GROUNDWATER AND RESIDENTIAL WELL EVALUATION
NORTH OAKS, MINNESOTA

JUNE 2005 - JANUARY 2006

HIGHWAY 96 SITE
WHITE BEAR TOWNSHIP, MINNESOTA

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LIST OF ACRONYMS

AMSL	above mean sea level
bgs	below sea level
CRA	Conestoga-Rovers & Associates
CWA	Consolidated waste area
DNR	Department of Natural Resources
DO	Dissolved oxygen
Eh	Redox potential
Feet	ft.
HRL	Health risk limit
MCES	Metropolitan Council Environmental Services
MDH	Minnesota Department of Health
MEK	Methyl ethyl ketone
MGS	Minnesota geological survey
MPCA	Minnesota Pollution Control Agency
MPN	Mean probable number
MS/MSD	Matrix spike/matrix spike duplicate
NDA	North Disposal Area
NOHA	North Oaks Homeowners Association
ORP	Oxidation reduction potential
QA/QC	Quality assurance/quality control
Reynolds	Reynolds Metals Company
SDA	South Disposal Area
STL	Severn Trent Laboratories
USEPA	US Environmental Protection Agency
VAP	Vertical Aquifer Profiling
VOC	Volatile organic compound
Whirlpool	Whirlpool Corporation

EXECUTIVE SUMMARY

Reynolds Metals Company (Reynolds) and Whirlpool Corporation (Whirlpool) have, as responsible parties, worked to remediate the Highway 96 Site and to monitor the groundwater west of the Site in areas that include the west shore of Gilfillan Lake in North Oaks, Minnesota. In October 2004, during this routine monitoring, their consultant, Conestoga-Rovers & Associates (CRA), detected low levels of vinyl chloride in water samples from two residential wells located on the west shore. Although the concentrations detected were below the health risk limit (HRL)[1] for vinyl chloride adopted by the Minnesota Department of Health (MDH), the Minnesota Pollution Control Agency (MPCA) requested that Reynolds and Whirlpool conduct a six-month residential well study to investigate the nature and extent of any vinyl chloride contamination in wells on the west shore. In June 2005, a report presented the results of the six-month study and provided recommendations for permanent solutions and continued monitoring.

On September 1, 2005, the MPCA issued a letter to CRA that stated the MPCA would use "a phased approach to approve, reject, or modify the additional response actions and recommendations proposed" in CRA's June 2005 Report. In its letter dated September 1, 2005, the MPCA outlined a list of response actions to be completed as part of a continued groundwater and residential well evaluation in North Oaks.

SCOPE

The report presents the results of the response actions conducted during the period from June 2005 through January 2006, as required by the MPCA, and provides an updated evaluation of the groundwater and residential wells in North Oaks.

In its letter dated September 1, 2005, the MPCA required that the groundwater and residential well evaluation focus on five geographic areas. The presentation of results by area is intended to assist the residents of North Oaks to understand the groundwater and residential well evaluation as it relates to their neighborhood. The five geographic areas are as follows:

- Area 1 - The immediate vicinity of the Highway 96 Site.
- Area 2 - The areas west and north of Gilfillan Lake and the Highway 96 Site that are free of contaminants related to the Highway 96 Site.

[1] Health Risk Limit (HRL) is the health standard adopted by the MDH for the safe consumption of water from a private water supply over a lifetime

- Area 3 - The areas immediately east and west of Gilfillan Lake, where vinyl chloride and other site-related contaminants were detected in 1993-1994 and again in 2004-2005.
- Area 4 - The area immediately north and northwest of Gilfillan Lake and the Highway 96 Site where contaminants were detected in 1993-1994 (i.e. Lily Pond Road).
- Area 5 - The area immediately south and southwest of Gilfillan Lake and the Highway 96 Site (e.g. Dove Lane), where contaminants were detected in 1993-1994.

A map showing the location of each geographic area is provided on Figure 1.1. A detailed map of Areas 3 through 5 is shown on Figure 1.2.

Section 6.0 of this report presents the conclusions of the groundwater and residential well evaluation as it pertains to each of the geographic areas.

CONCLUSIONS

Based on the groundwater and residential well evaluation conducted during this study period along with data collected from previous studies, CRA has reached the following general conclusions:

- The groundwater extraction system installed at the Highway 96 continues to capture and remediate groundwater contamination.
- The unconsolidated glacial drift aquifer is not contaminated by vinyl chloride west of the Highway 96 Site.
- The Prairie du Chien aquifer is not contaminated by vinyl chloride.
- Groundwater within the St. Peter Sandstone aquifer flows westward.
- Residual concentrations of vinyl chloride east of Gilfillan Lake are diminishing as a result of natural attenuation.
- Extensive residential well sampling has confirmed that vinyl chloride is limited to one area west of Gilfillan Lake at three residential wells located at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill.
- Installation of new water supply wells in the Prairie du Chien is a viable permanent remedy for the residents affected by the vinyl chloride contamination.
- The vinyl chloride detected in the area of 12/13 West Shore Road and 2 Hummingbird Hill is part of the Highway 96 remnant plume. The vinyl chloride observed in 2004/2005 west of Gilfillan Lake migrated from the

Highway 96 Site many years before discovery of contamination at the Site in 1986 and many years before the start of groundwater remediation in 1989.

- Vinyl chloride concentrations in the Dove Lane area detected in 1993 did not originate at the Highway 96 Site and likely resulted from the degradation of household wastewater, which migrated to groundwater via a residential septic system.
- The installation of a groundwater extraction system located in the Ski Lane ravine area west of the 12/13 West Shore Road/2 Hummingbird Hill Area appears feasible. However, it is necessary to obtain Vertical Aquifer Profiling (VAP)/monitoring well data from the proposed groundwater evaluation in the 12/13 West Shore Road area to evaluate fully the potential effectiveness of a groundwater pump-out system in the Ski Lane ravine.
- Periodic and random detections of VOCs such as methyl ethyl ketone, toluene, and benzene in samples from residential wells have been observed and are expected to continue into the future. These compounds are well below their respective health risk limits. These detections are not related to the Highway 96 Site but probably result from household wastewater which entered the groundwater from residential septic systems.
- Periodic detections of chlorination compounds such as chloromethane and chloroform have been observed and will continue to occur. The presence of these volatile organic compounds (VOCs) probably results from well disinfection.

RECOMMENDATIONS

Based on the groundwater and residential well evaluation conducted during this study period along with data collected from previous studies, CRA recommends the following:

- Residential well sampling should continue, as outlined in CRA's June 2005 report.
- Residential well sampling should be conducted at 13 West Shore Road as the location has not been sampled since the MDH issued a drinking water well advisory in April 2005.
- New water supply wells screened in the Prairie du Chien aquifer should be installed at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill.
- Vertical profiling of groundwater quality in the St. Peter aquifer in the 12 West Shore Road/13 West Shore Road/2 Hummingbird Hill area should be conducted.

1.0 INTRODUCTION

This report presents the results of a continued Groundwater and Residential Well Evaluation conducted during the period from June 2005 through January 2006 in North Oaks, Minnesota.

1.1 PURPOSE

The following response actions were conducted by Conestoga-Rovers & Associates (CRA) on behalf of Whirlpool Corporation (Whirlpool) and Reynolds Metals Company (Reynolds) (as required by the Minnesota Pollution Control Agency (MPCA) in its letter dated September 1, 2005) during this reporting period:

- Residential well sampling;
- Septic tracer study (caffeine analysis);
- Vertical aquifer profiling;
- Monitoring well installation and sampling;
- Hydraulic analysis;
- Groundwater flow analysis;
- Installation of a new extraction well;
- Feasibility study of pump-out system (Ski Lane ravine);
- Review of City of North Oaks records;
- Public information/education program; and
- Feasibility study of sampling former augmentation well.

The purpose of this report is to present the results of the response actions and to provide an updated evaluation of the groundwater and residential wells in North Oaks.

1.2 NORTH OAKS GEOGRAPHIC AREAS

In its letter dated September 1, 2005, the MPCA required that the groundwater and residential well evaluation focus on five geographic areas. The presentation of results by area is intended to assist the residents of North Oaks to understand the groundwater and residential well evaluation as it relates to their neighborhood. The five geographic areas are as follows:

- Area 1 - The immediate vicinity of the Highway 96 Site.
- Area 2 - The areas west and north of Gilfillan Lake and the Highway 96 Site that are free of contaminants related to the Highway 96 Site.
- Area 3 - The areas immediately east and west of Gilfillan Lake, where vinyl chloride and other site-related contaminants were detected in 1993-1994 and again in 2004-2005.
- Area 4 - The area immediately north and northwest of Gilfillan Lake and the Highway 96 Site where contaminants were detected in 1993-1994 (i.e. Lily Pond Road).
- Area 5 - The area immediately south and southwest of Gilfillan Lake and the Highway 96 Site (e.g. Dove Lane), where contaminants were detected in 1993-1994.

A map showing the location of each geographic area is provided on Figure 1.1. A detailed map of Areas 3 through 5 is shown on Figure 1.2.

Section 6.0 of this report presents the conclusions of the groundwater and residential well evaluation as it pertains to each of the geographic areas.

2.0 BACKGROUND

The Highway 96 Site, located north of Highway 96 and west of Allendale Drive in White Bear Township, was operated as a small burning dump from the 1920s to 1973 and accepted primarily solid waste. In the late 1960s, the dump owners and operators also ran a business involving the transport of waste paints and solvents to other facilities for recycling, and some paints and solvents were disposed of at the dump.

In 1986, a study conducted by the United States Environmental Protection Agency (USEPA) discovered that groundwater beneath the Highway 96 Site was contaminated with volatile organic compounds (VOCs), including industrial, solvent-like chemicals. As a result of the study, the MPCA placed the Site into the Minnesota Superfund program; identified Reynolds, Whirlpool, Mrs. Helen A. Krawczewski, and Red Arrow Waste Disposal Company as potentially responsible parties; and requested them to investigate and clean up the contamination. Wastes sent to the Site by Faberge were also evaluated by the MPCA, but Faberge was not named as a responsible party.

Figure 2.1 shows the Site Plan for the Highway 96 Site.

2.1 HIGHWAY 96 SITE REMEDIATION AND MONITORING PROGRAM

Remediation of the Highway 96 Site commenced in 1987 and consisted of four major components.

2.1.1 SOURCE REMEDIATION

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, the NDA and the SDA waste materials 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 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. 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. 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).

2.1.2 GROUNDWATER REMEDIATION

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 leachate collection well 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 leachate collection well to reduce the potential for degradation of the groundwater in the deeper, drinking-water aquifers.

2.1.3 ALTERNATE WATER SUPPLY

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 shore of the lake to the White Bear Township municipal water system. These connections were completed in 1994.

