Public Health Assessment

Public Comment Release

Former Gopher Ordnance Works

ROSEMOUNT, DAKOTA COUNTY, MINNESOTA

EPA FACILITY ID: MND980613780

Prepared by
Minnesota Department of Health

SEPTEMBER 24, 2014

COMMENT PERIOD ENDS: NOVEMBER 24, 2014

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

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FOREWORD

This document summarizes public health concerns related to a former industrial facility in Minnesota. It is based on a formal site evaluation prepared by the Minnesota Department of Health (MDH). For a formal site evaluation, a number of steps are necessary:

- *Evaluating exposure:* MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is found on the site, and how people might be exposed to it. Usually, MDH does not collect its own environmental sampling data. Rather, MDH relies on information provided by the Minnesota Pollution Control Agency (MPCA), the United States Environmental Protection Agency (EPA), and other government agencies, private businesses, and the general public.

- *Evaluating health effects:* If there is evidence that people are being exposed—or could be exposed—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. MDH's report focuses on public health— that is, the health impact on the community as a whole. The report is based on existing scientific information.

- *Developing recommendations:* In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to pollutants. The role of MDH is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA and MPCA. If, however, an immediate health threat exists, MDH will issue a public health advisory to warn people of the danger and will work to resolve the problem.

- *Soliciting community input*: The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the individuals or organizations responsible for the site, and community members living near the site. Any conclusions about the site are shared with the individuals, groups, and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, we encourage you to contact us.*

Please write to: Community Relations Coordinator
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On the web: http://www.health.state.mn.us/divs/eh/hazardous/index.html

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ACBM	asbestos containing building materials
AOC	area of concern
ATSDR	Agency for Toxic Substances and Disease Registry
BaP	benzo(a)pyrene
BaPE	benzo(a)pyrene equivalents
CDC	Centers for Disease Control and Prevention
cPAHs	carcinogenic polycyclic aromatic hydrocarbons
CT	coal tar
CWI	County Well Index
DBP	dibutylphthalate
DNR	Minnesota Department of Natural Resources
DNT	dinitrotoluene
DPA	diphenalylamine
DRO	diesel range organics
EPA	United States Environmental Protection Agency
GOW	Gopher Ordnance Works
GUE	George’s Used Equipment
HBV	Health Based Value
HRL	Health Risk Limit
IARC	International Agency for Research on Cancer
IEUBK	Integrated Exposure Uptake Biokinetic Model for Lead in Children
IRIS	Integrated Risk Information System
MCL	Maximum Contaminant Level
MDH	Minnesota Department of Health
MPCA	Minnesota Pollution Control Agency
MW	monitoring well
NC	nitrocellulose
NDPA	n-nitrosodiphenylamine
NO_2	nitrite
NO_3	nitrate
NPL	National Priorities List
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCDFs	polychlorinated dibenzofurans
PCDDs	polychlorinated dibenzodioxins
PCE	perchloroethylene (tetrachloroethylene)
PE	Porter Electric
ppb	parts per billion
ppm	parts per million

ppt	parts per trillion
PWL	Process Water Lagoon
RI	Remedial Investigation
RROC	Rosemount Research and Outreach Center
SLV	soil leaching value
SRV	soil reference value
SVOCs	semi-volatile organic compounds
TCDD	tetrachlorodibenzo-p-dioxin
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
UMN	University of Minnesota
UMORE	University of Minnesota Outreach, Research, and Education
UMRRC	University of Minnesota Rosemount Research Center
UN	unique well number
University	University of Minnesota
USACE	United States Army Corps of Engineers
UST	United States Transformer
VOCs	volatile organic compounds
VH	Vermillion Highlands, a Research, Recreation and Wildlife Management Area

I. Summary

INTRODUCTION

The Minnesota Department of Health's (MDH) mission is to protect, maintain, and improve the health of all Minnesotans. For communities living near state or federal Superfund sites, MDH's goal is to provide health information the community needs to take actions to protect their health. MDH also evaluates environmental data, and advises state and local governments on actions that can be taken to protect public health.

The Minnesota Pollution Control Agency (MPCA) asked the Minnesota Department of Health (MDH) to review environmental data for the former Gopher Ordnance Works (GOW) site and evaluate potential public health concerns.

The former GOW site, located in the City of Rosemount in Dakota County, Minnesota was constructed and operated by the federal government during World War II for the production of smokeless gunpowder and nitric and sulfuric acids. Following decontamination and demolition activities by the federal government, portions of the site were purchased by the University of Minnesota in 1947-1948. Since that time, the property has been used for a variety of purposes by the University and their tenants. As a result of the historic uses of the property, physical and chemical hazards are present at the site, which have been evaluated in a series of site investigations starting in the 1980s.

Extensive redevelopment is planned for much of the site; as development proceeds, additional environmental data will need to be collected to ensure the safety of the property for future use. Many data gaps currently exist, due in part to the large acreage of the site.

This document summarizes and catalogs information about the residual soil and groundwater contamination in Rosemount, Minnesota, at the former GOW site. It is written for multiple stakeholders who may be concerned about current exposures and/or future development of the property. The residents of Rosemount and nearby areas, the City of Rosemount, Dakota County, the Minnesota Pollution Control Agency, the University of Minnesota, and future residents and occupants of the site have varying interests in the site information.

This report reviews the environmental data and relevant site history from a large number of documents to provide recommendations and assist with future response action and development decisions.

OVERVIEW

MDH reached five major conclusions in this Public Health Assessment of the former Gopher Ordnance Works site.

CONCLUSION 1	MDH concluded that physical hazards are the most important public health hazard on the site.
Basis for conclusion	Crumbling building foundations and other ruins from the former GOW facilities and debris from dump sites pose physical hazards for workers and others on the site. The site is not fenced and evidence of trespassing was observed.
Recommendation	Remove physical hazards or fence areas where they are present to prevent injury.
CONCLUSION 2	MDH concluded that contaminated surface soil in some areas of the site pose a public health hazard.
Basis for conclusion	In limited areas of the site, concentrations of site-related contaminants in surface soil are significantly above their respective Soil Reference Values (SRVs) for industrial land use in these areas. Contaminants include lead, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), and polychlorinated biphenyls (PCBs). Exposure to the contaminants may be occurring. Exposure to these soils is expected to be limited mainly to onsite workers.
Recommendations	1. Remove and properly dispose of soils in selected areas that exceed the industrial SRVs. 2. Notify tenants in affected areas of the contamination in the vicinity of their rented properties.
CONCLUSION 3	MDH concluded that contaminated soils in some areas of the site pose an indeterminate public health hazard.
Basis for conclusion	Concentrations of site-related contaminants in soils exceed industrial and/or residential SRVs. Contaminants include lead, mercury, arsenic, cPAHs, and PCBs. Asbestos-containing building material debris was found in some areas of the site. Current exposure is expected to be limited in frequency and duration, but future land uses may result in greater exposures.
Recommendations	Asbestos containing building materials should be removed from the site. Soils with contaminants exceeding the industrial and/or residential SRVs may need to be removed and properly disposed of if future land use changes. Additional investigation may be needed in order to determine what actions are required.
CONCLUSION 4	MDH concluded that some areas of the site have not had adequate investigation to evaluate whether a public health hazard exists.
Basis for conclusion	Several areas of the site have had very limited or no sampling. The magnitude and extent of contamination, if present, is unknown.
Recommendation	More data may be needed prior to development of these areas including public recreational areas in the Vermillion Highland portion of the site. The data will provide more confidence in the suitability of the site for public use.

