquifer at the Site. Groundwater is encountered within this unit at an approximate elevation of 900 feet AMSL. Regional groundwater flow within this unit (unaffected by groundwater pumping) is towards the west. The hydraulic conductivity within the Lower Sand Aquifer varies due to its heterogeneous nature and ranges from 2×10^{-3} cm/s to 4×10^{-5} cm/s. The average linear groundwater flow velocity is estimated to be 40 ft/yr (Ref. 4).

The St. Peter Sandstone aquifer is hydraulically connected to the overlying Lower Sand aquifer. The potentiometric surface of the St. Peter Sandstone aquifer is approximately 896 feet AMSL. Hence, a downward component of flow exists between the Lower Sand and St. Peter Aquifers, under non-pumping conditions. Similar to the Lower Sand

aquifer, groundwater flow within this aquifer is to the west, except in areas affected by groundwater pumping. In the vicinity of the Site, the average hydraulic conductivity of the upper portion of the St. Peter Sandstone aquifer is calculated at 5×10^{-3} cm/s. The average linear groundwater flow velocity for the upper portion of the St. Peter Sandstone aquifer in the vicinity of the Site is estimated at 80 ft/yr (Ref. 4).

October 2008 on-Site groundwater contours for the Lower Sand/St. Peter Sandstone aquifers are presented on Figure 3.3. Overall, groundwater elevations continue to reflect the heterogeneous nature of the Lower Sand aquifer. Lower Sand aquifer elevations on the west side of the Site (e.g., MW10D) are higher than on the east side of the Site, which is hydraulically upgradient. The elevation differences are due to geologic changes with the lower permeability soil (i.e., higher silt/clay content) observed in the Lower Sand aquifer along the western boundary of the Site. Hence, groundwater pumping by the on-Site extraction wells influences the more permeable St. Peter Sandstone aquifer more than the Lower Sand aquifer, west of the Site.

Based on the recently completed North Oaks groundwater investigations (Ref. 11, Ref. 12), the St. Peter Sandstone can be divided into two stratigraphic sub-units immediately west of the Highway 96 Site: the upper St. Peter Sandstone and the basal St. Peter Sandstone. Groundwater flow in the St. Peter Sandstone aquifer is towards the west for both the upper and basal portions of the aquifer. The basal St. Peter has a lower permeability compared to the upper St. Peter aquifer due to its shale content. The shale layer which separates the upper and basal portions of the St. Peter Sandstone aquifer acts as an aquitard.

October 2008 off-Site groundwater contours for the upper St. Peter Sandstone aquifer are presented on Figure 3.4. For the upper St. Peter aquifer, groundwater flow is characterized by the St. Peter Sandstone monitoring wells at the Highway 96 Site along with off-Site monitoring wells located east of Gilfillan Lake (MW-17A) and west of Gilfillan Lake (MW-18A, MW-19A, and MW-21A).

October 2008 off-Site groundwater contours for the basal St. Peter Sandstone aquifer are presented on Figure 3.5. Groundwater flow in the basal St. Peter Sandstone aquifer is characterized by off-Site monitoring wells (MW-17B, MW-18B, MW-19B, and MW-20B), converted residential monitoring wells (1 Lily Pond, 11 Lily Pond, 6 Blue Goose and 11 Robb Farm Road), and two residential wells located on the west side of Gilfillan Lake (6 West Shore Road and 38 East Oaks Road). Groundwater flow in the basal St. Peter aquifer is approximately 10 times slower than in the upper St. Peter Sandstone aquifer.

Groundwater flow in the Prairie du Chien aquifer is regionally toward the west (Norvitch and others, 1973). The Prairie du Chien aquifer underlies the basal St. Peter Sandstone aquifer. The Prairie du Chien has a higher hydraulic conductivity compared to the St Peter Sandstone, which is attributed to its high fracture density. Based on single well response test data, the hydraulic conductivity of the Prairie du Chien aquifer ranges from 0.03 cm/s to 0.07 cm/s (72 ft/d to 187 ft/d) (Ref. 12), which is comparable to known published values. Applying a regional hydraulic gradient of 0.001 ft/ft and an effective porosity of 0.056 (Norvitch and others, 1973), the groundwater flow velocity in the Prairie du Chien ranges from 470 to 1,220 ft/yr. This range of flow velocity is attributed to the varying degrees of fracture present in the Prairie du Chien aquifer.

3.3 EW1A/EW2 PERFORMANCE ASSESSMENT

Since June 1989, operation of a groundwater extraction system in the Lower Sand/St. Peter Sandstone aquifers (EW1/EW1A/EW2) has prevented migration of VOCs from the Site. In addition to providing hydraulic containment, the extraction system removes VOCs from the Lower Sand/St. Peter Sandstone aquifers. The extracted water is discharged directly into the sanitary sewer under a MCES special discharge permit.

The gradual decline of the pumping capacity at the original extraction well (EW1) had been noted in previous annual monitoring reports. The decline of EW-1 was attributed to iron fouling and possible deterioration of the well casing. The decline was expected to continue and the need for a replacement well was inevitable in order to maintain flexibility within the groundwater extraction system and ensure groundwater containment. A new extraction well (EW-2) was installed in September 2005 and began operation in January 2006, replacing EW1. Installation and performance testing results were presented to MPCA in CRA's February 2006 Report (Ref. 11).

EW1A and EW2 operation and maintenance activities from January 2008 through December 2008 are summarized in Table 3.2. Table 3.3 summarizes the average monthly extraction rates for EW-1A, EW-2 and the dewatering sump.