Residential wells within the municipal water service area were sealed. Five residential wells on the east side of Gilfillan Lake were converted to long-term groundwater monitoring wells. One of these monitoring wells was sealed in 2000. The MPCA is requiring the responsible parties to undertake ongoing monitoring of the four remaining monitoring wells and periodic monitoring of residential wells that have not been connected to the municipal water system.

Figure 2.2 shows the area serviced by municipal water.

2.1.4 GROUNDWATER MONITORING PROGRAM

The MPCA and the responsible parties continue to monitor the groundwater at the Site and in downgradient residential areas.

2.1.4.1 MONITORING AT THE HIGHWAY 96 SITE

Prior to this reporting period, the on-site groundwater-monitoring network included 15 on-site monitoring wells screened in the perched groundwater, the unconsolidated glacial aquifer (Lower Sand aquifer), and the St. Peter Sandstone aquifer. In September 2005, an additional on-site monitoring/extraction well (EW-2) was installed in the St. Peter Sandstone aquifer. Installation of EW-2 is discussed in Section 4.0 of this report.

Groundwater samples are collected from on-site extraction wells on a quarterly 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.

2.1.4.2 MONITORING IN NORTH OAKS – EAST OF GILFILLAN LAKE

The current 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.

From 1993 to 2004, the MPCA and Whirlpool/Reynolds have monitored 20 residential wells located outside the municipal water service area and east of Gilfillan Lake on a regular basis.

Five residential wells on the east side 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, prior to the sale of the property. The other four converted residential monitoring wells are still in place and continue to be monitored on an annual basis.

Prior to this reporting period, the off-Site monitoring well network included four monitoring wells, screened in the Lower Sand aquifer and the St. Peter Sandstone aquifer, located west of the Highway 96 Site and east of Gilfillan Lake, along Robb Farm Road. In October 2005, two additional monitoring wells (MW-16B and MW16D) were installed along Robb Farm Road. Installation of these monitoring wells is discussed in Section 3.0 of this report.

The six off-site monitoring wells located along Robb Farm Road are also designated as compliance wells and are used to evaluate the effectiveness of the groundwater extraction system.

In September 2005 and December 2005, five additional off-site monitoring wells were installed. Three monitoring wells (MW-17A, MW-17B, and MW-17L) were installed west of the Highway 96 Site and east of Gilfillan Lake. The other two monitoring wells (MW-19B and MW-19L) were installed west of Gilfillan Lake, in the area known as the Ski Lane ravine. Installation of these monitoring wells is discussed in Section 3.0 of this report.

2.1.4.3 MONITORING IN NORTH OAKS - WEST OF GILFILLAN LAKE

From 1993 to 2004, the MPCA and Whirlpool/Reynolds have monitored 31 residential wells located west of Gilfillan Lake on a regular basis. Vinyl chloride was not detected in any residential well samples from 1994 through 2002.

In October 2004, during routine monitoring of residential wells west of Gilfillan Lake, low levels of vinyl chloride were detected in water samples collected from two residential wells: 12 West Shore Road (0.12 µg/L) and 13 West Shore Road (0.12 µg/L). Although the concentrations detected were below the health risk limit (HRL)[2] for vinyl chloride (0.2 µg/L) adopted by the Minnesota Department of Health (MDH), the Minnesota Pollution Control Agency (MPCA) requested that Reynolds and Whirlpool conduct a six-month groundwater and residential well evaluation to investigate the nature and extent of vinyl chloride contamination west of Gilfillan Lake.

[2] Health Risk Limit (HRL) is the health standard adopted by the MDH for the safe consumption of water from a private water supply over a lifetime

2.2 PREVIOUS GROUNDWATER AND RESIDENTIAL WELL EVALUATION (OCTOBER 2004 - MAY 2005)

The scope of the six-month groundwater and residential well evaluation was set forth by the MPCA in its letter to CRA dated January 7, 2005. CRA and the MPCA conducted five separate residential well sampling rounds between January 2005 and May 2005. During this period, 45 residential wells located west of Gilfillan Lake were sampled by CRA and the MPCA. Vinyl chloride was detected in only three residential wells, located in reasonably close proximity to each other, at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill. Vinyl chloride concentrations in these wells were detected at or below the HRL (0.2 µg/L). Vinyl chloride was not detected in any of the other 42 residential wells sampled (located north, south, and west of the three residences identified above).

Five other compounds, (1,1-dichloroethane, methyl ethyl ketone, cis-1,2-dichloroethene, chloroform, and methylene chloride) were detected in several samples collected during the January 2005 through May 2005 sampling events. However, all of these compounds were found at concentrations well below their respective HRLs.

Once the presence of vinyl chloride was confirmed at each location, Reynolds and Whirlpool began providing bottled water to 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill as an interim precautionary measure. Although not required by the MDH and the MPCA, the companies, as a voluntary measure, offered to provide bottled water to any resident in whose well vinyl chloride is detected at or above 0.08 µg/L. The companies have stated they will continue to provide bottled water to such residents until the groundwater situation has been fully evaluated or until the vinyl chloride concentration in their well declines below 0.08 µg/L for two consecutive sampling events. To date, Reynolds and Whirlpool continue to provide bottled water to 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill.

In April 2005, the MDH issued a drinking water well advisory to 13 West Shore Road. Because multiple compounds were detected at that location, the MDH took a conservative approach and issued an advisory even though no individual HRL had been exceeded.

CRA presented the results of the expanded sampling program to the MPCA in the "Groundwater and Residential Well Evaluation" Report (CRA, 2005). Based on the evaluation conducted from October 2004 to May 2005, CRA concluded the following:

- The presence of vinyl chloride is limited to three residential wells at 12 West Shore, 13 West Shore, and 2 Hummingbird Hill.
- The vinyl chloride now present in the wells at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill likely resulted from the westward migration of an area of vinyl chloride previously located east of Gilfillan Lake in the 15/17/22 Gilfillan Road area.
- If it is assumed that the vinyl chloride detected in the 12 West Shore Road/13 West Shore Road/ 2 Hummingbird Hill area originated from the Highway 96 Site, then the vinyl chloride would have left the Highway 96 Site well before the discovery of contamination at the Site in 1986.
- Residential septic systems are a potential source of groundwater contamination in North Oaks and a known source in other communities. Septic systems can release a variety of VOCs that may be found at low levels in residential wells. Further study is required to differentiate between contamination from the Highway 96 Site and septic systems.

Based on its conclusions, CRA recommended the following:

- A new water supply well screened in the Prairie du Chien aquifer should be installed at 13 West Shore Road. In the event the new well does not provide a potable water source, the residence should be provided with a home treatment system using activated carbon.
- Residential wells on the west side of Gilfillan Lake should continue to be monitored.
- An analysis of water samples for caffeine (a septic system tracer) should be conducted.
- Vertical profiling of groundwater quality in the St. Peter aquifer at two locations within North Oaks (12 West Shore/ 13 West Shore/ 2 Hummingbird Hill area and 15/17/22 Gilfillan Road area) should be undertaken.
- The potential for vinyl chloride to migrate to the west and the feasibility of purging the 12 West Shore Road/ 13 West Shore Road/ 2 Hummingbird Hill area should be evaluated.

On September 1, 2005, the MPCA issued a letter to CRA that stated the MPCA would use "a phased approach to approve, reject, or modify the additional response actions and recommendations proposed" in CRA's June 2005 Report. In its letter dated September 1, 2005, the MPCA outlined a list of response actions to be completed as part of a continued groundwater and residential well evaluation in North Oaks (see Section 1.0).

The results of the response actions and an updated groundwater and residential well evaluation are presented in the remaining sections of this report.

3.0 RESIDENTIAL WELL SAMPLING PROGRAM

As part of the continued groundwater and residential well evaluation, CRA and the MPCA conducted three residential well sampling rounds were conducted during this reporting period. These sampling rounds were conducted in June, August, and November 2005.

3.1 SAMPLING PROCEDURES

Water samples were only collected from well locations where express permission was obtained from the resident. Where possible, samples were collected from an outside tap and/or from an untreated water source (i.e., not softened or filtered). The water source was recorded for each sample collected. Before sample collection, the tap was allowed to run for at least 20 minutes to purge the water line and pressure tank of residual water. In a few cases, the purge time was reduced per request of the resident. If a sample was collected from an outside tap, the water was directed via a hose to an area of the yard that minimized the creation of ice or pooled water in an undesirable location. Water samples were collected directly from the tap after the purge hose was disconnected. Field measurements for pH, conductivity, temperature, dissolved oxygen, and oxidation reduction potential (ORP) were taken after purging, at the time of sampling. The date, purge rate, and purge time were also recorded. Samples were places on ice immediately following sample collection and were either sent by courier or hand delivered to the laboratory. All samples were handled using standard chain-of-custody procedures.

Appendix A presents a summary of field measurements and sampling notes for the June 2005, August 2005, and November 2005 residential well sampling events.

3.2 JUNE 2005 RESIDENTIAL WELL SAMPLING ROUND

The June 2005 residential well sampling round was conducted as part of the ongoing groundwater investigation in North Oaks on the west side of Gilfillan Lake. Samples were collected by CRA and the MPCA from 24 of 25 proposed sampling locations. A sampling summary is provided in Appendix A. One location, 13 West Shore Road, was not sampled because the resident did not grant access.

Each residential well sample was analyzed for VOCs and chloride. A total of four duplicate samples were collected for quality assurance/quality control (QA/QC) purposes. Duplicate sample locations are noted in Appendix A. A trip blank was also included with each sample cooler containing VOC samples submitted to the laboratory.

VOC samples collected on June 27 and June 28, 2005 were submitted to the MDH Environmental Laboratory for analysis (by MDH methods 468 and 460). VOC samples collected on July 6, 2005 were submitted to Columbia Analytical Services for analysis (by USEPA Method 524.2). All chloride samples were submitted to Pace Analytical Services, Inc. for analysis (by USEPA Method 325.2).

3.3 AUGUST 2005 RESIDENTIAL WELL SAMPLING ROUND

The August 2005 residential well sampling round was conducted as part of the Expanded Quarterly Residential Well Sampling Program (outlined in CRA's June 2005 Report). Samples were collected from 30 of 31 proposed sampling locations. A sampling summary is provided in Appendix A. One location, 13 West Shore Road, was not sampled because the resident did not grant access.

Each residential well sample was analyzed for VOCs, caffeine, and chloride. Split samples (for VOCs only) were collected at 10 of the residential well locations and a total of four duplicate samples were collected for QA/QC purposes. Split sample and duplicate sample locations are noted in Appendix A. A trip blank was also included with each sample cooler containing VOC samples submitted to the laboratory.

VOC samples were submitted to the MDH Environmental Laboratory for analysis (by MDH methods 468 and 460). Caffeine samples were submitted to Microbac Laboratories, Inc. for analysis. Chloride samples and split VOC samples were submitted to Columbia Analytical Services, Inc. for analysis (by USEPA Methods 325.2, and 524.2, respectively).