CONCLUSION 5	MDH concluded that groundwater poses an indeterminate public health hazard.
Basis for conclusion	There are no known exposures to site-related contaminants through drinking water at this time, but there are some areas that warrant additional evaluation to ensure groundwater contamination is not present. Site-related contaminants have been detected in the groundwater beneath some portions of the site and in off-site monitoring and private wells. Sampling of site monitoring wells in 2011 and 2012 indicates that contaminant concentrations have been decreasing over time and, with the exception of trichloroethylene (TCE) and nitrate+nitrite, do not exceed levels of health concern. Groundwater samples collected from soil borings in 2007 also detected PAHs, bis(2-ethylhexyl) phthalate, 2,4,6-trichlorophenol, and diesel range organics at concentrations above levels of health concern.
Recommendations	1. Install one additional monitoring well and complete a thorough private well survey to more fully understand the extent and magnitude of the contamination and the potential for exposure to groundwater contaminants. 2. Conduct vertical soil sampling in area AOC6 to determine if PAHs leached to groundwater in that area. 3.Conduct sampling of all private wells on properties within 1,000 feet down-gradient of the UMore East property. Test for VOCs (including 1,4-dioxane) and metals (including antimony, cadmium, chromium, copper, lead, thallium, and zinc). 4.Complete a thorough evaluation of all wells on the UM property and properly seal any wells not in use. 5. MDH should continue to sample wells near the Coates Dump and test for antimony, thallium, and VOCs, including 1,4-dioxane.
DATA LIMITATIONS	Many data gaps exist at the site in part due to the large size of the property. Portions of the site have not had adequate soil investigation to evaluate whether a public health hazard exists. More information is needed to better understand current land uses and potential exposures. There are a number of wells on and near the site for which little is known regarding their current use and water quality. Additional groundwater evaluation is warranted.

II. Introduction

The Minnesota Pollution Control Agency (MPCA) asked the Minnesota Department of Health (MDH) to review environmental data for the former Gopher Ordnance Works (GOW) site and evaluate potential public health concerns. Soil contamination, groundwater contamination, and data gaps are discussed as well as the potential for exposures to contaminants and impacts on drinking water resources due to planned future development.

The property is about 20 miles south of St. Paul and is located west of Highway 52 and east of Highway 3, and is bordered to the north by County Rd 42 and to the south by County Rd 62 (Figure 1). The federal government acquired 12,000 acres of farmland in Rosemount and Empire Township in Dakota County in 1942-1943 to manufacture smokeless gun powder and nitric and sulfuric acids for World War II. Production began in January of 1945 and ended in October of that year. A large portion of the property used for the war effort was transferred to the University of Minnesota (hereafter the "University") in 1947-1948, and over the years the land was used for University research, as well as leased for a variety of uses.

The University property is divided into three sections (Figure 2). The northern two sections are collectively referred to as the University of Minnesota Outreach, Research, and Education (UMore) Park. The future development vision for UMore Park is a "unique, sustainable, University-founded community of 20,000-30,000 people, a 25-30 year endeavor" (UMN, 2012a). Ruins of the former GOW and associated environmental impacts are largely located in the eastern section (approximately 3,500 acres) of UMore Park; this eastern section is often referred to as UMore East. Portions of this eastern land were listed on the federal Superfund's National Priority List (NPL) in 1986, with soil remediation largely occurring in 1990-1993. MDH prepared four health assessment documents on the Superfund site (ATSDR, 1989, 1990, 1993, and 1997a). The site was taken off the NPL in 2001 but continues to have EPA review every five years because soil contamination remains at the site in the area of the former George's Used Equipment.

The western portion of the UMore Park property, referred to as the UMore Mining Area, is currently being used for sand and gravel mining and processing and is not included in this document.

The southern portion of the University property, called Vermillion Highlands, is 2,822 acres managed jointly by the University and the Minnesota Department of Natural Resources (DNR).

Contaminants of concern in the soil at this site include metals (arsenic, lead, mercury), carcinogenic polycyclic aromatic hydrocarbons (cPAHs), polychlorinated biphenyls (PCBs), asbestos, and explosives [nitrocellulose and 2-4-dinitrotoluene (2,4-DNT)].

Contaminants in groundwater found above health based guidance in the last six years of sampling include: nitrates, trichloroethylene (TCE), PAHs, bis(2-ethylhexyl) phthalate, 2,4,6-trichlorophenol, and diesel range organics. A number of volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) have been detected in the groundwater at levels that are below health concern; several metals (antimony, thallium, and zinc) were detected at levels above health concern in early site samples but they have not been included in recent sample analyses.

III. Background and Site History

A. UMORE East

In the decades that followed acquisition of the property in 1947, the University has used the property for many purposes, and leased out the land and buildings to a variety of tenants. The current land use around the UMore East area is primarily agricultural (Barr, 2012). The on-site University staff consists of researchers and office workers, agricultural field workers, and property maintenance staff. In addition to areas being used by the University, currently there are two residences and several tenant-leased sites. Much of the land, some of which contains GOW ruins, is unused and some of this serves as wildlife habitat.

A number of site investigations have been completed for the 3,500 acre UMore East area, which includes the main production area of the former Gopher Ordnance Works. Most recently, the University completed a Remedial Investigation (RI) in 2011 (Barr, 2012), which included approximately 578 soil samples across the site, as well as groundwater samples, a geophysical survey, and a sewer investigation. Specific areas sampled and results from this and other previous investigations are found in Appendix A. This table also includes an evaluation of public health hazards and recommendations. A short summary of public health hazard categories and contaminants for all the subareas is found in Table 5.

Below (Table 1) are general descriptions of the subareas within UMORE East (Figures 3-10). Also below is a separate discussion of the NPL sub-sites.