From January 1 through December 31, 2008, approximately 4 million gallons of groundwater were extracted by EW1A, removing approximately 5.4 pounds of VOCs from the Lower Sand/St. Peter Sandstone aquifers. Since 1989, approximately 139 pounds of VOCs have been removed by EW1/EW1A. Groundwater monitoring of EW1A has shown a stable VOC mass removal rate since 1998. Figure 3.6 illustrates the pounds of TVOCs removed annually by EW1/EW1A since 1989. Figure 3.7 illustrates

the VOC removal efficiency (in pounds per million gallons) of the extraction wells since 1989. Figure 3.8 shows historic TVOC concentrations over time for EW1/EW1A.

From January 1, 2008 through December 31, 2008, approximately 8 million gallons of groundwater were extracted by EW2, removing approximately 1.9 pounds of VOCs from the Lower Sand/St. Peter Sandstone aquifers. Since 2006, approximately 5 pounds of VOCs have been removed by EW2. Figure 3.6 illustrates the pounds of TVOCs removed annually by EW2 since 2006. Figure 3.7 illustrates the VOC removal efficiency (in pounds per million gallons) of EW2 since 2006. Figure 3.8 shows historic TVOC concentrations over time for EW2.

Since 1989, approximately 229 million gallons of groundwater have been extracted by EW1/EW1A/EW2. The number of pore volume exchanges since groundwater extraction began can be estimated based on an assumed contaminated aquifer volume. The area would encompass the North Disposal Area, which would be from EW1/EW1A/EW2 to P3 in an east-west direction (500 feet), and MW1D to P4 in a north-south direction (450 feet). Assuming an aquifer thickness of 60 feet and a porosity of 30 percent, the aquifer volume would be 4,050,000 ft³, or approximately 30 million gallons. Therefore, approximately 8 aquifer pore volumes have been removed since 1989.

Groundwater elevation monitoring verifies hydraulic containment of the VOC plume by EW1A/EW2. As shown on Figure 3.3, groundwater migrating from the North Disposal Area is contained both in the Lower Sand aquifer and the upper portion of the St. Peter Sandstone aquifer, with an estimated capture width of approximately 300 feet.

As typically seen in groundwater extraction systems, TVOCs declined during the initial pumping years of 1989 through 1996 at EW1/EW1A. From 1996 through 2005, TVOCs remained at levels between 50 and 100 µg/L. The sharp increase in TVOC concentrations at EW1A in 2006 and 2008 is due almost entirely to increased trichloroethene (TCE) concentrations. The TCE was not seen downgradient of the extraction system. Increased TCE concentrations are attributed to delayed migration from the CWA. Delayed migration refers to the later release of VOCs to the Lower Sand Aquifer. The CWA is located above a perched groundwater unit that is hydraulically isolated from the regional water table aquifer such that the downward migration of VOCs to the water table aquifer occurs through a zone of partially saturated soil. The rate of downward migration through this partially saturated zone is substantially less than under saturated soil conditions and is dependent on several variable parameters, such as moisture content, soil permeability, and pressure head. Hence, the downward

migration rate and time required to reach the water table aquifer can vary both spatially and temporally underneath the CWA.

Figure 3.9 shows historic TVOC concentrations over time for 7 Robb Farm Road, a former downgradient residential well. TVOCs decreased dramatically at this location when the extraction system began operation in 1989. This residential well was abandoned during the installation of the municipal water system in North Oaks in 1993/1994 eliminating this well from further sampling.

Figure 3.10 presents a cross-section that depicts the groundwater extraction system. As shown on Figure 3.10, the groundwater extraction system effectively captures contaminated groundwater from upgradient monitoring wells (i.e. MW4D and MW8B). The effectiveness of the groundwater extraction system is demonstrated by low to non-detectable VOC concentrations at downgradient compliance wells and the converted residential monitoring wells.

3.4 DEWATERING SUMP PERFORMANCE ASSESSMENT

Since July 1995, the dewatering sump has removed VOCs from the perched groundwater system within the North Disposal Area. The extracted water is discharged directly into the sanitary sewer under a MCES Special Discharge Permit.

Sump operation and maintenance activities from January 2008 through December 2008 are summarized in Table 3.2.

Since 1995, approximately 26 million gallons of perched groundwater have been extracted by the sump. In 2008, the sump pumped approximately 2 million gallons of water to the sanitary sewer, removing approximately 1.6 pounds of VOCs from the perched groundwater unit. Since 1995, the dewatering sump has removed approximately 81 pounds of VOCs. Figure 3.6 illustrates the pounds of TVOCs removed annually by the dewatering sump since 1995. Figure 3.7 illustrates the VOC removal efficiency (in pounds per million gallons) of the dewatering sump since 1995.

3.5 ASSESSMENT OF POTENTIAL EFFECTS FROM ST. PAUL REGIONAL WATER SERVICE (SPRWS) SUPPLY WELLS

As stated a letter from CRA to MPCA dated July 26, 2007, Whirlpool and Reynolds share the City of North Oaks and North Oaks Home Owners Association (NOHOA) concern

that future pumping of certain St. Paul Regional Water Services (SPRWS) supply wells located in the Vadnais Heights area may affect contaminant migration in North Oaks. As such, Whirlpool and Reynolds made the commitment to include as part of the Highway 96 Annual report, an annual assessment of the SPRWS activities.