3.4 NOVEMBER 2005 RESIDENTIAL WELL SAMPLING ROUND

The November 2005 residential well sampling round combined three separate sampling programs: the Routine Annual Residential Well Sampling Program, the Expanded Quarterly/Annual Residential Well Sampling Program (outlined in CRA's June 2005 Report), and the one-time Additional Duck Pass Area Sampling Program (as requested by the MPCA in their letter dated September 1, 2005). Samples were collected from 67 of 78 proposed sampling locations. A sampling summary is provided in Appendix A. Eleven locations were not sampled because the resident declined sampling or did not grant access.

Each residential well sample was analyzed for VOCs and chloride. One rinsate blank, one matrix spike/matrix spike duplicate (MS/MSD) sample set, and a total of seven duplicate samples were collected for QA/QC purposes. QA/QC sample locations are noted in Appendix A. A trip blank was also included with each sample cooler containing VOC samples submitted to the laboratory.

VOC samples were submitted to the MDH Environmental Laboratory for analysis (by MDH methods 468 and 460). Chloride samples were submitted to Severn Trent Laboratories for analysis (by EPA method 300.0).

3.5 RESIDENTIAL WELL SAMPLING RESULTS (JUNE – NOVEMBER 2005)

Laboratory analytical reports and data quality assessment memos associated with the June, August, and November 2005 residential well sampling rounds are provided in Appendix B. Table 3.1 presents a summary of detected compounds in residential wells from June 2005 through November 2005. Table 3.1 also provides the current HRLs for comparison.

3.5.1 VINYL CHLORIDE

Vinyl chloride was detected in water samples collected from two residential well locations sampled between June 2005 and November 2005 (12 West Shore Road and 2 Hummingbird Hill). A third location, 13 West Shore Road, where vinyl chloride was previously detected, was not sampled during the study period because access was not provided.

Vinyl chloride concentrations in residential well samples collected during the June, August, and November 2005 residential well sampling rounds are presented on Figures 3.1, 3.2, and 3.3, respectively.

Minnesota has one of the most stringent drinking water standards for vinyl chloride in the United States. The state HRL for vinyl chloride is 0.2 µg/L, which is ten times more stringent than the federal standard (2.0 µg/L). The maximum concentration of vinyl chloride detected during this reporting period was 0.19 µg/L (estimated) at 12 West Shore Road in June and August 2005. The vinyl chloride results from this reporting period are consistent with results from previous sampling rounds conducted from October 2004 through May 2005. To date, vinyl chloride has never been detected above the HRL in any residential well located west of Gilfillan Lake.

The vinyl chloride detected in the area of 12/13 West Shore Road and 2 Hummingbird Hill is part of the Highway 96 remnant plume. The vinyl chloride observed in 2004/2005 west of Gilfillan Lake migrated from the Highway 96 Site many years prior to discovery of contamination at the Site in 1986 and many years prior to the start of groundwater remediation in 1989.

3.5.2 OTHER VOCs

Other VOCs were detected in various water samples collected from residential well locations between June 2005 and November 2005. All detections were well below their respective HRLs (where HRLs have been established). Each of these VOCs is discussed below.

1,1-dichloroethane was detected in four residential wells (12 West Shore Road, 2 Hummingbird Hill, 9 Duck Pass Road, and 22 Duck Pass Road) sampled during the study period. The maximum concentration detected was 0.5 µg/L at 9 Duck Pass Road and 22 Duck Pass Road in November 2005. The maximum concentration of 1,1-dichloroethane detected during this reporting period is well below its HRL (70 µg/L). The 1,1-dichloroethane detections at 12 West Shore Road and 2 Hummingbird Hill are attributed to the remnant plume from the Highway 96 Site. The detections of 1,1-dichloroethene at 9 and 22 Duck Pass Road were low in concentration and were infrequently detected. As such, the data are insufficient to determine a source.

Cis-1,2-dichloroethene was detected in two residential wells (12 West Shore Road and 2 Hummingbird Hill) sampled during this reporting period. The maximum concentration detected was 0.13 µg/L (estimated) at 12 West Shore Road in August and November 2005. The maximum concentration of cis-1,2-dichloroethene detected during this reporting period is well below its HRL (70 µg/L). The cis-1,2-dichloroethene detections are attributed to the remnant plume from the Highway 96 Site.

Freons, dichlorodifluoromethane (Freon 12) and dichlorofluoromethane (Freon 21) were detected in one residential well (10 Ski Lane) during the June 2005 sampling round and two residential wells (9 Duck Pass Road and 22 Duck Pass Road) sampled during the November 2005 sampling round. The maximum concentrations of Freon 12 and Freon 21 were 1.6 µg/L and 0.9 µg/L, respectively, at 22 Duck Pass Road. The maximum concentration of Freon 12 detected during this reporting period is well below its HRL

(1,000 µg/L). There is no HRL established for Freon 21. The Freon detections were low and were infrequently detected. As such, the data are insufficient to determine a source.

Chloroform was detected in one residential well (9 West Shore Road) sampled during the August 2005 sampling round. The concentration detected was 0.90 µg/L, which is well below its HRL (60 µg/L). The presence of chloroform can result from the use of chlorine to disinfect drinking water wells. The homeowner at 9 West Shore Road confirmed their well had been disinfected/chlorinated prior to the August 2005 sampling event. Therefore, the presence of chloroform in the August 2005 sample is attributed to the recent disinfection/chlorination of the well.

Chloromethane was detected in nine residential wells sampled during the November 2005 sampling round. The maximum concentration detected was 0.97 µg/L (estimated) at 4 Gadwall Lane. There is no HRL established for chloromethane. However, chloromethane can be associated with well disinfection. The presence of chloromethane in residential well samples collected during the November 2005 sampling round is inconsistent with results from previous sampling rounds. The detection of chloromethane is attributed to well disinfection.

Benzene was detected in one residential well sample (1 Thompson Lane) collected during the June 2005 sampling round. The concentration detected was 0.10 µg/L (estimated), which is well below its HRL (10 µg/L). The presence of benzene in this residential well is inconsistent with results from previous sampling rounds. In addition, benzene was not detected at this location during the subsequent August and November 2005 sampling rounds. The detection of benzene is attributed to household wastewater discharged to groundwater via residential septic systems.

Methyl ethyl ketone (MEK) was detected in two residential well samples (35 Robb Farm Road and 44 Robb Farm Road) collected during the June 2005 sampling round. The maximum concentration detected was 7.37 µg/L (estimated) at 44 Robb Farm Road, which is well below its HRL (4,000 µg/L). The presence of MEK in these residential wells is inconsistent with results from previous sampling rounds. In addition, MEK was not detected at these locations during the subsequent November 2005 sampling round. The detection of MEK is attributed to household wastewater discharged to groundwater via residential septic systems.

Toluene was detected in two residential wells (41 Robb Farm Road and 43 Robb Farm Road) sampled during the June 2005 sampling round. The maximum concentration detected was 1.7 µg/L at 41 Robb Farm Road, which is well below its HRL (1,000 µg/L). The presence of toluene in these residential wells is inconsistent with results from

previous sampling rounds. In addition, toluene was not detected at these locations during the subsequent November 2005 sampling round. The detections of toluene are attributed to household wastewater discharged to groundwater via residential septic systems.

3.5.3 CHLORIDE

Chloride is an inorganic chemical that occurs naturally in all groundwater. Chloride can also be related to landfills, road salt, and septic systems. The June, August, and November 2005 residential well samples were all analyzed for chloride. Chloride results are also presented on Table 3.1.

3.5.4 CAFFEINE

As recommended in CRA's June 2005 Report, residential well samples collected during the August 2005 sampling event were analyzed for caffeine (a known septic system tracer). The purpose of the caffeine analysis was to potentially identify the presence of septic system impacts to groundwater.

Caffeine was not detected in any of the residential well samples collected during the August 2005 sampling event. However, the absence of caffeine does not mean that septic systems do not impact groundwater, as further described in Section 5.3.

4.0 GROUNDWATER EVALUATION FIELD PROGRAM

This section discusses the field activities beyond residential well sampling that were conducted during this reporting period to further define the groundwater systems in the southeastern area of North Oaks. Based on these activities, an updated evaluation of the geology and hydrogeology is also presented.

4.1 FIELD ACTIVITIES

The groundwater evaluation field program consisted of the following seven field activities:

1. Vertical aquifer profiling (VAP);
2. Monitoring well installation;
3. Monitoring well and residential well surveying;
4. Groundwater level monitoring;
5. Single well response testing;
6. Monitoring well sampling; and
7. Geophysical logging.

All of these tasks were conducted in accordance with the MPCA's approval. Requested changes to the original scope of work were forwarded to the MPCA for its comments and approval. During the implementation of these activities, CRA communicated regularly with the MPCA and the MDH. The MPCA and the MDH visited the Site during the course of the field activities to observe VAP sampling and monitoring well installation procedures. Detailed descriptions of the tasks completed under the groundwater evaluation field program are presented in the following subsections.

4.1.1 VERTICAL AQUIFER PROFILING (VAP)

VAP was proposed at two locations (east and west of Gilfillan Lake). The purpose of VAP was to characterize the water quality in the three major water bearing units: the glacial drift aquifer, the St. Peter Sandstone aquifer, and the Prairie du Chien aquifer. Based on the VAP results, monitoring well screen locations were selected for further characterization. During the VAP program, access could not be obtained in the 12/13 West Shore Road area. An additional VAP location was selected further to the west in the Ski Lane ravine area.

VAP was conducted in accordance with the work plan submitted to the MPCA on August 11, 2005 and approved (with modifications) on September 2, 2005. VAP locations are shown on Figure 4.1.

VAP boreholes were advanced to the top of the Prairie du Chien using a 6-inch inside diameter rotosonic drill. As the VAP borehole was advanced, continuous sample cores were collected for geologic classification. The VAP boreholes were advanced to predetermined intervals for groundwater sample collection.

At MW-17L, one VAP groundwater sample was collected from the unconsolidated glacial drift aquifer, three VAP samples were collected from the upper, middle, and lower portions of the St. Peter Sandstone aquifer, and two VAP samples were collected from the Prairie Du Chein aquifer. Prior to collection of the VAP samples from the Prairie du Chien aquifer, the borehole was extended into the competent portion of the Prairie du Chien. The 6-inch borehole was then overdrilled using an 8-inch inside diameter (ID) rotosonic drill bit. A 4-inch low carbon steel casing was set inside the borehole and its annulus was tremie grouted to surface with a neat bentonite cement. After 48 hours, the VAP borehole was advanced into the Prairie du Chien aquifer.

At MW-19B, one VAP groundwater sample was collected from the unconsolidated glacial drift aquifer and three VAP samples were collected from the upper, middle, and lower portions of the St. Peter Sandstone aquifer. A VAP sampling summary is provided in Appendix C.