Table 1: Sub-sites within UMORE East

GOW East	
GOW uses:	nitric acid plant, coal ash pond, wastewater treatment plant, and coal-fired power plant
Former University uses:	aeronautical research laboratory and hazardous waste storage, oxidation pond; tenant uses include explosives manufacturing and storage, laboratories, and plastics production
Current uses:	one residence and agricultural fields
Soil contaminants:	lead, cPAHs, mercury, arsenic, and PCBs
Concerns:	The United States Army Corps of Engineers (USACE) in earlier investigations acknowledged the need for further investigation of the former power plant area of concern (AOC-7). It was not included in the 2011 RI (Barr, 2012).
ABC Line	
GOW uses:	powder production lines, temporary and main shops (e.g. pipe shop, paint shop, machine shop)
Former University uses:	tenant use resulted in NPL site, see below
Current uses:	University office space; tenant use includes the Minneapolis Bomb Squad and the FBI, buildings leased for storage, limited agriculture
Soil contaminants:	arsenic, mercury, lead, PCBs, cPAHs, and asbestos
GOW Central	
GOW uses:	powder processing and packaging, East 160th St. Dump – demolition dump, Suspected Disposal Area that contains metal debris
Former University uses:	dump, chemical waste disposal – resulted in NPL site, see below
Current uses:	agriculture, one residence, buildings leased to commercial tenants
Soil contaminants:	arsenic, cPAHs, and 2,4-DNT
Concerns:	data gaps within the East 160th St. Dump, the Suspected Disposal Area, and the NPL sub-site
DEF Line	
GOW uses:	aniline plant area, the DEF powder production line ruins, and the suspected "J" and "L," Street dumps; reportedly the aniline plant and DEF lines were never used
Former University uses:	hazardous waste storage (soil excavated due to PCB contamination), tenant

GOW East	
	use included Jensen airfield
Current uses:	agriculture
Soil contaminants:	arsenic, PAHs, asbestos, construction debris
Navy/Burning Grounds	
GOW uses:	off-specification gun powder and building materials were burned in this area from 1945-1948; three known dump sites are located in this area - the 10th, 30th, and "B" Street dumps.
Former University uses:	buildings and land were leased to the U.S. Air Force and Navy to store ammunition magazines, gas cylinders containing rocket propellant, and small quantities of hazardous waste; the Navy created an operations center and constructed a firing range; in 2009 the Navy removed PCB contaminated soil, concrete and asphalt
Current uses:	dormant land, some agriculture
Contaminants:	lead, mercury, cPAHs, arsenic and 2,4-DNT
GOW West	
GOW uses:	construction and demolition debris disposal area - the 154th St. Dump (AOC-6)
Current uses:	agriculture
Soil contaminants:	cPAHs, debris, asbestos
Concerns:	The USACE in earlier investigations acknowledged the need for further investigation of AOC-6. It was not included in the 2011 RI (Barr, 2012).
GOW North	
GOW uses:	guard tower, administrative offices, septic system drain field, and parking
Former University uses:	the guard tower was leased to a resident who may have used PCB oil to heat the residence
Current uses:	agriculture
Soil contaminants:	no evidence of contamination found

Other UMore East Investigation Areas

Focused investigation occurred in some areas to address potential contamination across the UMore East site including the former heavy gauge railroad, transformers, ditches, and the Laminex Wood Box Sewer.

- Railroad rails and ties were removed during decommissioning of GOW. Soil sampling near railroad tracks occurred in both 2009 and 2011. The only contamination detected was one sample of elevated cPAHs.
- Lead, cPAHs, mercury, and PCBs were found at GOW transformer buildings.
- No contamination was found in the GOW ditch sampling.
- Laminex Woodbox Sewer System: Both process water and treated sanitary water from the GOW operations were collected into a Laminex Woodbox Sewer System and directed into the waste disposal ditch in the southeast corner of Vermillion Highlands. "Laminex" is a patented name of a wood box that was manufactured in Minnesota and used to build sewer systems (USACE, 2006). According to USACE, the wood box was made from pressure-treated wood and likely preserved with chromated copper arsenate. However, it is also possible that a local lumber company and creosote plant provided pressure-treated wood preserved with creosote. The sewer system was designed to collect 100,000,000 gallons per day of process water (USACE,

2009a). The length of the sewer was approximately 11,160 feet and was approximately 4 feet wide and 3.5 feet tall (Barr, 2010a). Further details can be found in the Vermillion Highlands Phase 1 Environmental Site Assessment (Barr, 2010a). A video of a portion of the sewer system was taken during the RI and although small holes were found, the condition of the system was generally considered good (UMN, 2011). Twelve sewer sediment samples were taken during the RI and nine samples were found to contain mercury, PCBs, cPAHs, or arsenic above MPCA residential soil reference values (SRVs; screening values). 2,4-DNT was detected below the residential SRV in six samples.

Former Superfund National Priorities List (NPL) site -– University of Minnesota Rosemount Research Center (UMRRC)

In 1984, an investigation was started when chloroform was found in 16 residential wells to the northeast of the University property. In 1986, the University of Minnesota Rosemount Research Center was placed on the U.S. EPA NPL. The site includes groundwater contaminated with chloroform from the University Burn Pit (located in GOW Central) and soil contaminated with PCBs, lead, and copper from University tenants: George's Used Equipment, Porter Electric, and US Transformer (located in ABC Line).

University Burn Pit and groundwater plume

From 1967 (or possibly earlier) to 1974 the University operated a burn pit for the disposal of chemical waste (Figures 6 and 11). An estimated 90,000 gallons of lab chemicals, solvents, corrosives, salts, heavy metals, organics and inorganics were allowed to soak into the soil or were burned (USEPA, 2007). In 1980, the pit was lined with lime, backfilled with sand, and capped with clay to prevent additional infiltration of rain or meltwater that could help move the contaminants through the soil to the groundwater (USEPA, 2007).

In 1984, chloroform was found in 16 residential drinking water wells north and northeast of Subsite GOW North and down-gradient of the Burn Pit site. Chloroform was found at concentrations up to 16 parts per billion (ppb), which exceeded the drinking water guidelines at that time. MDH issued well advisories to 27 properties where the wells were contaminated with chloroform (ATSDR, 1997a). The maximum concentration of chloroform found in groundwater was 72 ppb in a monitoring well one mile east of the Burn Pit, with the plume extending approximately 4 miles east-northeast of the site (USEPA, 2007).

The remedy selected was a groundwater pump and treatment system combined with a new community rural water supply provided by the University in 1989. The pump and treatment system was shut down in 1991 because the groundwater was meeting all drinking water criteria. Sampling of monitoring wells located downgradient of the University Burn Pit in the 1990s detected a suite of chlorinated VOCs including chloroform, carbon tetrachloride, dichloroethane, trichloroethane (TCA), and trichloroethylene (TCE). Groundwater monitoring in 2002 detected chloroform in all five monitoring wells sampled, ranging from 2.3-23 ppb. Trichloroethylene (TCE) was also detected in one monitoring well, at 2.6 ppb (Delta, 2002).