In 2004, the engineering firm of Bonestroo, Rosene, Anderlik & Associates (Bonestroo), on behalf of the SPRWS, developed a groundwater model for the SPRWS to evaluate the effects of their proposed water supply system on the regional municipal water supply aquifers. Based on a proposed pumping rate of 50 million gallons per day (Mgpd), the 2004 groundwater model predicted up to 20 feet of drawdown in the Prairie du Chien (PdC) aquifer and up to 10 feet of drawdown in the St. Peter Sandstone aquifer, in the vicinity of North Oaks.

In May/June 2005, Bonestroo conducted a 30-day pumping test of the four municipal wells in the Lake Vadnais area, located approximately 12,000 feet southwest of Gilfillan Lake. During the pumping test, the MDNR monitored a PdC aquifer well located near Sucker Lake (approximately 5,000 feet west of Gilfillan Lake), a former Shoreview PdC/Jordan aquifer production well located near County Road E and Lexington Avenue (approximately 22,000 feet west/southwest of Gilfillan Lake), and a PdC/Jordan well located near the White Bear Township Municipal Building (approximately 8,300 feet east/northeast of Gilfillan Lake). The combined pumping rate during the 30-day pumping test was 19 Mgpd (approximately 3,500 gpm, per well). The pumping test results showed that the well located near Sucker Lake and the former Shoreview production well exhibited 4 to 5 feet of drawdown. The pumping test results also showed that the well located near the White Bear Township Municipal Building was outside the pumping influence. Based on the 2005 pumping test results, the MDNR determined that the 2004 groundwater model overpredicted drawdown in the vicinity of North Oaks. The MDNR attributed the drawdown differences between the model and the pumping test to a low transmissivity value used in the model. The SPRWS indicated they do not plan to update the model, but would do so if requested by the MDNR.

According to SPRWS, their goal is still to have an water supply system capable of pumping 50 Mgpd. Currently, there are six supply wells, which pump at a combined rate of 27 Mgpd. The MDNR and SPRWS are proceeding in a step-wise fashion that will likely take several years and involve commission of another four supply wells before the SPRWS can reach the 50 Mgpd capacity.

The MDNR requires that a pumping test be performed on any new municipal supply well in order to verify its yield, define the surrounding aquifer hydraulic properties, and

examine possible well interference effects with other municipal supply wells. The MDNR has indicated that they will require additional multi-well pumping tests (e.g., at pumping rates of 40 Mgalpd and 50 Mgalpd), as the SPRWS completes commission of additional supply wells. The next multi-well pumping test (40 Mgalpd) is tentatively scheduled for Spring 2010. CRA informed the MDNR that the Highway 96 Group would allow use of the existing monitoring wells in North Oaks as part of any upcoming aquifer tests.

4.0 GROUNDWATER ASSESSMENT

Groundwater sampling associated with the Highway 96 Site has been conducted since 1986. A total of 60 rounds of groundwater sampling have been conducted at on-Site monitoring wells, off-Site monitoring wells, and residential wells. A summary of historic groundwater sampling events is provided in Table 4.1.

Groundwater sampling events conducted during 2008 are summarized in the following paragraphs.

April/May 2008 - Residential Well Sampling Event

During the period from April 21, 2008 through May 7, 2008, 30 residential wells were sampled as part of the "Revised Residential Well Sampling Program" (submitted to MPCA on September 11, 2006 and approved on October 2, 2006). A complete description of the April/May 2008 residential well sampling event and the associated analytical results were previously submitted to MPCA in CRA's "April/May 2008 Residential Well Data Report", dated July 17, 2008.

September 2008 - Monitoring Well Sampling Event

On September 3, 2008, the two new upper St. Peter Sandstone monitoring wells in the Ski Lane Ravine (MW-19A and MW-21A) were sampled, in accordance with CRA's Work Plan dated September 25, 2007 and as approved by MPCA, with modifications, on October 11, 2007. A complete description of the September 2008 monitoring well sampling event and the associated analytical results were previously submitted to MPCA in CRA's "Completion Report - Monitoring Well Installation (MW-19A & MW-21A)", dated December 30, 2008.

October/November 2008 - Residential Well Sampling Event

During the period from October 13, 2008 through October 24, 2008 and on November 24, 2008, 62 residential wells were sampled as part of the long-term monitoring program outlined in CRA's Feasibility Study Report (dated July 26, 2007) and approved by MPCA on November 7, 2007. A complete description of the October/November 2008 residential well sampling event and the associated analytical results were previously submitted to MPCA in CRA's "October/November 2008 Residential Well Data Report", dated December 30, 2008.

October 2008 - Annual Monitoring Well Sampling Event

During the period from October 6, 2008 through October 13, 2008, on-Site and off-Site monitoring wells and the four converted residential monitoring wells were sampled as

part of the Routine Annual Monitoring Well Sampling Program. A technical memo that summarizes the October 2008 Annual Monitoring Well Sampling Event is presented in Appendix C.

4.1 HISTORICAL OVERVIEW OF GROUNDWATER DATA

Groundwater analytical laboratory data are validated for quality assurance by CRA and compiled into a computer database for the purpose of data management and reporting. Groundwater data are managed according to five well groupings:

- Perched groundwater unit;
- Lower Sand aquifer;
- St. Peter Sandstone aquifer;
- Prairie du Chien aquifer; and
- Residential wells.