VAP groundwater samples were collected using a temporary well screen, sample pump, and inflatable packer system to isolate the VAP sample interval. Once the desired depth was reached, the temporary screen was placed at the bottom of the borehole and the casing was pulled back to expose the screen. For the samples collected in the Prairie du Chien aquifer, the temporary screen was set inside the open borehole.

Prior to VAP sampling, water in the borehole was pumped out to obtain a representative groundwater sample. Based on the recorded amount of drilling water used to drill each sample interval, a minimum of two times the volume of water introduced during that drilling phase was pumped and containerized for proper disposal. The volumes of water purged prior to sampling are included in the VAP sampling summary (Appendix C).

After purging, an inflatable packer system was then placed at the top of the temporary well screen. Once the packer system was inflated, the sampling pump was lowered

inside the temporary screen. Each VAP sample was collected under low-flow purge and sampling methods using a bladder pump or an electric submersible pump capable of pumping at 250 to 500 mL/minute. New polyethylene discharge tubing was used for each VAP sample.

Approximately every five minutes during the purging process, the following field parameters were measured and recorded: pH, temperature, conductivity, dissolved oxygen (DO), turbidity, redox potential (Eh), and the downhole water level. Field instruments were calibrated daily at the beginning of the day in accordance with manufacturer's specifications. Purging continued until stabilization occurred based on three consecutive readings within the following ranges:

+/- 0.5 for pH

+/- 10% for temperature

+/- 10% for conductivity

+/- 10% for DO and turbidity

+/- 10 mV for redox potential

Once stabilized, the sample was collected at a flow rate of 250 mL/min using the sampling procedures outlined in the work plan. Field parameters recorded during VAP sampling are summarized in Appendix C. Purge water was containerized and discharged to the sanitary sewer near the intersection of Blue Goose Road and Robb Farm Road with the approval of Metropolitan Council Environmental Services (MCES).

After sample collection, the samples were placed in coolers with ice and transported to the MDH laboratory for 24-hour turn-around laboratory analysis. VAP samples were analyzed using low-level VOC analysis MDH methods 460 and 468.

Analytical data reports were provided to the MPCA, via e-mail, during the VAP field investigation as CRA received them from the laboratory. Based on the results of the VAP sampling, monitoring well screen placement intervals were proposed to the MPCA for their approval.

4.1.2 MONITORING WELL INSTALLATION

Five new monitoring wells were installed east and west of Gilfillan Lake as a result of the VAP program (MW-17A, MW-17B, MW-17L, MW-19B, and MW-19L). In addition, two new compliance wells (MW-16B and MW-16D) were installed along Robb Farm

Road. Installation of the new compliance wells was proposed in 2003, but access to the proposed drilling locations was not finalized until this reporting period.

Monitoring wells were installed in accordance with the work plan submitted to the MPCA on August 11, 2005 and approved (with modifications) on September 2, 2005. Monitoring well locations are shown on Figure 4.1. Drilling and well installation activities were performed in accordance with MDH regulations. A well construction summary is presented on Table 4.1.

Based on the results of the VAP program, Whirlpool and Reynolds requested approval to install another monitoring well in the upper portion of the St. Peter Sandstone aquifer. Monitoring well MW-17A was installed to help further evaluate groundwater conditions in the St. Peter Sandstone aquifer. The depths of MW-17A, MW-17B, and MW-19B were determined based on the stratigraphy encountered and the results of VAP sample analyses described above. Prior to installation, analytical data and stratigraphic information were provided to the MPCA for concurrence and approval of screen depths.

Upon reaching the desired depth, a 2-inch diameter, 10-foot long, stainless steel well screen, with 2-inch diameter low carbon steel well casing, was installed at MW-16B, MW-16D, MW-17A, MW-17B, and MW-19B. A filter sand pack was placed around and approximately 2 to 3 ft. above the well screen. Above the filter sand, a minimum of 3 ft. of fine sand was used as a protective layer between the filter pack and grout. The remaining annulus was tremie grouted with cement containing 3 percent bentonite. A locking protective steel casing was placed over the well pipe to complete the well construction. Well construction and stratigraphic logs are presented in Appendix D.

MW-17L and MW-19L were completed as open-hole monitoring wells in the Prairie du Chien. While trying to install MW-19L, 20 ft. of 8-inch casing broke off from 220 ft. to 240 ft. below ground surface (bgs). The drillers were unable to retrieve it from the borehole. The borehole was then used to complete the MW-19B well installation. The bottom of the borehole was tremie grouted with cement containing 3 percent bentonite up to 5 ft. below the screen. Sand was placed from the top of the grout up to the bottom of the screen. The rest of the well installation is detailed above.

The Prairie du Chien wells were completed as open hole wells. An 8-inch borehole was advanced down into the competent portion of the Prairie du Chien. A 4-inch low carbon steel casing was then placed insided the borehole and tremie grouted in place with a neat bentonite cement. After allowing a minimum of 48-hours for the grout to set, a 4-inch borehole was advanced into the Prairie du Chien. A lockable protective cover was placed on the 4-inch casing to complete the well installation.

All borehole cuttings were containerized and then thin spread on the landfill cap for disposal. For the MW-17 well installation a staging area was designated for temporary storage of well installation materials and soil cuttings. Drilling equipment was also decontaminated at this location. The open area on the northwest corner of Gilfillan Road and Dove Lane was used as the staging area with approval from North Oaks Home Owners Association (NOHOA). All drilling equipment was decontaminated by hot water, high pressure cleaning prior to use at each borehole location. All pumps, screens, and other sampling equipment were decontaminated by hot water, high pressure cleaning and rinsed with clean water prior to collecting each sample. All decontamination fluids were containerized and discharged to the sanitary sewer near the intersection of Blue Goose Road and Robb Farm Road under MCES approval.

After installation, the monitoring wells were developed by the drilling contractor via airlifting and pumping to a sand-free condition. During development, field parameters were collected to verify well stabilization. Well developments records are provided in Appendix E.

4.1.3 SURVEYING

After well construction was completed, each new monitoring well was surveyed for elevation and location by a licensed surveyor. Two residential wells (6 West Shore Road and 38 East Oaks Road) were also surveyed (with approval from the homeowners and the MPCA) to assist in groundwater level monitoring.

4.1.4 GROUNDWATER LEVEL MONITORING

Groundwater flow patterns were evaluated by determining groundwater elevations at the seven new off-Site monitoring wells, plus existing compliance wells MW-12B, MW-12D, MW-13B, MW13D, the converted residential monitoring wells (1 Lily Pond, 11 Lily Pond, 6 Blue Goose Road, and 11 Robb Farm Road), and two additional residential wells (6 West Shore Road and 38 East Oaks Road). Groundwater elevations were measured using an electric measuring tape. The depth to water was measured to the nearest 0.01 foot. Groundwater elevations measured in the North Oaks area between October 2005 and January 2006 and are provided in Table 4.2.

4.1.5 SINGLE WELL RESPONSE TESTS

Single well response tests were performed on the seven new off-Site monitoring wells (MW-16B, MW-16D, MW-17A, MW-17B, MW-17L, MW-19B and MW-19L) to estimate the hydraulic conductivity of the unconsolidated glacial drift, upper and basal St. Peter Sandstone, and the upper portion of the Prairie du Chien (i.e., Shakopee Formation) groundwater systems.

Both falling head and rising head single well response tests were performed at each of the new well locations. The tests were performed by introducing and removing a precleaned PVC slug of known volume into the column of water in the well. For the glacial drift and St. Peter Sandstone well locations, a 2.5-foot by 1.25-inch PVC slug was used. For the Prairie du Chien well locations, a 5-foot by 3-inch PVC slug was used. The water level response in the well was recorded using a pressure transducer with an electronic datalogger.

The single well response data were entered into the computer software AQTESOLV® for Windows (Version 3.5). The single well response test data were analyzed using the Bouwer-Rice Method (1976) for an unconfined aquifer. The single well response test results are summarized in Table 4.3 and the AQTESOLV® reports are provided in Appendix F.

As shown on Table 4.3, the hydraulic conductivity values vary between the unconsolidated glacial drift, the St. Peter Sandstone, and the Prairie du Chien groundwater systems. The glacial drift exhibits the lowest hydraulic conductivity values, which is indicative of its fine-grained composition. The St. Peter Sandstone aquifer show a wider range of hydraulic conductivity values. At the MW-17 well nest, the upper St. Peter Sandstone location (MW-17A) has an expected higher hydraulic conductivity than the shaley basal St. Peter Sandstone (MW-17B). However, on the west side of Gilfillan Lake at MW-19B, the hydraulic conductivity of the basal St. Peter Sandstone is higher. The Prairie du Chien locations exhibit the highest hydraulic conductivity values.

4.1.6 MONITORING WELL SAMPLING

A minimum of one week after well development was completed, each of the seven new off-Site monitoring wells, and the existing compliance monitoring wells MW-12D, MW-12B, MW-13B, and MW-13D, were sampled. Monitoring wells were sampled in accordance with the work plan submitted to the MPCA on August 11, 2005 and approved (with modifications) on September 2, 2005.

Prior to sample collection, the monitoring wells were purged using an electric submersible pump or a bladder pump with dedicated polyethylene tubing. The pump was placed at the midpoint of the well screen or open hole interval. Low flow groundwater purging techniques were utilized in general accordance with USEPA guidance[3]. Purging was conducted at a steady flow rate of approximately 250 to 500 mL/min. Approximately every five minutes during the purging process, the groundwater level and the following field parameters were measured and recorded: pH, temperature, conductivity, DO, turbidity, and Eh. Purging continued until there was stabilization based on three consecutive readings within the following ranges:

+/- 0.5 for pH

+/- 10% for temperature

+/- 10% for conductivity

+/- 10% for DO and turbidity

+/- 10 mV for redox potential

After three consecutive readings were obtained, groundwater samples were collected. Monitoring wells were sampled using low flow techniques (<250 mL/min). A monitoring well sampling summary is provided in Appendix G.

For QA/QC purposes, field duplicate samples, rinsate samples, and MS/MSD samples were collected. QA/QC sample locations are noted in Appendix G. A trip blank was also included with each sample cooler containing VOC samples submitted to the laboratory.

After sample collection, monitoring well samples were placed in coolers with ice and transported to the MDH Environmental Laboratory. All samples were analyzed for VOCs. Samples collected from monitoring wells MW-17A, MW-17B, MW-17L, MW-19B, and MW-19L were analyzed using low-level VOC analysis MDH methods 460 and 468. Samples collected from MW-16B, MW-16D, MW-12B, MW-12D, MW-13B, and MW-13D were analyzed using USEPA Method 8260.