Monitoring well sampling in 2011 showed contaminant concentrations in the groundwater downgradient of the burn pit continued to decline. Chloroform and TCE were the only contaminants detected, with the highest results being 7.9 ppb and 0.92 ppb, respectively (Barr, 2012). The current MDH drinking water standard (Health Risk Limit; HRL) for chloroform is 30 ppb. The TCE HRL is 5 ppb, but this is superseded by recent guidance from MDH. The current guidance is a non-promulgated

Health Based Value (HBV) for TCE in drinking water which is set at 0.4 ppb to protect infants and children.

In 2013, MDH sampled five private water supply wells still in use downgradient of the UMore property and detected VOCs in one well on a commercial property immediately east of Subsite GOW North. A well advisory was issued for that well and additional sampling is planned (see section IV. Groundwater below for more information).

Despite the large volumes of chemicals disposed at the Burn Pit, no soil sampling was reportedly ever conducted there. The depth of the fill material is unknown. Two surface soil samples in a former temporary burn pit east of the University Burn Pit were analyzed for metals and SVOCs in 2011. No evidence of contamination was found (Barr, 2012). As acknowledged in the RI report, significant data gaps exist because of the lack of investigation in this area (Barr, 2012). Additional sampling is needed to understand the contamination in this area. The University Burn Pit area is marked by fence posts, but no fence exists.

George's Used Equipment (GUE), Porter Electric (PE), and United States Transformer (UST)

George's Used Equipment (GUE) was an electrical equipment salvage facility from 1968-1985 (USEPA, 2007). PCB oils were disposed of in the ground as well as through incineration. Surface soil concentrations of PCBs up to 42,000 parts per million (ppm) were detected in this area. Handling of lead acid batteries and reclamation of copper wire resulted in lead and copper contamination in the soil, up to 40,000 ppm and 310,000 ppm, respectively (USEPA, 1997). Antimony and thallium were also found at elevated concentrations in surface soil at 676 ppm and 11 ppm, respectively.

Limited dioxin and furan sampling was done during the initial investigation. The 1986 RI report notes that PCB oil was alleged to have fueled an incinerator at the GUE site (TCT, 1986). Dioxins and furans are known to form during the burning of PCBs. The highest concentrations found on-site were west and south of the GUE concrete slab (up to 3,150 ppt TCDD dioxin equivalents west of the slab, and up to 87,500 ppt TCDD dioxin equivalents south of the slab) (TCT, 1986; UMN, 2013a). At the time, these concentrations were not considered to represent a threat to public health or the environment (TCT, 1986; USEPA, 1990).

Storage and transfer of other hazardous materials also occurred at the site (USEPA, 2007). The Porter Electric (PE) site, just south of GUE, was used to store and recondition used industrial electrical equipment from 1968-1971, and also had PCB contamination in soil up to 63,000 ppm (USEPA, 2007). United States Transformer (UST), approximately 2000 feet northeast of GUE, dismantled and salvaged electrical transformers from 1973-1978. The soil at UST was contaminated by waste PCB oil that was washed off a concrete slab (USEPA, 2007). See Figure 12 for site locations.

Antimony, cadmium, thallium, lead, and zinc were found at concentrations of health concern in groundwater. Copper was also detected at elevated levels (830 ppb) in one water sample. Elevated levels of these metals were not detected in monitoring wells later installed approximately one-half mile downgradient, although samples from these wells were not tested for antimony, copper, thallium, or zinc. No groundwater samples have been analyzed in this area or downgradient for PCBs, but given the low mobility of PCBs and later soil samples at GUE and PE which detected no PCBs at depths of 11-12 feet, it is unlikely that PCB contamination in this area moved downward as far as the groundwater (see "Subsequent data" below).

NPL remedial actions

In 1990, over 4,000 tons of soil contaminated with PCBs, lead, and copper from GUE were excavated and disposed in appropriate off-site landfills (USEPA, 1997). Additional soil from GUE contaminated with lead and PCBs was transferred off-site in 1993 (USEPA, 1997). Over 12,000 tons of PCB contaminated soil from all three site areas (GUE, PE, and UST) was excavated and thermally destroyed on site in a mobile hazardous-waste incinerator in 1993 (USEPA, 1997).

In a large portion of the GUE site, called GUE Shallow, soil above 10 ppm PCBs was excavated. A large concrete pad and the soil below it was found to be clean, and therefore left intact (ITC, 1994). Soil with less than 10 ppm PCBs and 1000 ppm lead was considered clean (ITC, 1994). After achieving desired grade, a ten-inch cover of soil with less than 1 ppm PCBs was placed over all areas left with between 1 and 10 ppm PCBs.

In the southwest corner of GUE Shallow is a subsection of land with PCB contamination that extended to approximately 35 feet below the ground surface, called GUE Deep (ITC, 1994). Soil containing PCBs between 10 and 25 ppm from GUE, PE, and UST sites and lead from GUE Shallow were consolidated along with pieces of concrete into the restricted access disposal area of GUE Deep (USEPA, 1997). Sixteen inches of soil with less than 2 ppm PCBs was placed over GUE Deep. The top six inches contained less than 1 ppm PCBs. Sampling at that time indicated that the highest lead concentration remaining outside of GUE Deep was 669 ppm (USEPA, 2007). The land was vegetated and fenced (USEPA, 1997). Fences are not considered a permanent remedy.

At the Porter Electric site, PCBs were found to a depth of 74.5 feet but concentrations were less than 10 ppm below 43 feet (USEPA, 1997). PCBs in the soils above 43 feet were found up to 63,000 ppm (USEPA, 1997). This area, known as PE Deep, was excavated in the fall of 1992 and backfilled that winter (ITC, 1994). A concrete pad next to the contaminated soil was found be to clean but was partially removed during the excavation. The concrete was placed in GUE Deep. An additional shallow area, 10 feet by 10 feet and 10 inches deep, was also excavated at the PE site (ITC, 1994). No cap was needed for the PE site because after excavations it met the 1 ppm PCB clean up criterion (USEPA, 1997).

Three excavations were done at the United States Transformer site – the first to remove all soil with PCBs greater than 25 ppm, the second to remove all soil with PCBs greater than 10 ppm, and the third to remove additional contaminated soil along the road to the north (ITC, 1994). In addition, debris from the former salvage operation and piping was removed (ITC, 1994). Ten inches of clean soil was placed on top of excavated soils.

The final goal, after a 1992 amendment to the Record of Decision for the site remediation, was to leave no contamination above 10 ppm PCBs outside of GUE Deep (ATSDR, 1997a). In 2000, the University recorded a declaration and affidavit with Dakota County that requires maintenance of the 10 inch soil cover over areas with contamination exceeding 10 ppm PCBs. It also limits the sites to commercial and industrial use. The following uses are prohibited: day care centers, educational facilities, churches, social centers, hospitals, elder care facilities, nursing homes, housing, or recreational uses.