A historical data summary, which identifies chemical concentrations of select VOCs over time at each monitoring location, is presented in Appendix D. The VOCs listed in Appendix D include: acetone, vinyl chloride, dichlorodifluoromethane (DCDFM), dichlorofluoromethane (DCFM), 1,1-dichloroethane (11DCA), 1,2-dichloroethane (12DCA), and methylene chloride (MC)). Historical VOC data for the current compliance wells (EW1, EW1A, EW2, MW4D, MW8B, MW10B, MW12B, MW12D, MW13B, MW13D, MW16B, and MW16D) are provided in Appendix D.1. Historical VOC data for all other monitoring wells are provided in Appendix D.2. Historical VOC data for residential wells and the four converted residential monitoring wells are presented in Appendix D.3.

A set of graphs showing TVOC concentrations over time for select wells are presented on Figures 3.8, 3.9, and 4.1 through 4.9.

TVOC concentrations in the perched groundwater unit are represented by LW3 (Figure 4.1).

- LW3 data represent perched groundwater in the CWA. Figure 4.1 illustrates TVOC concentrations in the perched groundwater unit decreasing from 1987 through 1991, and remaining relatively stable and less than 50 µg/L since 2001. In October 2008, the TVOC concentration at LW3 was 7 µg/L.

TVOC concentrations in the Lower Sand aquifer are represented by MW4D (Figure 4.2), EW1/EW1A (Figure 3.8), and MW12D (Figure 4.3).

- MW4D data represent impacted groundwater in the Lower Sand aquifer immediately downgradient of the North Disposal Area. Figure 4.2 illustrates TVOC concentrations at MW4D decreasing from 1987 through 1991, and ranging from 50 µg/L to 500 µg/L since 1991. In October 2008, the TVOC concentration at MW4D was 392 µg/L.
- EW1/EW1A data represent impacted groundwater from the Lower Sand and St. Peter Sandstone aquifers that is captured by the extraction system. Figure 3.8 illustrates TVOC concentrations at EW1/EW1A decreased from 1989 through 1996. With the exception of elevated TVOC concentrations in 2006 and 2008, TVOC concentrations at EW1/EW1A have remained below 150 µg/L since 1990. The sharp increases in TVOC concentrations observed in 2006 and 2008 are almost entirely due to increased TCE concentrations. The increased TCE concentrations are attributed to delayed migration from the CWA.
- MW12D data represent groundwater in the Lower Sand aquifer downgradient of the extraction system. Figure 4.3 illustrates TVOC concentrations at MW12D, which have historically remained below 3 µg/L since 1997. In October 1996, the TVOC concentration was near 400 µg/L. That sample is considered anomalous because that TVOC concentration was never observed before or after that sample date. In October 2008, the TVOC concentration at MW12D was zero (i.e., no VOCs were detected).

TVOC concentrations in the St. Peter Sandstone aquifer, are illustrated by MW8B (Figure 4.4), EW2 (Figure 3.8), MW12B (Figure 4.5), and four former residential monitoring wells (Figure 4.6 through Figure 4.9).

- MW8B is located between the consolidated waste area and the groundwater extraction system. MW8B data represent impacted groundwater in the St. Peter Sandstone aquifer immediately downgradient of the North Disposal Area. Figure 4.4 illustrates TVOC concentrations at MW8B, which have ranged from 1 µg/L to 300 µg/L over the past 10 years. In October 2008, the TVOC concentration at MW8B was 26 µg/L. TVOC concentrations at MW8B have decreased significantly since the commission of extraction well EW2 in January 2006.
- EW2 data represent impacted groundwater from the Lower Sand and St. Peter Sandstone aquifers that is captured by the extraction system. EW2 was installed in

September 2005 and commissioned in January 2006. Figure 3.8 illustrates TVOC concentrations at EW2, which have remained below 100 µg/L since 2005.

- MW12B data represent groundwater in the St. Peter Sandstone aquifer downgradient of the extraction system. Figure 4.5 illustrates TVOC concentrations at MW12B which have historically remained below 6 µg/L since 1997. In October 2008, the TVOC concentration at MW12B was zero (i.e., no VOCs were detected).
- Data from the four converted residential monitoring wells represent groundwater in the St. Peter Sandstone aquifer downgradient of the Highway 96 Site. Figure 4.6 illustrates TVOC concentrations at 11 Robb Farm Road decreased from 1989 through 1992 and have remained relatively stable (below 10 µg/L) since 1990. In October 2008, the TVOC concentration at 11 Robb Farm Road was 0.7 µg/L. Figure 4.7 illustrates TVOC concentrations at 1 Lily Pond Road have fluctuated between not detected and 30 µg/L since sampling began in 1990. In October 2008, the TVOC concentration at 1 Lily Pond Road was 26 µg/L. Figure 4.8 illustrates TVOC concentrations at 11 Lily Pond Road have typically remained below 5 µg/L since 1996. In October 2008, the TVOC concentration at 11 Lily Pond Road was zero (i.e. no VOCs were detected). Figure 4.9 illustrates TVOC concentrations at 6 Blue Goose Road have remained below 5 µg/L since 1997. In October 2008, the TVOC concentration at 6 Blue Goose Road was zero (i.e., no VOCs were detected). The overall decline of TVOC concentrations at the four converted residential well locations can be attributed to the removal of buried drums on-Site and the groundwater extraction system containing and removing VOCs from the aquifer.

TVOC concentrations will continue to be evaluated through future monitoring.

4.2 2008 DATA PRESENTATION

Laboratory analytical reports for samples collected in 2008 are presented in Appendix E. Analytical data quality assessment and validation of all results was conducted by the CRA quality control/quality assurance (QA/QC) officer. Data quality assessment and validation memos are also presented in Appendix E.