Groundwater samples from MW-17L, MW-19B, and MW-19L were also analyzed for one or more general water quality parameters (i.e., alkalinity, hardness, iron, sulfate, sulfide, and total dissolved solids). These samples were placed in coolers with ice and shipped

[3] Puls, Robert W. and Barcelona, Michael J., Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, USEPA Office of Solid Waste and Emergency Response, EPA/540/S-95/504, April 1996.

to Severn Trent Laboratories (STL) in North Canton, Ohio under standard chain of custody procedures.

4.1.7 GEOPHYSICAL LOGGING

With assistance from the Minnesota Geological Survey (MGS), the two newly installed Prairie du Chien wells, MW-17L and MW-19L, were geophysically logged. MGS used a tool to log the natural gamma, electrical resistivity and electric self-potential at each well. The geophysical logging was used to identify contact zones between the glacial drift, upper and basal St. Peter Sandstone, and the upper Prairie du Chien (i.e., Shakopee Formation). Geophysical logs are presented in Appendix H.

The geophysical logs delineate the above mentioned stratigraphic units, particularly the separation between sands and shale/clays. For instance, the separation between the upper and basal St. Peter Sandstone is defined when the gamma ray count (i.e., API units) exceeds 50. Dense clays or shales typically have API units greater than 140, whereas clean sands record API units between 10 and 20 (Respold, 1989).

4.2 ANALYTICAL RESULTS

4.2.1 VAP SAMPLING RESULTS

Laboratory analytical reports and data validation memos associated with the VAP activities are provided in Appendix B and a summary of detected compounds is presented in Table 4.4. Vinyl chloride concentrations from VAP samples are shown on Figure 4.2.

VAP samples were collected at two locations, MW-17 and MW-19, which are situated on the east side and west side of Gilfillan Lake, respectively. VAP samples were collected from the glacial drift; from the upper, middle, and basal portions of the St. Peter Sandstone; and from the Prairie du Chien.

At MW-17, the VAP samples collected from the glacial drift and Prairie du Chien did not contain vinyl chloride or other site-related compounds (e.g., 1,1-dichloroethane). Of the three St. Peter Sandstone aquifer samples, both the upper and basal samples detected vinyl chloride at concentrations of 0.5 µg/L and 0.2 µg/L, respectively. The middle St. Peter Sandstone aquifer sample that was collected at the upper and basal St. Peter Sandstone interface did not contain vinyl chloride. Based on the VAP results for MW-17, two monitoring wells placed in the upper and basal portions of the St. Peter

Sandstone were proposed to the MPCA. The MPCA approved the installation of two wells in the St. Peter Sandstone aquifer.

Vinyl chloride or other site-related VOCs were not found in any of the VAP samples collected from the MW-19 area. Based on the MW-19 analytical data, only one St. Peter Sandstone aquifer monitoring well was installed in the basal portion of the aquifer.

4.2.2 MONITORING WELL SAMPLING RESULTS

Laboratory analytical reports and data validation memos associated with the monitoring well sampling are provided in Appendix B and a summary of detected compounds is presented in Table 4.5.

4.2.2.1 VOCs

Compliance Wells

Vinyl chloride was not detected in the samples collected from the three unconsolidated glacial drift compliance wells. Some site-related compounds were detected in the samples collected from MW-13D and MW-16D, such as 1,1-dichloroethane and cis-1,2-dichloroethene, but at concentrations well below their respective HRLs (70 µg/L).

Vinyl chloride was not detected in the samples collected from the three upper St. Peter Sandstone aquifer compliance wells. Some site-related compounds were detected in the samples, such as dichlorodifluoromethane (Freon 12) and 1,1-dichloroethane, but at concentrations well below their HRLs (1,000 µg/L and 70 µg/L, respectively).

MW-17 Location

MW-17A was the only location where vinyl chloride was detected. Vinyl chloride was detected at a concentration of 0.7 µg/L. The basal St. Peter Sandstone well (MW-17B) and the upper and lower Prairie du Chien well samples from MW-17L did not detect vinyl chloride or other site related VOCs, such as 1,1-dichloroethane. Toluene was detected in some of the samples at estimated concentrations well below its HRL (1,000 µg/L). The presence of toluene is considered to be unrelated to the Highway 96 Site.

MW-19 Location

None of the samples collected from MW-19B or MW-19L contained vinyl chloride or other Highway 96 Site-related compounds. Toluene was detected in the samples

collected from MW-19L at estimated concentrations well below its HRL (1,000 µg/L). The presence of toluene is considered to be unrelated to the Highway 96 Site.

4.2.2.2 GENERAL WATER QUALITY

General water quality samples were collected to compare the water quality within the St. Peter Sandstone and Prairie du Chien aquifers. General water quality results are also presented on Table 4.5. The primary water quality difference between the two aquifers is that the Prairie du Chien aquifer has overall lower iron concentrations than the St. Peter Sandstone aquifer. In addition, other water quality parameters such as hardness and sulfate are generally lower in the Prairie du Chien aquifer. These lower concentrations make groundwater from the Prairie du Chien aquifer more aesthetically pleasing (i.e. better taste, smell, and appearance) than groundwater from the St. Peter Sandstone aquifer.

4.3 GROUNDWATER EVALUATION

4.3.1 GEOLOGY

The geology of the North Oaks area consists of three significant stratigraphic units: unconsolidated glacial deposits, St. Peter Sandstone, and the Prairie du Chien Group (an interbedded limestone and sandstone unit).

The variable topography of the eastern North Oaks area is typical of a glacial deposit terrain, and ranges in elevation from 910 ft above mean sea level (AMSL) to greater than 970 ft AMSL. The unconsolidated deposits are comprised of a mixture of sediment with appreciable amounts of clay, silt, sand, and gravel particles. This area has been identified by the MGS as a complex intermixed deposit of glacial till with sandy loam and sandy clay loam (Meyer, 1985[4]). The unconsolidated glacial deposit ranges from 50 to 150 ft and is rarely used as a potable water supply in the North Oaks area.

The unconsolidated glacial deposits are typically underlain by the St. Peter Sandstone. However, erosional remnants of the younger Platteville Limestone and Glenwood Shale formations are sporadically observed in this area.

[4] Meyer, G.N. 1985. Quaternary Geologic Map of the Minneapolis-St. Paul Urban Area; Minnesota Geological Survey, Misc. Map Series M-54.

Regionally, the St. Peter Sandstone is classified as a white, fine to medium grained, well sorted, silica sandstone. The St. Peter Sandstone typically ranges in thickness from 0 to 150 ft. The lower 5 to 50 ft of the St. Peter Sandstone exhibits varying amounts of siltstone and shale (Stone, 1965).

Based on the recently completed North Oaks drilling program, the St. Peter Sandstone can be divided into two stratigraphic sub-units: the upper St. Peter Sandstone and the basal St. Peter Sandstone. The division of St. Peter Sandstone into two sub-units is based on lithologic differences. The upper St. Peter Sandstone appears as a soft, white fine grained quartz sandstone, which typically fits the standard description of the St. Peter Sandstone. In the southeast portion of North Oaks, the upper St. Peter Sandstone is of variable thickness from approximately 10 ft. to 100 ft. The variable thickness is due primarily to glacial erosion.

The basal St. Peter Sandstone is first identified by the presence of a shale unit. The shale unit is a gray, weakly consolidated, shale that ranges in thickness from 10 to 20 ft. In the southeast portion of the North Oaks area, this shale unit is encountered at an elevation between 770 and 750 ft. AMSL. At MW-17 and MW-19, a 13 to 21 ft shale layer is observed on both the eastern and western sides of Gilfillan Lake.

Below the shale unit the remaining basal St. Peter Sandstone described as a gray shaley sandstone that can be interbedded with thin shale layers. The basal portion of the St. Peter Sandstone is approximately 60 to 70 ft. thick. The basal portion of the St. Peter Sandstone transitions into the Shakopee Formation of the Prairie du Chein Group. The transition zone consists of St. Peter Sandstone intermixed with gravel-size pieces of the Shakopee Formation, which represents the upper part of the Prairie du Chien Group.

As noted above, the bedrock surface of the St. Peter Sandstone in the eastern North Oaks area is highly variable due to glacial erosion. Figure 4.3 presents the bedrock topographic surface of the St. Peter Sandstone. As shown on Figure 4.3, the bedrock surface elevation can vary by more than 100 ft. Another noted feature is the presence of a bedrock trough underneath Gilfillan Lake. The depth of this trough likely extends beyond a depth of 765 ft. AMSL, which is the lowest recorded elevation of the St. Peter Sandstone at 15 Lilly Pond. At that depth, the shale unit in the basal St. Peter Sandstone may have been exposed and possibly eroded away.

The Prairie du Chien Group consists of the upper Shakopee Formation followed by the Oneta Dolomite and is classified as an interbedded dolomitic limestone and sandstone. Regionally, the Prairie du Chien Group ranges in thickness from 0 to 250 ft. The Prairie du Chien Group and the underlying Jordan Sandstone together form the primary

aquifer for municipal water supply in the Minneapolis-St. Paul metropolitan area. For example, White Bear Township and the City of Vadnais Heights municipal wells draw water from this combined bedrock formation.

Two geologic cross-sections have been constructed to show the underlying geologic conditions and the depth of monitoring wells and residential wells in the area. Geologic cross-section locations are presented on Figure 4.4. 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. Both geologic cross-sections are provided in Appendix I.

4.3.2 HYDROGEOLOGY

In this section groundwater and surface water are discussed as they relate to the North Oaks area. For groundwater, there are three significant groundwater-stratigraphic units: the unconsolidated glacial drift aquifer, the St. Peter Sandstone aquifer and the Prairie du Chien aquifer. However, as noted in the previous section, the St. Peter Sandstone consists of two stratigraphic subunits, each with their own unique hydrogeologic characteristics. For this report, the glacial drift, St. Peter Sandstone, and Prairie du Chien aquifers were evaluated.

4.3.2.1 GLACIAL DRIFT AQUIFER

At the Highway 96 Site, the natural groundwater flow direction is to the west. However, this westerly pattern is influenced by changes in the unconsolidated glacial drift lithology. The hydrogeology of the glacial drift is variable depending on its sand, silt and clay content. For instance at the Highway 96 Site, the glacial drift has a sufficient amount of sand such that it is classified as the Lower Sand aquifer. Immediately to the west of the Highway 96 Site, the percentage of silt and clay increases thereby reducing its ability to readily transmit groundwater. At MW-16D, single well response tests calculated an average hydraulic conductivity of 2×10^{-5} ft/min (0.03 ft/d), which is one to two orders of magnitude less than the values calculated for the underlying St. Peter Sandstone wells (Appendix F).