<u>Subsequent data</u>

A 2006 assessment quantified and assessed the remnants of the former GOW concrete foundations and walls and evaluated the condition of the soils adjacent to the concrete structures (Peer, 2006). Samples were taken at the former GUE buildings (716A, 716B). Two samples contained high levels of PCBs (128, 273 ppm), lead (1390, 2470 ppm), and 1,4-dichlorobenzene (49 ppm) from sediment samples taken from the drain within the building floor slab on 716A. Sampling near building 716A detected PCBs at 2.7

ppm. Other 2006 samples collected near building 716B detected elevated concentrations of benzo(a)pyrene equivalents (16 ppm), PCBs (1.4 ppm), mercury (5.5 ppm), and lead (897 ppm) at a depth of 18 inches.

Limited soil, but no groundwater, sampling was conducted in these areas in 2011. Five surface soil samples were collected near GUE on the gravel roads where PCB oil was suspected to have been used as a dust suppressant, three of which had detections (0.32, 1.0, and 1.3 ppm PCBs). Additional data from the 2011 RI (Barr, 2012) include three samples collected at 12 feet below the ground surface at GUE that were all non-detect for PCBs. There were no 2011 analyses for SVOCs near GUE, only three soil samples for metals, and one for VOCs. They showed no evidence of contamination (except very low detections of methylene chloride and tetrahydrofuran in one sample). See related discussion below under Current Tenants (page 32).

Only one sample was collected at the Porter Electric site in 2011 during the RI at 14 feet below the ground surface with no detections of PCBs. Seven soil samples were taken near the UST site in 2011 during the RI and only two surface samples had detections for PCBs (0.64 and 2.3 ppm).

EPA conducts Five-Year Reviews to ensure the remedy remains protective of human health and the environment because contaminants remain at the site above levels that allow unrestricted use. The fourth Five-Year Review was completed in June 2012 (USEPA, 2012b). EPA's 2012 Five-Year Review recommended further soil investigation and cleanup for areas that exceed cleanup levels or current risk-based levels for lead and PCBs. EPA also noted the issue of uncertainty concerning dioxin/furans in site soils.

As a result of the 2012 Five Year Review, during the fall of 2013 the University cleaned the concrete slab at the former GUE building 716A, removed the impacted sediment, and sealed the floor drains (Janet Dalgleish, personal communication, 2/7/14). Composite samples were collected from each side of the 716A foundation. PCB concentrations were less than 1 ppm in samples from the west and south sides of the foundation; concentrations in samples from the north and east side were 5.8 ppm and 2.3 ppm, respectively (UMN, 2013b). A second round of samples was collected in October 2013 from the north and east sides of the slab. The samples on the east side were less than 2 ppm PCBs, while the north side samples ranged from 3 - 60 ppm PCBs (UMN, 2013c). According to the University, additional investigation and response actions will be completed in 2014 to address the north side of building 716A.

Also in 2013, three samples were collected from the upper 10 inches of soil on the west side of the building 716B foundation. PCB concentrations ranged from 0.31 - 1.7 ppm and concentrations of benzo(a)pyrene equivalents ranged from 1.2 -3.8 ppm. Mercury and lead were not found to be elevated (UMN, 2013b).

B. Vermillion Highlands

The Vermillion Highlands makes up 2,822 acres south of the UMore Park property boundary (Figure 2). In 2006, this property was designated a permanent natural area through legislative action and is jointly managed by the Minnesota Department of Natural Resources (DNR) and the University of Minnesota, in conjunction with Dakota County and Empire Township (DNR, 2007). The property is called "a research, recreation, and wildlife management area" and a concept master plan was completed in 2010. The preferred scenario in the plan calls for an increased intensity of use in the northwestern corner of the site with trail connections and park use, while the southern and eastern portions are planned for habitat restoration and wildlife management (CRD, 2010). In addition, the plan's preferred scenario continues to designate approximately 1,000 acres for University of Minnesota agricultural field research (CRD, 2010). The portion of the Vermillion Highlands associated with historic Gopher Ordnance Works (GOW) activities is currently either open space with little public use (Barr, 2010a) or fenced off and unavailable for public use.

Environmental Data

There are several reports from 1996-2011 that include environmental data, but the majority of data are from the U.S. Army Corps of Engineers investigations (USACE, 2009a, 2009b). Most of the data are from soil sampling, but there are also data from groundwater, sediment, and surface water within the Vermillion Highlands boundary (see Appendix A). Parameters analyzed for include metals, SVOCs, VOCs, PCBs, explosives, and nitrocellulose.

The Vermillion Highlands boundary is divided into four sections (Figure 13), which are the same divisions used in Table 2, below. A detailed listing of the four areas, description of sites within those areas, environmental data, evaluation of public health hazard and recommendations are found in Appendix A.

Table 2: Sub-sections within Vermillion Highlands

Area 1 – Figure 14	
GOW uses:	powder production buildings
Former University uses:	tenant uses included storage of explosives
Current uses:	agricultural, shooting range, contains fenced off area of building ruins called the Northern Notch area
Contaminants:	asbestos
Area 2 – Figure 15	
GOW uses:	no evidence of use by GOW
Former University uses:	sewage sludge application research area
Current uses:	University Rosemount Research and Outreach Center, Vermillion Highlands research, recreation, and wildlife management area
Contaminants:	no evidence of contamination found
Area 3 – Figure 16	
GOW uses:	no evidence of use by GOW
Former University uses:	no known University uses
Current uses:	Vermillion Highlands research, recreation, and wildlife management area
Contaminants:	no evidence of contamination found, abandoned farm sites may pose physical hazards
Area 4 – Figure 17	
GOW uses:	wastewater drainage area, Coates dump
Former University uses:	Coates dump, law enforcement shooting range
Current uses:	Vermillion Highlands research, recreation, and wildlife management area
Contaminants:	arsenic, mercury, lead, antimony, thallium

Area 2 contained the University's former sewage sludge application research area. Sewage from eight metropolitan wastewater treatment plants was land applied in Area 2 (Linden, et al., 1995). Sloan et al.

(2001) measured mercury concentrations in biosolids-treated agricultural soils at the research area in 1995 after 20 years of applications (1974-1993). The highest total soil mercury concentrations in the biosolids application area reported in the paper were 0.5 ppm at a depth of 15-30 cm and 0.38 ppm at 0-15 cm. No subsequent soil analysis for mercury or other contaminants has been done. Historic biosolids applications may have contributed metals and organic pollutants to the soil; however quantities of these contaminants would be expected to be very low and not likely to pose a concern.

Both process water and treated sanitary water from the GOW operations were collected into the Laminex Woodbox Sewer system and directed into the waste disposal ditch in Area 4. USACE investigations divided the water drainage areas into the northern, middle, and southern sections (AOC-1N, AOC-1M, and AOC-1S). The northern section begins north of the Vermillion Highlands boundary and contains the sewer outfall. The middle section contains the primary settling basin and lower process wastewater ditch. The southern section includes the secondary settling basin and a secondary acid neutralization plant, and is the only part of the former drainage ditch where surface water is present (USACE, 2009a). Data from this area can be found in Appendix A.