Analytical results for samples collected in 2008 from the perched groundwater unit, Lower Sand aquifer, St. Peter Sandstone aquifer, and Prairie du Chien aquifer monitoring wells are presented in Tables 4.2 through 4.5, respectively. Analytical results for samples collected in 2008 from residential wells are presented in Table 4.6.

To illustrate the data, Figures 4.10 through Figure 4.15 show the distribution of TVOCs in the perched groundwater unit, Lower Sand aquifer, St. Peter Sandstone aquifer (on-Site monitoring wells), St. Peter Sandstone aquifer (off-Site monitoring wells), Prairie du Chien aquifer, and in residential wells, respectively.

4.2.1 PERCHED GROUNDWATER UNIT

Four perched groundwater monitoring wells (LW2, LW3, MW1S, and the dewatering sump) were sampled in 2008. Two perched groundwater monitoring wells (LW-1 and MW-4U), were not sampled due to insufficient water levels. Perched groundwater analytical results from 2008 are presented in Table 4.2 and on Figure 4.10. Historical perched groundwater VOC results for select parameters are presented in Appendix D.2.

Compliance Wells

None of the perched monitoring well locations are included in the current list of compliance wells.

Other Monitoring Wells

VOCs detected in 2008 in perched groundwater samples included chlorinated VOCs, acetone, benzene, ethyl ether, ethylbenzene, isopropylbenzene, methyl ethyl ketone, methyl isobutyl ketone, styrene, toluene, and xylenes. Detections of these VOCs are generally consistent with historical sampling results.

The 2008 chloride concentrations in the perched groundwater unit ranged from 15 mg/L (LW2) to 139 mg/L (LW3). Chloride has historically been detected in the perched groundwater unit at concentrations within this range.

4.2.2 LOWER SAND AQUIFER

Nine Lower Sand aquifer monitoring wells (MW1D, MW4S, MW4D, MW10D, MW11D, MW12D, MW13D, MW16D, and EW1A) were sampled in 2008. Lower Sand aquifer analytical results from 2008 are presented in Table 4.3 and on Figure 4.11. Historical Lower Sand aquifer VOC results for select parameters at the current compliance wells and other monitoring wells are presented in Appendix D.1 and Appendix D.2, respectively.

Near-Source Compliance Wells

MW4D is located between the consolidated waste area and the groundwater extraction system, and represents Lower Sand aquifer groundwater immediately downgradient of the North Disposal Area. In 2008, 11DCA, 12DCA, MC, and vinyl chloride were detected at concentrations above their respective Site Clean-up Goals (SCGs) at this location, which is generally consistent with historical sampling results. Elevated levels of chloroethane are also observed at MW4D. Chloroethane represents the reductive dechlorination (i.e. degradation) by-product of both 11DCA and 12DCA.

EW1A represents affected groundwater from the Lower Sand and St. Peter Sandstone aquifers that is captured by the extraction system. In 2008, MC, TCE and vinyl chloride were detected at concentrations above their respective SCGs at this location, which is generally consistent with historical sampling results.

Downgradient Compliance Wells

The Lower Sand aquifer downgradient compliance wells (MW12D, MW13D, and MW16D) are located along Robb Farm Road and represent Lower Sand aquifer groundwater immediately downgradient of the on-Site extraction system. All 2008 analytical results from the Lower Sand aquifer downgradient compliance wells were below their respective SCGs.

Other Monitoring Wells

VOC detections in the remaining Lower Sand aquifer monitoring wells sampled in 2008 (MW1D, MW4S, MW10D, and MW11D) included chlorinated VOCs, benzene, ethyl ether, methyl ethyl ketone, and toluene. Vinyl chloride was detected above its respective SCG at MW4S. The concentrations of the other detected VOCs were below their respective SCGs.

The 2008 chloride concentrations in the Lower Sand aquifer ranged from 13 mg/L (MW11D) to 945 mg/L (MW4S). The highest concentrations were exhibited at MW-4S and MW4D. These wells are immediately downgradient of the North Disposal Area and also exhibit the highest VOC concentrations in the aquifer.

4.2.3 ST. PETER SANDSTONE AQUIFER

Fifteen St. Peter Sandstone aquifer monitoring wells (MW8B, MW10B, MW12B, MW13B, MW16B, MW17A, MW17B, MW-18A, MW-18B, MW-19A, MW19B, MW-20B, MW-21A, EW2, and EW-3) were sampled in 2008. St. Peter Sandstone aquifer analytical results

from 2008 are presented in Table 4.4 and on Figure 4.12 (on-Site monitoring locations) and Figure 4.13 (off-Site monitoring locations). Historical St. Peter Sandstone aquifer VOC results for select parameters at the current compliance wells, and other monitoring wells are presented in Appendix D.1 and Appendix D.2, respectively.

Near-Source Compliance Wells

MW8B is located between the consolidated waste area and the groundwater extraction system, and represents St. Peter Sandstone aquifer groundwater immediately downgradient of the North Disposal Area. In 2008, no VOCs were detected above their respective SCGs at MW8B.

EW2 represents groundwater in the St. Peter Sandstone aquifer, immediately downgradient of the North Disposal Area that is captured by the groundwater extraction system. In 2008, TCE and vinyl chloride were detected in the groundwater sample collected from EW2 at concentrations above their respective SCGs.

Downgradient Compliance Wells

The St. Peter Sandstone aquifer downgradient compliance wells (MW10B, MW12B, MW13B, and MW16B) are located along Robb Farm Road and represent St. Peter Sandstone aquifer groundwater immediately downgradient of the on-Site extraction system. All 2008 analytical results from the St. Peter Sandstone aquifer downgradient compliance wells were below their respective SCGs.