The reduction in permeabilty affects groundwater flow migration pattern by inducing a stronger downward flow component to the St. Peter Sandstone aquifer. This relationship is recognized by comparing groundwater elevation difference between the glacial drift and St. Peter Sandstone groundwater systems. At monitoring well nests

MW-10, MW-12, and MW-13, there is substantial groundwater elevation differences between the glacial drift (D wells) and St. Peter Sandstone wells (B wells). The strong downward vertical gradients between the two systems is due to the low permeability of the glacial drift. The result of the reduced permeability is that groundwater from the Lower Sand aquifer originating from the Site, prior to remediation, was directed downwards into the St. Peter Sandstone aquifer. Hence, the glacial drift aquifer further to the west of the Highway 96 Site should not be affected by historical groundwater plume migration. Figure 4.5 shows 2004/2005 vinyl chloride concentrations at VAP locations and well locations screened within the glacial drift aquifer, west of the Highway 96 Site. As shown on Figure 4.5, vinyl chloride is not detected in the glacial drift aquifer.

4.3.2.2 ST. PETER SANDSTONE AQUIFER

Groundwater flow in the St. Peter Sandstone aquifer is towards the west for both the upper and basal portion of the aquifer. For the upper St. Peter aquifer, groundwater flow is characterized by the St. Peter Sandstone monitoring wells at the Highway 96 Site along with MW-17A. Figure 4.6 shows the upper St. Peter Sandstone aquifer groundwater contours for November 2005.

Groundwater flow in the basal St. Peter Sandstone aquifer is characterized by monitoring wells MW-17B and MW-19B, the four converted residential monitoring wells (1 Lily Pond, 11 Lily Pond, 6 Blue Goose and 11 Robb Farm Road), and supplemented by two residential wells located on the west side of Gilfillan Lake (6 West Shore Road and 38 East Oaks Road). Figure 4.7 shows the basal St. Peter Sandstone aquifer groundwater contours for December 2005. As shown on Figure 4.7, the groundwater contours steepen immediately west of the Site. The increased hydraulic gradient is attributed to lithologic changes in the glacial drift and the undulating thickness of the St. Peter Sandstone.

The hydrogeologic characteristics of the upper and basal portions of the St. Peter Sandstone aquifer are unique based on their respective lithology. The upper portion of the St. Peter Sandstone has an overall higher permeability than the underlying basal St. Peter Sandstone. The single well response tests performed at MW-17A (upper St. Peter Sandstone) showed a hydraulic conductivity value four times greater than at MW-17B (basal St. Peter Sandstone) (see Appendix F). The hydraulic conductivity of the upper St. Peter Sandstone aquifer has been characterized previously by work conducted at the Highway 96 Site and by the single well response tests at MW-16B and MW-17A. At the Highway 96 Site, the hydraulic conductivity analysis of the upper St. Peter Sandstone aquifer gave an average value of 0.01 ft/min (15 ft/d). The single response tests

conducted at MW-16B and MW-17A determined a lower value ranging from 0.002 ft/min to 0.004 ft/min (3 to 6 ft/d).

The basal portion of the St. Peter Sandstone has an overall lower permeability due to the presence of the shale unit, as well as the overall shaley nature of the basal St. Peter Sandstone. At MW-17, a downward vertical gradient of 0.07 ft/ft is observed, which is attributed to the increased shale content in the basal St. Peter Sandstone.

For the basal St. Peter Sandstone, single well response tests were conducted at MW-17B and MW-19B. The single well response test presented a hydraulic conductivity value ranging from 0.0002 ft/min to 0.005 ft/min (0.3 to 7 ft/d). Overall, the basal St. Peter Sandstone has a lower hydraulic conductivity value by approximately an order of magnitude compared to the upper St Peter Sandstone aquifer. It should also be noted that as the basal St. Peter Sandstone transitions into the Prairie du Chien, its hydraulic conductivity likely increases. This situation may be the case at MW-19B where the well screen is located closer to the contact between the St. Peter Sandstone and Prairie du Chien (i.e., Shakopee Formation). A review of the well logs show that MW-19B is a few ft. above the contact (see Appendix D).

Figure 4.8 shows 2004/2005 vinyl chloride concentrations at monitoring well locations and residential well locations screened within the St. Peter Sandstone aquifer, west of the Highway 96 Site. As shown on Figure 4.8, vinyl chloride was detected in this aquifer in two locations: east of Gilfillan Lake in the 15 Gilfillan Road/17 Gilfillan Road/8 Edgewater Lane area and west of Gilfillan Lake in the 12 West Shore Road/13 West Shore Road/2 Hummingbird Hill area.

The presence of vinyl chloride in the St. Peter Sandstone aquifer on the east side of Gilfillan Lake in the 15 Gilfillan Road/17 Gilfillan Road/8 Edgewater Lane area is consistent with historical sampling results. However, vinyl chloride concentrations east of the lake have decreased since 1993. The decreasing vinyl chloride concentrations are attributed to two factors: the Highway 96 groundwater extraction system and natural attenuation. The Highway 96 Site groundwater extraction system has been capturing groundwater contamination at the site since 1989. Hence, no new vinyl chloride is affecting off-site groundwater. Natural attenuation is reducing the residual vinyl chloride concentrations by mechanical (i.e. dispersion) and chemical (biodegradation) processes.

The Highway 96 Site groundwater extraction system has been capturing the groundwater contamination at the site since 1989. Hence, no new vinyl chloride is

affecting off site groundwater. Natural attenuation is reducing the residual concentrations by mechanical (dispersion) and chemical (biodegradation) processes.

Vinyl chloride concentrations in the St. Peter Sandstone aquifer on the west side of Gilfillan Lake in the 12 West Shore Road/13 West Shore Road/2 Hummingbird Hill area have remained essentially unchanged since October 2004 (although no data has been collected from 13 West Shore Road since April 2005). The sampling data collected over the past 13 months indicate that there is a narrow vinyl chloride plume of limited extent. However, VAP and monitoring well data from the 12/13 West Shore Road would help to characterize further the nature and extent of the vinyl chloride contamination in this area.

4.3.2.3 PRAIRIE DU CHIEN AQUIFER

Groundwater flow in the Prairie du Chien is regionally towards the west (Norvitch and others, 1973). The Shakopee Formation, which underlies the basal St. Peter Sandstone, has a substantially higher hydraulic conductivity compared to the St Peter Sandstone aquifer. Single well response tests conducted at MW-17L and MW-19L determined hydraulic conductivity values of 0.06 ft/min to 0.13 ft/min (86 to 187 ft/d). Figure 4.9 shows 2004/2005 vinyl chloride concentrations at monitoring well locations and residential well locations screened within the Prairie du Chien aquifer, west of the Highway 96 Site. As shown on Figure 4.9, vinyl chloride is not detected in the Prairie du Chien aquifer.

The Prairie du Chien aquifer is utilized as part of the primary groundwater supply for the Minneapolis - St. Paul metropolitan area. Water quality data obtained from the City of Vadnais Heights is provided in Appendix J. The water quality results from the Prairie du Chien in North Oaks (MW-17L and MW-19L) are consistent with the water quality of the Prairie du Chein in Vadnais Heights. The recent groundwater evaluation has shown the Prairie du Chien has not been impacted by contamination from the Highway 96 Site and represents a safe alternative water supply.

4.3.3 GROUNDWATER FLOW ANALYSIS

Prior to the implementation of the groundwater extraction system in 1989, groundwater flow in both the glacial drift and St. Peter Sandstone aquifer was westward from the Highway 96 Site. Immediately west of the Highway 96 Site, groundwater in the glacial drift is directed downwards towards the St. Peter Sandstone, due to geologic changes.

This condition is evidenced by the strong downward vertical gradients observed at monitoring well nests: MW-10, MW-12, and MW-13.

As the groundwater enters into the St. Peter Sandstone from the drift, the St. Peter Sandstone aquifer responds to the additional groundwater flux from the glacial drift with an enhanced horizontal hydraulic gradient, as shown on Table 4.2. As groundwater from the glacial drift enters the St. Peter Sandstone aquifer, groundwater from both the glacial drift and the upper St. Peter Sandstone recharges the basal St. Peter Sandstone as it moves westward.

Groundwater flow in the St. Peter Sandstone aquifer east of Gilfillan Lake is influenced by the composition and thickness of the glacial drift on top of the undulating St. Peter Sandstone. These geologic features cause localized variations in groundwater flow. As St. Peter Sandstone groundwater approaches the east side of Gilfillan Lake, the flow direction appears to stabilize to a consistent westward direction, such that the horizontal hydraulic gradients decrease. The hydraulic conductivity of the St. Peter Sandstone aquifer can vary based on the lithology. However, the overall range is relatively comparable and does not differ by much more than an order of magnitude. The flow velocities in the St. Peter Sandstone aquifer can vary locally, depending on the hydraulic conductivity and hydraulic gradient. However, the average linear velocity estimated at 80 ft/yr for the area of the Highway 96 Site still represents a reasonable approximation for average groundwater flow rates for the St. Peter Sandstone aquifer.

5.0 ADDITIONAL RESPONSE ACTIONS

In addition to the recommendations presented in CRA's June 2005 Report, the MPCA also required the following response actions be performed.

5.1 INSTALLATION OF NEW EXTRACTION WELL

5.1.1 BACKGROUND

The groundwater extraction system at the Highway 96 Site captures contaminated groundwater and prevents off site migration of the contaminant plume. Figure 5.1 shows a geologic cross-section that depicts the groundwater extraction system and the Highway 96 Site. The performance of the groundwater extraction system is monitored through measurement of groundwater pumping rates, water levels, and groundwater chemistry. A performance assessment of the groundwater extraction system is provided to the MPCA on an annual basis as part of the Highway 96 Site Annual Monitoring Report.

The gradual decline of EW-1 pumping capacity 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. Based on these conditions, in its letter dated September 1, 2005, the MPCA required that a new extraction well be installed in the St. Peter Sandstone aquifer. The MPCA also stipulated that the new extraction well should be capable of pumping at a rate between 15 and 25 gpm and must capture contamination as groundwater moves downgradient.

On September 8, 2005 CRA submitted a work plan to install a new St. Peter Sandstone aquifer extraction well (EW-2). On September 15, 2005, the MPCA approved the EW-2 Installation Work Plan on the condition that the groundwater sample from the step test confirmed the presence of vinyl chloride and other VOCs.

A letter report describing installation and performance testing results associated with the new extraction well was provided to the MPCA on December 7, 2005. The following sub-sections provide the results of the report and provide an evaluation of the hydraulic influence of the groundwater extraction system.

5.1.2 WELL INSTALLATION

EW-2 was installed adjacent to EW-1A. EW-2 was initially drilled using rotary drilling techniques and was completed using a rotosonic drill rig. A 10-inch borehole was advanced to a depth of 125 ft. bgs. A six-inch ID low carbon steel well casing attached to 10-ft. of stainless steel well screen (#10 slot). A filter sand pack was placed around and a minimum of two ft. above the well screen. A 2-foot bentonite seal was placed above the sand filter pack. The remaining annulus was tremie grouted to surface with a neat bentonite cement. A well construction log for EW-2 is presented in Appendix D.