C. UMore Mining

The western portion of the University property includes approximately 1,722 acres for a sand and gravel mining and processing operation, Dakota Aggregates LLC, (or the UMore Mining Area) and is not included in this document. The University completed an Environmental Impact Statement (UMN, 2010a) for the sand and gravel mining in 2010. Dakota Aggregates LLC obtained the necessary permits, and mining began in 2013.

IV. Groundwater

Groundwater contamination and data gaps are discussed below to address the potential for future impacts on drinking water resources due to planned future development.

Geology and Hydrogeology

The GOW and Vermillion Highlands are underlain by 30 to 200 feet of unconsolidated glacial deposits consisting of:

- Outwash composed of stratified (i.e. layered) sands and gravels
- Glacial till (also referred to as diamicton) composed of unstratified clay, sand and gravel
- Lake deposits composed of stratified clay and sand

These unconsolidated sediments, collectively referred to as Quaternary deposits (for the geologic period during which they formed), overlie a bedrock surface that is deeply cut by ancient valleys that were eroded down to the limestone-dolostone of the Prairie du Chien formation. In areas outside of these bedrock valleys are small, isolated remnants of the St. Peter Sandstone, a rock layer that once capped the tops of hills that are now buried by the Quaternary deposits. The Prairie du Chien formation and underlying Jordan Sandstone comprise the primary aquifer used locally for drinking water and irrigation. The top of the regional groundwater table is located approximately 50 to 80 feet below the ground surface, but shallower water may be encountered in small pockets “perched” on top of clay layers within the Quaternary deposits.

Groundwater beneath UMore East generally flows northeast towards the Mississippi River, but in the northern portion of the site flow directions may be affected locally by the presence of bedrock valleys as shown in Figures 18 and 19 (Barr, 2009a). Depth to groundwater in UMore East varies from approximately 50 to 70 feet below the ground surface.

Groundwater in the upper unconsolidated deposits beneath the Vermillion Highlands flows to the northeast towards the Mississippi River (Figure 18). Groundwater in the bedrock beneath the northeastern portion of the Vermillion Highlands flows to the east-northeast towards the Mississippi River, while groundwater in the bedrock beneath the central and southern Vermillion Highlands flows east-southeast towards the Vermillion River (Figure 19: Barr, 2009a). In the northern portions of the site, the depth to groundwater is greater than 60 feet but can be less than ten feet near the Vermillion River (Barr, 2010a).

Groundwater Sampling

Since 1984, groundwater sampling has occurred at various times and locations at the site. While a wide range of contaminants have been detected in the groundwater, only a few VOCs, SVOCs, metals, diesel range organics (DRO), and nitrate+nitrite have actually exceeded levels of health concern (as determined by MDH health based criteria that are used by Minnesota regulatory agencies for decision-making). These criteria are either Health Risk Limits (HRLs), which are promulgated through a formal rule-making process, or Health Based Values (HBVs), which are derived in the same way as HRLs but have not yet been promulgated (MDH, 2014). In some cases, MDH has adopted the USEPA Maximum Contaminant Level (MCL) as a HRL. Benzo[a]pyrene is used as an index chemical to evaluate the toxicity of carcinogenic PAHs (MDH, 2013). For contaminants, such as lead, where no MDH value exists, Minnesota agencies use USEPA values.

All groundwater sample results that exceeded any health based drinking water guidance values are summarized below in Table 3. A more comprehensive groundwater discussion and data set which includes contaminants that do not exceed guidance values are presented in Appendix B. Groundwater sample locations and other wells discussed in this section and elsewhere are shown in Figures 20 and 21, respectively.

Table 3: Summary of groundwater samples that exceeded current health based drinking water criteria

Sample Location	Contaminant	Concentration(s) exceeding health based guidance value (in ppb)	Dates when health based guidance value exceeded	Most recent sample result (in ppb) & (year)	Drinking water criteria (in ppb)	Sources of drinking water criteria
MW-21D	Carbon tetrachloride	1.1 - 2.1	1990, 1992, 1993	0.25 J (2011)	1	HBV
	1,2-Dichloroethane	1.4	1990	ND (2011)	1	HBV
	Trichloroethene	0.43 J	2011	4.3 J (2011)	0.4	HBV
	Nitrate + nitrite	11,000	2011	11,000 (2011)	10,000	MCL/HRL
MW-23D	Trichloroethene	0.7 - 6.4	1990, 1992,1993, 1995, 2002, 2011	0.92 (2011)	0.4	HBV
MW-28	Carbon tetrachloride	1.1 - 1.7	1990, 1992, 1993, 1995, 2002	ND (2011)	1	HBV
	Chloroform	31-36	1992, 1993	7.9 (2011)	30	HRL
	1,2-Dichloroethane	1.2 - 1.8	1992, 1993, 1995	ND (2011)	1	HBV

Sample Location	Contaminant	Concentration(s) exceeding health based guidance value (in ppb)	Dates when health based guidance value exceeded	Most recent sample result (in ppb) & (year)	Drinking water criteria (in ppb)	Sources of drinking water criteria
	Trichloroethene	0.75 J	2011	0.75 J (2011)	0.4	HBV
MW-29	Nitrate + nitrite	11,000	2011	11,000 (2011)	10,000	MCL/HRL
GUE MW-19	Antimony	12	1985	12 (1985)	6	HRL
	Cadmium	10	1985	3.8 (1986)	4	HRL
	Chromium	160	1986	160 (1986)	100	HRL
	Lead	900	1986	900 (1986)	15	NPDWR
	Thallium	2	1985	2 (1985)	0.6	HRL
	Zinc	3,550 - 20,200	1985, 1986	3,550 (1986)	2,000	HRL
GUE MW-20	Antimony	7	1985	7 (1985)	6	HRL
	Cadmium	10	1985	ND (1986)	4	HRL
	Zinc	2,090	1986	2,090 (1986)	2,000	HRL
GUE GW-1	Lead	20	1986	20 (1986)	15	NPDWR
Coates MW-D1	Antimony	16	1984	16 (1984)	6	HRL
	Thallium	8	1984	8 (1984)	0.6	HRL
Lagoon PWL-1	Antimony	9	1984	9 (1984)	6	HRL
	Thallium	8	1984	8 (1984)	0.6	HRL
Lagoon PWL-2	Antimony	16	1984	ND (1985)	6	HRL
	Thallium	13	1984	ND (1985)	0.6	HRL
	Nitrate + nitrite	18,000	1984	18,000 (1984)	10,000	MCL/HRL
Lagoon PWL-3	Antimony	19	1984	ND (1985)	6	HRL
	Thallium	12	1984	ND (1985)	0.6	HRL
	Nitrate + nitrite	18,000	1984	18,000 (1984)	10,000	MCL/HRL
AOC-1N-W-GP1	bis(2-ethylhexyl)phthalate	74 J	2007	74 J (2007)	6	MCL/HRL
AOC-1M-W-GP3	Trichloroethene	0.47 J	2007	0.47 J (2007)	0.4	HBV
AOC-5-W-GP7	Diesel range organics	410	2007	410 (2007)	200	HBV
AOC-7B-W-GP2	Benzo(k)fluoranthene	4.4 J	2007	4.4 J (2007)	0.6	HBVeq
	bis(2-ethylhexyl)phthalate	6.4 J	2007	6.4 J (2007)	6	MCL
AOC-7B-W-GP3	Benzo(a)pyrene	0.91 J	2007	0.91 J (2007)	0.06	HBV
AOC-7C-W-GP3	bis(2-ethylhexyl)phthalate	6.6 J	2007	6.6 J (2007)	6	MCL
AOC-7C-W-GP7	Benzo(a)anthracene	1.4 J	2007	1.4 J (2007)	0.6	HBVeq
AOC-7D-W-GP5	2,4,6-Trichlorophenol	94	2007	94 (2007)	30	HRL
AOC-7A-W-HSA105	Trichloroethene	0.48 J	2009	0.48 J (2007)	0.4	HBV
MW-B7-014	Nitrate + nitrite	30,000	2011	30,000 (2011)	10,000	MCL/HRL