Other Monitoring Wells

MW17A, MW17B, MW-18A, MW-18B, MW-19A, MW19B, MW-20B, MW-21A, EW-3, and the four converted residential monitoring wells (6 Blue Goose Road, 1 Lily Pond Road, 11 Lily Pond Road, and 11 Robb Farm Road) are located off-site and represent groundwater in the St. Peter Sandstone aquifer, downgradient of the Highway 96 Site. VOCs detected in groundwater samples collected from these locations in 2008 include chlorinated VOCs, ethyl ether, and toluene.

In 2008, vinyl chloride was detected in the sample and duplicate sample collected from MW17A at concentrations of 1.1 µg/L and 1.0 µg/L, respectively. Vinyl chloride was also detected in the sample collected from MW17B at a concentration of 0.2 µg/L. The presence of vinyl chloride in the St. Peter Sandstone aquifer on the east side of Gilfillan Lake, as represented by MW17A and MW17B, is consistent with historical sampling results from 1993/1994 in the 15 Gilfillan Road/17 Gilfillan Road/8 Edgewater Lane area. However, vinyl chloride concentrations east of the lake have decreased since 1993.

The decreasing vinyl chloride concentrations are attributed to the Highway 96 groundwater extraction system and natural attenuation.

The 2008 chloride concentrations in the St. Peter Sandstone aquifer ranged from 1.8 mg/L (MW12B) to 74 mg/L (MW19A). Chloride has historically been detected at similar concentrations in the St. Peter Sandstone aquifer.

4.2.4 PRAIRIE DU CHIEN AQUIFER

Three Prairie du Chien aquifer monitoring wells (MW17L, MW-18L, and MW19L) were sampled in 2008. Prairie du Chien aquifer analytical results from 2008 are presented on Table 4.5 and Figure 4.14. Historical Prairie du Chien aquifer VOC results for select parameters are presented in Appendix D.2.

Compliance Wells

None of the Prairie du Chien aquifer monitoring well locations are included in the current list of compliance wells.

Other Monitoring Wells

MW17L, MW-18L, and MW19L are located off-site and represent groundwater in the Prairie du Chien aquifer, downgradient of the Highway 96 Site.

Analytical results from MW17L, MW-18L, and MW19L demonstrated the Prairie du Chien aquifer has not been impacted by contamination from the Highway 96 Site and represents a safe alternative water supply.

The 2008 chloride concentrations in the Prairie du Chien aquifer ranged from 11 mg/L (MW17L and MW19L) to 12 mg/L (MW18L).

4.2.5 RESIDENTIAL WELLS

Sixty-two residential well locations were sampled in 2008. Residential well analytical results from 2008 are presented in Table 4.6 and on Figure 4.15. Historical residential well VOC results for select parameters are presented in Appendix D.3.

In 2008, vinyl chloride was detected at two residential well locations (2 Hummingbird Hill and 12 West Shore Road). Figure 4.16 presents the maximum vinyl chloride

concentrations detected in residential wells in 2008. As shown on Figure 4.16, vinyl chloride was only detected above the HRL at one location (12 West Shore Road) in 2008.

The remaining VOCs detected in the residential well samples collected in 2008 primarily included 1,2-dichloroethene, cis-1,2-dichloroethene, and common chlorination bi-products. All detected concentrations were below their respective HRLs, with the exception of a bromodichloromethane (BDCM) detection at 1 Thompson Lane. The October 2008 detection of BDCM is unrelated to the Highway 96 Site remnant plume. BDCM is a common bi-product of residential well chlorination. The resident at 1 Thompson Road utilizes a whole-house chlorination unit and access to an untreated water tap for sampling is no longer available (i.e. sample results reflect water quality post-chlorination).

The 2008 chloride concentrations in the residential wells and converted residential monitoring wells ranged from <1.0 mg/L (1 Poplar Lane) to 135 mg/L (4 Thompson Lane).

4.2.5.1 STATUS OF MDH HRL RULE REVISION FOR VINYL CHLORIDE

In a letter from CRA to MPCA dated July 26, 2007, Whirlpool and Reynolds made the commitment to include as part of the Highway 96 Annual Report, a status update on the MDH HRL Rule Revision for vinyl chloride.

- The current HRL for vinyl chloride (0.2 µg/L) was established by the MDH in 1993/1994.
- In December 2004, the MDH proposed a draft revised HRL for vinyl chloride (0.08 µg/L), as part of the 2004 Draft HRL Rule Revision.
- In April 2007, the MDH withdrew the proposed draft revised HRL for vinyl chloride.
- In September 2007, the MDH recommended that the HRL for vinyl chloride be included on the list of compounds to be reviewed as part of the Draft HRL Rule Revision.
- *In February 2008, MDH completed their review of the HRL for vinyl chloride and proposed that the HRL remain at 0.2 µg/L (no change).*
- In July 2008, MDH posted a draft of the Proposed HRL Rule Revision and Statement of Need and Reasonableness (SONAR), a technical document explaining and supporting the revised Rules.

- In September 2008, a copy of the July 2008 Proposed HRL Rule Revision was published in the State Register.
- In October 2008, a public hearing on the July 2008 Proposed HRL Rule Revision was held before an Administrative Law Judge. The hearing was followed by a 20-day comment period (ending October 30, 2008) and a five-day rebuttal period (ending November 6, 2008).