Extraction well development began no sooner than 48 hours after the well installation was completed. EW-2 was developed by mechanical surging and groundwater pumping. Well development continued until a sand-free condition was obtained. The well development record for EW-2 is provided in Appendix E.

5.1.3 PERFORMANCE TESTING

EW-2 well performance testing was performed on October 21, 2005. Well performance testing involved pumping EW-2 at three successively higher rates of 10 gpm, 20 gpm, and 30 gpm for one hour periods. During each step test, the depth to water inside EW-2 was measured every five minutes and the pumping rate was periodically verified. Groundwater from the well performance test was directly discharged into the sanitary sewer under MCES approval.

The water level monitoring data associated with the EW-2 step tests are provided in Appendix K. The data were evaluated to determine the specific capacity of EW-2. Specific capacity is the ratio of the groundwater pumping rate (Q) to measured drawdown (dh). The specific capacity values for the three different pumping rates are also presented in Appendix K. The specific capacity values ranged from 0.38 gpm/ft to 0.50 gpm/ft. Although the specific capacity increases slightly with the increasing pumping rate, the values are quite similar. By averaging the three values, an initial overall specific capacity value of 0.45 was determined to represent the well performance of EW-2.

During the EW-2 step tests, nearby monitoring wells were periodically monitored for hydraulic response due to pumping. The hydraulic response measurements from these monitoring wells are presented in Appendix K. Monitoring wells MW-8B and MW-10B showed a substantial hydraulic response (i.e., >0.6 ft). Monitoring wells MW-4D and MW-16B showed a measurable hydraulic response of approximately 0.38 ft. MW-16D showed some hydraulic response, while the water level at MW-10D was non-responsive.

5.1.4 GROUNDWATER CHEMISTRY

During the EW-2 step tests, groundwater samples were collected for analysis of VOCs, chloride, pH, total dissolved solids, and chemical oxygen demand, as required by the MCES discharge permit. A sampling summary is provided in Appendix K. Samples were shipped to Columbia Analytical under standard chain of custody procedures.

The laboratory analytical report and data validation memo associated with the EW-2 step tests are provided in Appendix B. The analytical results are summarized in Appendix K. The VOC sample contained predominantly chlorinated VOCs with a total concentration of approximately 16 µg/L. Vinyl chloride was detected a concentration of 1.6 µg/L. The sample results confirm that EW-2 was installed within the Highway 96 groundwater plume.

5.1.5 OPERATION OF EW-2

Based on the results of the EW-2 step test and analysis of groundwater samples, EW-2 is an appropriate replacement extraction well for EW-1. EW-2 meets the requirements of the MPCA, as outlined in its letters dated September 1 and September 15, 2005, with respect to both pumping rate and effluent water quality.

On January 9, 2005, EW-2 began operation at a pumping rate of 15 gpm. The resultant combined pumping rate for EW-1A and EW-2 was approximately 27 gpm. Upon start-up of EW-2, groundwater level measurements were collected on a scheduled basis, as outlined in Appendix K, from surrounding monitoring wells to evaluate the hydraulic influence of EW-2/EW-1A on the glacial drift and St. Peter Sandstone aquifer systems. Groundwater level measurements associated with the EW-2/EW-1A hydraulic influence evaluation are summarized in Table 5.1.

Figures 5.2, 5.3, and 5.4 show groundwater contours associated with EW-2 for pre-startup, Day 2, and Day 23, respectively. Figure 5.2 shows the capture area of EW-1A, before start-up of EW-2. Figures 5.3 and 5.4 show the combined capture area of the EW-1A/EW-2 extraction system.

5.2 FEASIBILITY OF PUMP-OUT SYSTEM (SKI LANE RAVINE)

One of the recommendations presented in CRA's June 2005 Report was to evaluate the feasibility of purging contaminated groundwater in the vicinity of the Ski Lane ravine. The recommendation was based on the potential for a groundwater pump-out system located in this area to prevent westward migration of the vinyl chloride contamination detected in the 12 West Shore Road/13 West Shore Road/2 Hummingbird Hill area. In its letter dated September 1, 2005, the MPCA conditionally approved the concept, pending review of a work plan to be submitted to the MPCA by December 1, 2005.

On November 29, 2005, the MPCA granted CRA an extension for submitting the evaluation. The extension was granted due to access issues associated with the proposed groundwater investigation to be conducted in the area of 12/13 West Shore Road. The feasibility study of the pump-out system was to be based, in part, on data obtained from the proposed investigation in this area. To date, access to 12/13 West Shore Road area has not been granted. Hence, this evaluation has been completed without the benefit of this key information.

As noted previously, additional monitoring wells were installed in the Ski Lane Ravine area (MW-19B and MW-19L) to characterize the water quality downgradient of 2 Hummingbird Hill. Vinyl chloride was not detected in the monitoring well samples collected from MW-19B and MW-19L. Since future westward migration of the vinyl chloride contamination is possible, CRA performed a preliminary design evaluation associated with installation of a groundwater pump-out system in the Ski Lane ravine. Results of the preliminary evaluation are as follows:

- Groundwater extraction wells would be installed in Ski Lane ravine in the upper and lower portions of the St. Peter Sandstone aquifer. The extraction wells would pump at a combined rate of approximately 30-50 gpm in order to achieve an approximate capture width of 800 ft. A pumping test would be conducted to verify the pumping rate required to achieve containment.
- The groundwater would be pumped to a recharge area within the ravine. The vinyl chloride would volitalize from the groundwater upon discharge to the recharge area. The uncontaminated water would then be allowed to infiltrate back into the ground at the base of the ravine.
- Preliminary calculations indicate an area of 10,000 square ft. would be required to allow for a 50 gpm flow to infiltrate back into the ground. This area is based on a typical hydraulic conductivity of 15 to 65 ft/day for medium grained sand. The soil boring log for monitoring well MW-19L (see Appendix D) indicates that medium grained sand is present to a depth of approximately 50 ft. in the ravine.

- Additional testing would be completed in the bottom of the ravine to verify that the soil has the capacity to handle a constant flow of 50 gpm.

The preliminary design evaluation indicates a groundwater pump-out system could be installed in the Ski Lane ravine. However, VAP/monitoring well data should be obtained from the 12/13 West Shore Road area in order to fully evaluate the potential effectiveness of a groundwater pump-out system in the Ski Lane ravine. For instance, the vertical extent of vinyl chloride contamination would affect the design of the extraction well with respect to screen length and depth. The vertical extent of contamination would also affect the volume of groundwater designed to be captured, which is a critical factor for managing the extracted groundwater (e.g. 30 gpm versus 50 gpm). Groundwater quality data from the 12/13 West Shore Road area would help to determine the nature and extent of vinyl chloride contamination on the west side of Gilfillan Lake.

In addition to obtaining VAP/monitoring well data in the 12/13 West Shore Road area, access to the Ski Lane Ravine area would need to be arranged with the property owner (NOHOA).

5.3 REVIEW OF CITY OF NORTH OAKS RECORDS

In its letter dated September 1, 2005, the MPCA required CRA to "review the City's septic tank inspection and compliance records to evaluate the potential for septic tank releases in the Lake Gilfillan Area". In addition, the City of North Oaks suggested that the City's records from the routine residential well sampling program conducted by the League of Women Voters be reviewed as well. In September and October 2005, CRA reviewed the City septic system inspection and compliance records and the League of Women Voters data. Preliminary findings were provided to the MPCA in a letter dated November 1, 2005. The following sub-sections summarize the results of each review and provide an evaluation of the findings.

5.3.1 SEPTIC SYSTEM INSPECTION AND COMPLIANCE RECORDS

Since the late 1980's, the City of North Oaks has maintained records on residential septic systems. These records include:

- Septic tank pumping/inspection reports;
- As-built drawings/reports;

- Construction permits;
- Independent sewage treatment system worksheets/calculations/soil boring logs/percolation tests; and
- MPCA/building inspector septic system condition reports/compliance inspections.

CRA's review focused on the records available for Area 5 (see Figure 1.2) east of Gilfillan Lake. This area was the focus of the investigation because groundwater samples collected from former residential wells in 1993/1994 from this area had elevated levels of chlorides, which appeared to be unrelated to the Highway 96 Site. In addition, vinyl chloride was detected at 17 Dove Lane in a shallow well, which was only 68 ft. bgs.

CRA's review of the septic records show that 4 out of 12 properties for which records were reviewed had some form of septic issue. Some systems were noted to have failed; others were noted to have overflowed or discharged to surface water.

The detection of low levels of vinyl chloride in 1993 within the Dove Lane area is not related to the Highway 96 Site based on the following lines of evidence:

- The area is not directly downgradient of the Highway 96 Site (based on flow directions, as discussed in Section 4.0);
- Other compounds associated with the Highway 96 Site (e.g., 1,1-dichloroethane) have never been detected in this area;
- Chloride concentrations in the area (as discussed in Section 3.0) are elevated compared to chloride concentrations at the Highway 96 Site;
- The vinyl chloride detected in 1993 was found in a shallow residential well (68-ft deep) which suggests that the source of the vinyl chloride was local;
- The USEPA lists vinyl chloride as a known groundwater contaminant caused by septic systems; and
- There have been a number of documented septic failures in the area and periodic detections of coliforms and nitrates in groundwater.

5.3.2 LEAGUE OF WOMEN VOTERS DATA

The League of Women Voters routinely conducts a residential well sampling program throughout North Oaks, which involves annual sampling of 50 residential wells. Records for this program date back to 1980. The samples are tested for nitrates and coliforms, which can be indicators of septic related contamination.

A total of 974 sampling results were reviewed by CRA for the period from 1982 through 2005. Within Area 2 (see Figure 1.1), which represents the greater North Oaks area, nitrates and/or total coliforms were detected in 140 out of 874 samples (approximately 16 percent). Within Areas 3, 4, and 5 (see Figure 1.2), nitrates or total coliforms were detected in 19 out of 100 samples (19 percent).

At locations where nitrates were detected, none of the sampling results exceeded the health risk limit of 10 mg/L. Nitrate concentrations ranged from 0.01 to 6 mg/L.

At locations where total coliforms were detected, the concentrations ranged from 1.1 to greater than 23.0 mean probable number (MPN)/100 mL. Fecal coliforms were usually not present, but were sometimes noted. The detection of total coliforms at any concentration, indicates a potential health risk.

Sample results were used to advise homeowners (where appropriate) that additional actions may be needed to evaluate the quality of their well water. Recommended follow-up actions generally involved retesting and/or well disinfection.

5.3.3 EVALUATION OF FINDINGS

The review of septic system files shows that septic system failures are not uncommon. The review of the League of Women Voters data shows that septic impacts to groundwater can occur, as the most likely source of elevated levels of nitrates and/or total coliforms in groundwater are septic systems.

Further evaluation of septic system impacts is provided in the Area 5 discussion in Section 6.0 of this report.