Shaded cells indicate exceedences of the state health based drinking water criterion within the last 7 years.
"J" indicates an estimated concentration below the laboratory reporting limit
HBVeq: Health Based Value equivalent; criterion derived based on toxic equivalency factors of various PAHs compared to benzo(a)pyrene.
NPDWR: National Primary Drinking Water Regulation; established by the EPA

VOCs: In 1984, samples collected from on-site monitoring wells down-gradient of the University Burn Pit area contained several chlorinated VOCs (chloroform, carbon tetrachloride, and dichloroethane) that exceeded the levels allowed in drinking water at that time, with the highest concentrations having been detected in monitoring well MW-21D (ATSDR, 1989; TCT 1985). Trichloroethylene (TCE) was also detected at concentrations that exceed the current MDH Health Based Value (HBV) of 0.4 ppb. To assess the extent of the chlorinated VOC contamination, 60 residential drinking water wells north of the UMore Park property were also sampled; 16 were found to contain levels of chloroform above the allowable levels at that time and MDH issued 27 drinking water advisories (ATSDR, 1989; TCT, 1985; ATSDR, 1997a).

As discussed in Section III, a pump and treatment system was installed in the University Burn Pit area and sampling of monitoring wells MW-21D, MW-22, MW-23D, MW-25, MW-28, and MW-29 between 1990 and 2011 detected decreasing concentrations of the chlorinated VOCs over time (see Table 1 in Appendix B; Delta, 2002; Barr, 2012). However, as shown in Table 3, TCE in wells MW-21D, MW-23D and MW-28 still exceeded the HBV as recently as 2011. In 2007-2009, groundwater samples collected from temporary boring samples in the AOC-7 area contained low levels of VOCs, none of which exceeded any health based criteria (USACE, 2009a and 2009b); no VOCs were detected in monitoring wells installed down-gradient of that area in 2011 (wells MW-B7-013, MW-B7-014, and MW-B-7-015; Barr, 2012).

Metals: In 1984, samples from monitoring wells at the former Coates Dump (MW-D-1) and the Process Water Lagoon (PWL-1, PWL-2, PWL-3) contained antimony and thallium at concentrations exceeding their drinking water criteria (although they were not detected in 1985 samples from wells PWL-2 and PWL-3; TCT, 1986). In 1985-1986 sampling of monitoring wells at GUE (GUE-MW-19 and GUE-MW-20), detected antimony, cadmium, thallium, and zinc at concentrations above their health based drinking water criteria (TCT, 1986). Sampling of well GUE-MW-19 also detected chromium and lead that exceeded their health based drinking water criteria, but these results were not confirmed in a duplicate sample. Cadmium was not detected in later samples at the site, but the magnitude and extent of antimony, thallium and zinc in groundwater has not been delineated, as no samples after 1986 were analyzed for these metals.

SVOCs: The first time groundwater samples were analyzed for SVOCs appears to have been in 2007, when water samples were collected from temporary borings during the USACE investigation of AOC-7 (GOW East), the Waste Disposal Ditch and Settling Ponds (AOC-1) and the DNR Storage Bunkers (AOC-5; USACE, 2009a and 2009b). Trace levels of many SVOCs were detected, but only four exceeded their health based drinking water criteria in samples from AOC-7 – benzo(a)pyrene (BaP), benzo(k)fluoranthene, benzo(a)anthracene, and bis(2-ethylhexyl)phthalate and only one (bis(2-ethylhexyl)phthalate) exceeded its drinking water criterion in AOC-1. Monitoring well samples collected in 2011 did not detect any of these compounds (Barr, 2012).

DRO: This chemical mixture was only tested for in selected temporary boring samples collected in AOC-5 and AOC-7 (USACE, 2009a). Only one sample (AOC-5-W-GP7) exceeded the HBV of 200 ppb. Although no later monitoring well samples were tested for DRO, the absence of petroleum compounds in the groundwater at the site suggests this is not a significant site contaminant.

Nitrate+nitrite: This compound was found to exceed its MDH HRL in samples from the Process Water Lagoon area (PWL-2, PWL-3) and in several of the monitoring wells (MW-21D, MW-28, MW-29, MW-B7-014, MW-E4-10). However, nitrate+nitrite is a common groundwater contaminant in agricultural areas and one of the highest levels detected was in MW-E4-10, located upgradient of the entire UMore Park area. It therefore seems likely that the nitrate+nitrite detected in the groundwater at the site is primarily from regional agricultural activities on and around the UMore Park property.

Drinking Water Sampling:
In 1991, after chlorinated VOCs were detected in several private wells north of the site, the University of Minnesota installed two wells and water lines north of the UMore property to provide a drinking water supply to the affected residential area (this is discussed in further detail in Appendix B). The city of Rosemount now maintains these two community water supply wells (well #1, UN 457167; well #2, UN 474335). Both draw water from the Jordan Sandstone. These wells have been tested regularly since 1994 for VOCs, SVOCs (including pesticides), metals, radionuclides, nitrate, and bacteria. Only one sample, in 1996, slightly exceeded a drinking water standard, when nickel was detected at 110 ppb (the HRL is 100 ppb; there is no MCL).