Specific information regarding the MDH Draft HRL Rule Revision can be obtained by contacting the MDH or by visiting the MDH website:

<http://www.health.state.mn.us/divs/eh/groundwater/data/index.cfm>

4.2.5.2 NEW RESIDENTIAL WELL INSTALLATIONS

As stipulated in the recent MDD amendment for the Highway 96 Site (signed August 26, 2008), the MPCA-selected remedy, for homes located within Operable Unit 4 of the Site that have been issued a well advisory due to site-related VOCs, is provision of a new/deeper residential well in the Prairie du Chien Aquifer.

To date (March 2009), MDH has only issued well advisories to two locations in Operable Unit 4 due to site-related VOCs:

13 West Shore Road

On August 15, 2007, the MDH issued a well advisory to 13 West Shore Road based on the April 2007 detection of vinyl chloride equal to the HRL and the additive risk associated with additional VOC detections. On October 10, 2008, Whirlpool and Reynolds sent a letter to the homeowner at 13 West Shore Road to initiate arrangements for installation of a new residential well in the Prairie du Chien aquifer, in accordance with the MDD amendment. In January 2009, the homeowners at 13 West Shore Road agreed to allow installation of a new residential well. Installation of the new residential well at 13 West Shore Road was conducted in February and March 2009. As part of that well installation, the homeowners decided, at their own expense, to have the new residential well advanced into the underlying Jordan Sandstone aquifer for their drinking water source.

12 West Shore Road

On December 8, 2008, the MDH issued a well advisory to 12 West Shore Road based on the October/November 2008 detections of vinyl chloride above the HRL. On December

16, 2008, Whirlpool and Reynolds sent a letter to the homeowner at 12 West Shore Road to initiate arrangements for installation of a new residential well in the Prairie du Chien aquifer, in accordance with the MDD amendment. Whirlpool and Reynolds are currently awaiting a response from the homeowner at 12 West Shore Road (March 2009).

2 Hummingbird Hill

Although not required by MPCA under the MDD amendment, Whirlpool and Reynolds also extended voluntary offers to provide a new residential well in the Prairie du Chien aquifer to the homeowner at 2 Hummingbird Hill. In January 2009, the homeowners at 2 Hummingbird Hill accepted Whirlpool's and Reynolds' voluntary offer to install a new residential well. Installation of the new residential well at 2 Hummingbird Hill was conducted in March 2009. As part of that well installation, the homeowners decided, at their own expense, to have the new residential well advanced into the underlying Jordan Sandstone aquifer for their drinking water source.

5.0 GAS PROBE MONITORING

During the second and third quarters of 2008, the six gas probes shown on Figure 5.1 were monitored for combustible gas. Per MPCA approval, a LandTec GEM 500 portable gas meter was used to perform combustible gas monitoring. Table 5.1 presents the results of the gas probe monitoring conducted using an MSA combustible gas meter from 1995 through 2001. Table 5.2 presents the results of gas probe monitoring using the LandTec GEM 500 from 1999 to date.

Results from the monitoring program described in the O&M Plan (Ref. 8) indicate the presence of measurable levels of combustible gas within the buried waste of the reconsolidated North Disposal Area. Typical readings for other landfill sites have ranged from 0.5 to 65 percent combustible gas. As Table 5.1 shows, readings from the Highway 96 Site range from 0 to 93 percent combustible gas. This is likely an indication that all combustible gas may not be landfill related and may also be attributed in part to the wetlands (swamp) setting.

The LandTec meter reads the percentage by volume of methane (CH_4), oxygen (O_2), and carbon dioxide (CO_2). Typical concentrations of these parameters recorded at other landfills sites are: CH_4 (30 to 60%), CO_2 (20 to 50%), and O_2 (<2%). The results on Table 5.2 are generally within or below the typical concentrations. The CH_4 results from the LandTec meter generally corresponded to the combustible gas readings observed using the MSA meter. As such, monitoring with both the MSA meter and the LandTec meter was not needed, and discontinued per MPCA approval.

Figure 5.2 through Figure 5.7 show the percent combustible gas vs. time graphs for GP1 through GP6, respectively. Data were collected from the MSA meter from 1995 to January 2001. Data after January 2001 were collected using the LandTec meter. Over the ten years that combustible gas has been monitored at the Site, no clear Site-wide trend has emerged.

Each probe was also monitored for positive pressure using the Land Tec meter (accurate to 0.1 inch of H_2O). Pressure readings were between 0.0 inch of H_2O and 0.1 inch of H_2O at all locations. The lack of appreciable pressure observed at the gas probes indicates that the passive gas venting system is relieving any potential pressure build-up from combustible gas generation. Off-cap monitoring should be conducted in the areas of future development prior to any construction.

In accordance with the O&M Plan (Ref. 8), gas probe monitoring is scheduled to continue through 2014.

MEH commenced construction activities for the Weston Woods townhome development at the Site during the spring of 2001. MEH installed 10 gas probes, and a gas interceptor trench during the fall of 2001 to track potential lateral gas migration. In July 2005, MEH installed six passive gas vents on the landfill cap to reduce off-site migration of methane. The location of the gas probes, gas vents, and gas interceptor trench are illustrated in Figure 5.8. MEH conducts routine gas monitoring under MPCA's Voluntary Investigation and Clean-up (VIC) program to evaluate the potential of lateral gas migration. MEH's gas monitoring data and migration evaluation is not included in this report.