5.4 PUBLIC INFORMATION/EDUCATION PROGRAM

In its letter dated September 1, 2005 the MPCA required that CRA, on behalf of Whirlpool and Reynolds, coordinate with the City of North Oaks, MDH and the MPCA to implement a public information/education program in North Oaks.

The MDH and the City of North Oaks are currently developing and implementing a formal information and education program. In addition to the formal program, the following steps have been taken to keep the community and affected residents informed of developments associated with the vinyl chloride contamination in North Oaks:

- The MPCA continues to provide residents with data notification letters following each residential well sampling event;
- The MPCA has issued a revised Fact Sheet regarding the Highway 96 Site;
- The MPCA and CRA have presented progress updates at recent North Oaks City Council Meetings; and
- The MPCA and CRA, with approval of the City of North Oaks, continues to post information and periodic updates on the City's web site.

5.5 FEASIBILITY OF SAMPLING FORMER AUGMENTATION WELL

In its letter dated September 1, 2005, the MPCA required CRA to evaluate the feasibility of sampling the former augmentation well located near the intersection of Blue Goose Road and Duck Pass Road.

The former augmentation well was a 432-foot deep, multi-aquifer well once used to add groundwater to Teal Pond and Gilfillan Lake to help maintain the lake levels. The former augmentation well was removed from service in the in the late 1980's by the Minnesota Department of Natural Resources (DNR) due to draught conditions.

CRA contacted the MDH Well Management Section and determined that the former augmentation well was sealed on June 19, 1995. A copy of the well sealing record is provided in Appendix L.

6.0 CONCLUSIONS

As requested by the MPCA and the City of North Oaks, this section provides conclusions arising from the groundwater and residential well evaluation with respect to each of the geographic areas (shown on Figures 1.1 and 1.2).

6.1 GENERAL CONCLUSIONS

Based on the groundwater and residential well evaluation conducted during this study period along with data collected from previous studies, CRA has reached the following general conclusions:

- The unconsolidated glacial drift aquifer is not contaminated by vinyl chloride west of the Highway 96 Site.
- The Prairie du Chien aquifer is not contaminated by vinyl chloride.
- Groundwater within the St. Peter Sandstone aquifer flows westward.
- The vinyl chloride detected in the area of 12/13 West Shore Road and 2 Hummingbird Hill is part of the Highway 96 remnant plume. The vinyl chloride observed in 2004/2005 west of Gilfillan Lake migrated from the Highway 96 Site many years before discovery of contamination at the Site in 1986 and many years before the start of groundwater remediation in 1989.
- Periodic and random detections of VOCs such as methyl ethyl ketone, toluene, and benzene in samples from residential wells have been observed and are expected to continue into the future. These compounds are well below their respective health risk limits. These detections are not related to the Highway 96 Site but probably result from household wastewater which entered the groundwater from residential septic systems.
- Periodic detections of chlorination compounds such as chloromethane and chloroform have been observed and will continue to occur. The presence of these VOCs probably results from well disinfection.

6.2 AREA 1

Area 1 is the immediate vicinity of the Highway 96 Site.

The following conclusions pertain to Area 1:

- The groundwater extraction system installed at the Highway 96 Site continues to capture and remediate groundwater contamination. The groundwater remedy has prevented off-site migration of vinyl chloride since 1989. Vinyl chloride has not been detected in the converted residential monitoring well located at 11 Robb Farm Road (across from the Site) since 1990.
- The groundwater extraction system has been upgraded with the installation of EW-2 in the St Peter Sandstone aquifer. The extraction system has extra pumping capacity such that groundwater capture will be achieved for many years even with iron fouling.
- The compliance monitoring network has been upgraded and has confirmed that vinyl chloride is not migrating off site.
- A network of 16 monitoring wells are in place at the Highway 96 Site and will continue to be monitored into the future in order to provide ongoing performance data on the groundwater remedy. Results of the 2005 annual on-Site monitoring well sampling event will be submitted to the MPCA in the Highway 96 2005 Annual Monitoring Report (due March 2006). Monitoring and reporting on the remedy will continue for many years until the performance standards of the Consent Order are met and the MPCA determines that no further remediation or monitoring is necessary.

6.3 AREA 2

Area 2 consists of the areas west and north of Gilfillan Lake and the Highway 96 Site that are free of contaminants related to the Highway 96 Site.

The following conclusions and recommendations pertain to Area 2:

- Vinyl chloride migration into Area 2 from the Highway 96 Site is unlikely due to remediation and natural attenuation;
- No vinyl chloride had been detected in community wells within the greater North Oaks area (see Figure 6.1);
- The MDH and the City of North Oaks are developing a public information and education program related to the recent vinyl chloride contamination; and
- Information and periodic updates will continue to be presented at City Council meetings and posted on the North Oaks Web site.

6.4 AREA 3

Area 3 consists of the areas immediately east and west of Gilfillan Lake, where vinyl chloride and other site-related contaminants were detected in 1993-1994 and again in 2004-2005.

The following conclusions pertain to Area 3:

- The eastern portion of Area 3 has had municipal water since 1994. Thus, none of its residents draw water from the St. Peter Sandstone aquifer.
- Residual levels of vinyl chloride within Area 3, east of Gilfillan Lake continue to decline as a result of natural attenuation. The groundwater extraction system at the Highway 96 Site effectively contains the source of vinyl chloride and prevents future off site migration. Residual vinyl chloride concentrations naturally decline by both mechanical (i.e. dispersion) and chemical (i.e. biodegradation) processes.
- Extensive residential well sampling has confirmed that vinyl chloride is limited to one area west of Gilfillan Lake at three residential wells located at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill. In order to develop conclusions regarding potential future migration of vinyl chloride to neighboring residential wells, additional study is needed to define the vertical aquifer profile in the 12/13 West Shore Road area. This profiling has not been conducted as proposed because access has not been provided.
- Vinyl chloride was not detected at two new monitoring well locations installed in the Ski Lane ravine located in Area 3 west of 12 West Shore Road/13 West Shore Road/2 Hummingbird Hill.
- Monitoring of residential wells in Area 3 will continue. The scope and frequency of future monitoring will be determined by the MPCA.
- The installation of a groundwater extraction system located in the Ski Lane ravine area west of the 12/13 West Shore Road/2 Hummingbird Hill Area appears feasible. This system would be installed in the area of new monitoring wells (where vinyl chloride has not been detected to date) in the event that vinyl chloride migrates westward toward residential wells located on Ski Lane. A full evaluation of this potential remedy is hampered by the absence of data from the proposed VAP testing in the 12/13 West Shore Road area. Access issues have prevented work in this area.
- Installation of new water supply wells in the Prairie du Chien is a viable permanent remedy for the residents affected by the vinyl chloride contamination.

6.5 AREA 4

Area 4 consists of the areas immediately north and northwest of Gilfillan Lake and the Highway 96 Site, where contaminants were detected in 1993-1994 (e.g., Lily Pond Road).

The following conclusions pertain to Area 4:

- The eastern portion of Area 4 has had municipal water since 1994. Thus, none of its residents draw water from the St. Peter Sandstone aquifer.
- Residual levels of vinyl chloride within Area 4, east of Gilfillan Lake, continue to decline as a result of natural attenuation. Annual monitoring of converted residential monitoring wells over the past decade has shown that the vinyl chloride concentrations have declined in this area. For example, vinyl chloride concentrations at the converted residential monitoring well located at 1 Lily Pond have decreased from 1.1 µg/L in 1993 to "not detected" in 2005. Vinyl chloride has not been detected in the other two converted wells in this area since 1996.
- Groundwater within Area 4 migrates to the northwest beneath Duck Pass Road. Residential wells on Duck Pass Road have been routinely monitored since 1993 and have never detected vinyl chloride.
- Future detections of vinyl chloride, associated with the Highway 96 Site, within Area 4 are unlikely given the long history of monitoring data that shows no detections of vinyl chloride in the Duck Pass Road area located immediately downgradient of the water service area. Also, the low residual levels of vinyl chloride east of Gilfillan Lake are expected to attenuate naturally as groundwater migrates to the west. With time and distance, concentrations naturally decline as a result of mechanical (i.e. dispersion) and chemical (i.e. biodegradation) processes.
- Continued, periodic monitoring of residential wells in Area 4 will continue. The scope and frequency of future monitoring will be determined by the MPCA.

6.6 AREA 5

Area 5 consists of the areas immediately south and southwest of Gilfillan Lake and the Highway 96 Site (e.g., Dove Lane), where contaminants were detected in 1993-1994.

The following conclusions pertain to Area 5:

- The eastern portion of Area 5 has had municipal water since 1994. Thus, none of its residents draw water from the St. Peter Sandstone aquifer.

- Vinyl chloride concentrations in the Dove Lane area detected in 1993 at 0.3 µg/L did not originate at the Highway 96 Site and likely resulted from the degradation of household wastewater, which migrated to groundwater via a residential septic system.
- Future detections of vinyl chloride, associated with the Highway 96 Site, within Area 5, west of the water service area, are unlikely given the long history of monitoring data that shows no detections of vinyl chloride in residential wells located along the south shore of Gilfillan Lake in the area immediately downgradient (west) of Dove Lane. Also, the low levels of vinyl chloride detected in the mid-1990s are expected to attenuate naturally prior to reaching residential wells located in Area 5 west of Gilfillan Lake. With time and distance, concentrations naturally decline as a result of mechanical (i.e. dispersion) and chemical (i.e. biodegradation) processes.
- Continued, periodic monitoring of residential wells in Area 5 will continue. The scope and frequency of future monitoring will be determined by the MPCA.

7.0 RECOMMENDATIONS

Based on the groundwater and residential well evaluation conducted during this study period along with data collected from previous studies, CRA recommends the following:

- Residential well sampling should continue, as outlined in CRA's June 2005 report.
- Residential well sampling should be conducted at 13 West Shore Road because the location has not been sampled since the MDH issued a drinking water well advisory in April 2005. It is important to determine if the vinyl chloride concentrations at this location have changed since April 2005. This information will help characterize the nature and extent of the vinyl chloride contamination and potentially help predict future migration.
- New water supply wells screened in the Prairie du Chien aquifer should be installed at 12 West Shore Road, 13 West Shore Road, and 2 Hummingbird Hill. The recent groundwater evaluation has shown the Prairie du Chien has not been impacted by contamination from the Highway 96 Site. The Prairie du Chien represents a safe, readily available, and more aesthetically pleasing water supply.
- Vertical profiling of groundwater quality in the St. Peter aquifer in the 12 West Shore Road/13 West Shore Road/2 Hummingbird Hill area should be conducted. VAP and monitoring well data would help to determine the nature and extent of vinyl chloride contamination on the west side of Gilfillan Lake and to evaluate further the feasibility of a groundwater extraction system in the Ski Lane ravine.

8.0 REFERENCES

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