6.0 SOIL CAP INSPECTIONS

In accordance with the O&M Plan (Ref. 8), and MPCA approval modifications on July 19, 2001, routine inspection of the Site was performed during the second and fourth quarters of 2008. The following items were evaluated during the inspections:

- The soil cover was inspected for detrimental erosion, settlement and stressed or overgrown vegetation;
- Access roads were inspected for physical damage and obstructions; and
- Methane gas monitoring probes and groundwater monitoring wells were inspected for physical damage.

A record of each inspection is maintained on a checklist. To date, the cover has shown no signs of detrimental erosion or stressed vegetation. Minor settlement has been detected and repaired by placing fill. The cap vegetation is well established. Gas probes, and monitoring wells are in good condition.

In accordance with the O&M Plan (Ref. 8), cap inspections are scheduled to continue until 2014.

7.0 CONCLUSIONS

Based on the information presented in this 2008 Annual Monitoring Report, the following conclusions are made:

1. The groundwater extraction system is effectively capturing VOCs from the CWA based on the evaluation of hydraulic conditions (i.e. groundwater elevation contours) and groundwater chemistry (i.e. analytical results from downgradient compliance wells).
2. Groundwater samples from monitoring wells continue to indicate that the unconsolidated Glacial Drift aquifer (Lower Sand aquifer) in North Oaks is not contaminated by vinyl chloride.
3. Groundwater samples from monitoring wells continue to indicate that vinyl chloride contamination in North Oaks, west of Gilfillan Lake, in the St. Peter Sandstone aquifer, is of limited horizontal extent.
4. Groundwater samples from monitoring wells continue to indicate that the Prairie du Chien aquifer in North Oaks is not contaminated by vinyl chloride.
5. Residential well sampling of homes in North Oaks, west of Gilfillan Lake (Operable Unit 4), confirms that vinyl chloride contamination is limited to four residential wells (12 West Shore Road, 13 West Shore Road, 15 West Shore Road and 2 Hummingbird Hill).

8.0 RECOMMENDATIONS

Based on the information presented in this 2008 Annual Monitoring Report, CRA recommends the following:

1. Operation of the on-Site groundwater extraction system in the perched groundwater system (via the dewatering sump) and in the Lower Sand/St. Peter Sandstone aquifers (via extraction wells EW1A and EW2) should continue.
2. Annual groundwater sampling of on-Site and off-Site monitoring well locations should continue.
3. Installation of additional off-Site monitoring wells (angled from the west shore under Gilfillan Lake) should proceed as outlined in Alternative A2 (Long-Term Monitoring) of the Feasibility Study (Ref. 15) and CRA's Work Plan dated September 25, 2007, as approved by MPCA, with modifications, on November 7, 2007 and October 11, 2007, respectively. *[Note: To date, the angle wells under Gilfillan Lake have not been installed because specified North Oaks property owners have not agreed to provide access. A separate correspondence will be submitted to MPCA regarding the progress/completion of the proposed angle well installations.]*
4. Residential well sampling should continue, in accordance with the long-term monitoring program outlined in Alternative A2 of CRA's Feasibility Study Report (Ref. 15) and approved by MPCA on November 7, 2007. Future residential well sampling will be based on MPCA requirements.
5. New residential wells in the Prairie du Chien aquifer should be provided to homes in Operable Unit 4 that have been issued a well advisory due to site-related VOCs, as stipulated in the recent MDD amendment for the Highway 96 Site (dated August 26, 2008).
6. Gas probe monitoring should continue, as outlined in the O&M Plan (Ref. 8).
7. Soil cap inspections should continue, as outlined in the O&M Plan (Ref. 8).

REFERENCES

1. Conestoga-Rovers & Associates. March 1988. Remedial Investigation/Interim Response Action Plan.
2. Conestoga-Rovers & Associates. October 1988. Alternatives Analysis Report.
3. Conestoga-Rovers & Associates. April 1989. Detailed Analysis Report.
4. Conestoga-Rovers & Associates. October 1993. North Oaks - Southeast Area Groundwater Investigation.
5. Conestoga-Rovers & Associates. January 1994. Response Action Plan.
6. Conestoga-Rovers & Associates. May 1994. Phase II Response Action Plan.
7. Conestoga-Rovers & Associates. January 1994. South Disposal Area Groundwater Investigation.
8. Conestoga-Rovers & Associates. May 1994. Post Closure Operation and Maintenance Plan.
9. Conestoga-Rovers & Associates. January 1995. Remedial Action Final Report.
10. Conestoga-Rovers & Associates. June 2005. Groundwater and Residential Well Evaluation Report - North Oaks, Minnesota.
11. Conestoga-Rovers & Associates. February 2006. Groundwater and Residential Well Evaluation Report - North Oaks, Minnesota (June 2005 - January 2006).
12. Conestoga-Rovers & Associates. February 2007. Groundwater and Residential Well Evaluation Report - North Oaks, Minnesota (February 2006 - January 2007).
13. Conestoga-Rovers & Associates. May 2007. Subsurface Geophysical Survey Report.
14. Conestoga-Rovers & Associates. December 2008. Completion Report - Monitoring Well Installation (MW-19A/MW-21A)
15. Conestoga-Rovers & Associates. July 2007. Feasibility Study - VOCs in Groundwater - West of Gilfillan Lake - North Oaks, Minnesota.
16. Meyer G.N. 1985. Quarternary Geologic Map of the Minneapolis-St. Paul Urban Area, Minnesota. Minnesota Geological Survey, Miscellaneous Map Series M-54, and Scale 1:48,000.