In 2013, following the publication of the new HBV for TCE, MDH sampled four private water supply wells still in use down-gradient of the UMore East property (Figures 20). The samples were analyzed for VOCs, including 1,4-dioxane, and two metals (thallium and antimony) which previously had been detected at elevated concentrations in on-site soil and groundwater samples. The two metals were not detected, but several chlorinated VOCs were detected in one well at a commercial property immediately east of Subsite GOW North ("Well A"): 0.24 ppb carbon tetrachloride, 4.8 ppb chloroform, 0.39 ppb TCE, 0.92 ppb 1,4-dioxane. None of these VOCs exceed their individual health risk criteria, but their combined concentrations exceed a calculated additive risk level. MDH issued a drinking water advisory for this well. The property already had a city water connection for several buildings; the property owner indicated the affected well will be posted for non-potable use only and all drinking water will be obtained from the city water supply. MDH was unable to obtain samples from the remaining properties where private wells may still be in use, but plans to attempt additional sampling in the areas north and east of UMore East.

Drinking water on the UMore property is supplied by two community water supply wells (UN 207611 and 207618) located near the north boundary of the UMore East Section of the property (Fig. 21). Well #2 (UN 207618) is the primary well and draws water from the base of the Jordan Sandstone and top of the St. Lawrence Formation. Well #1 (UN 207611) is an emergency backup well; the log for this well does not clearly identify which aquifer it uses, but it likely draws water from the Jordan Sandstone and possibly the base of the Prairie du Chien Group. These wells are regularly tested for bacteria, nitrate, VOCs, pesticides, and metals. Pesticides or bacteria have never been detected. Infrequent trace level detections of ethylbenze and xylenes (petroleum constituents) and routine detections of total trihalomethanes (disinfection by-products) have all been far below federal and state drinking water standards. Nitrate + nitrite nitrogen has ranged from 2.3 – 11 ppm, but has not exceeded the MCL of 10,000 ppb since 1997. Mercury was detected once at a trace level (0.1 ppb) well below the MCL (2 ppb), but antimony and thallium have not been detected.

In 1988, MDH began monitoring private water supply wells near the former Coates Dump in the Vermillion Highlands (Figure 21); some of these wells are also located down-gradient of the GOW Drainage Ditch area. Nitrate levels above the MCL of 10,000 ppb were detected in 11 of 15 wells sampled and four VOCs [TCA, TCE, tetrachloroethylene (PCE), and carbon tetrachloride] were detected below their respective drinking water criteria in four wells. VOC concentrations have decreased over time. In 2009, MDH tested the water from six of the private wells for VOCs; three of the six also were tested for perfluorinated chemicals (PFCs). Low levels of two VOCs (PCE and carbon tetrachloride) were detected in three of the wells and low levels of perfluorobutanoic acid (PFBA) were detected in two of the wells; all results were below the MDH drinking water criteria used by Minnesota agencies (PCE MCL/HRL = 5 ppb; carbon tetrachloride HBV = 1 ppb; PFBA HRL = 7 ppb). These wells will continue to be monitored by MDH in the future to ensure that the residents are not exposed to contaminants above MDH individual or additive health-based drinking water criteria. In the event that drinking water contaminant concentrations exceed MDH criteria, MPCA will provide clean drinking water.

Until 2004, three wells (UN 208403, 270266, 270267) were used as non-community public water supply wells by Riaten, one of the tenant businesses located within the former Navy/Burning Grounds area. MDH sample analyses from 1995 to 2003 found occasional low to trace levels of disinfection byproducts and 1,2 dichloropropane; none of these exceeded the HRLs. The Riaten wells were tested twice for metals, including antimony and thallium, which were not detected. According to MDH records, these wells were sealed in 2009 (Versar, 2010).

Finally, although not part of the University property being evaluated in this report, it must be noted that elevated levels of thallium, antimony, and other metals were detected in several drinking water wells (UN 207605, 207607, 207617, 208402 and 208405; Figure 21) in the UMore Mining Area (Barr, 2009b and 2010b). Samples collected in September 2009 detected thallium in one well (UN 207607; workman's change house) and lead in another (UN 208402; UM office building) at levels above health concern; however sampling in April 2010 detected no thallium in well 207607 and lead in 208402 below levels of health concern. Two of the wells (207605 and 207607) are identified in the County Well Index (CWI) as "public supply/non-community" wells; the rest are classified as "domestic" wells that served the University swine & sheep farm, office building, and superintendent's residence (the latter was sealed in 2010).

Areas of Concern (AOCs) with No Groundwater Data:
Information from the soil investigations at AOC-6 and Building 237G in the ABC Line area suggest there may be sufficient contamination to warrant additional investigation. At AOC-6, the deepest soil samples (at 2 to 5 feet) collected from two sample locations (FGOW-AOC-6-S-TP3 and FGOW-AOC-6-S-TP5), which span more than 325 feet of the northern half of this area, contained levels of BaP and other PAHs that significantly exceeded the SRVs and soil leaching values (SLVs). Although PAHs generally have low mobility in soil, the lack of sampling data below 5 feet makes it impossible to rule out groundwater contamination, particularly as the nearest monitoring wells are located more than a mile from this area. Additional sampling may be needed before any development occurs and, if this indicates contaminants have migrated downward, groundwater monitoring wells may be needed.

At Building 237G, a soil boring advanced in 2008 encountered soils that contained "…a frothy liquid that smelled of mothballs…from 25-45 feet below ground surface" (as cited in Barr, 2011a). This odor may indicate naphthalene or related PAHs. The depth to groundwater in this area is approximately 50-55 feet (based on figure 10 of Barr, 2012). Later surface and near surface sampling near this location and a sample collected at 30 feet from a deep soil boring (237G-SB1) located 5 feet from the original boring did not detect any PAHs or VOCs (Barr, 2012). The disparity between the visual and odor observations in the initial boring and the absence of contamination in the second boring leaves this as an unresolved question. There are no monitoring wells in this area or down-gradient of it, but there are drinking water wells located less than a mile down-gradient, in the town of Coates. For this reason, it would be advisable to sample groundwater at this location to confirm that no contamination has occurred.

While every effort was made to locate all site groundwater data for this review, some data were presented in only summary form. MDH understands that MPCA intends to request a comprehensive evaluation of the hydrogeology and groundwater sampling for the entire property, to compile all of the known information about the groundwater in one document.

V. Contaminants of Concern

Contaminants in the soil at this site are compared to the MPCA's soil reference values (SRVs) (MPCA, 1999b). SRVs represent acceptable soil concentrations for exposure to soil under different scenarios. Residential SRVs are values that are protective for children in a residential setting, and industrial SRVs are calculated to protect an outdoor adult worker. These values are routinely used by MPCA to screen contaminants at sites for further investigation and may be used to determine clean-up levels in Minnesota. There are differences in soil screening levels between states and federal agencies - see Appendix C for ATSDR's soil Comparison Values, the SRVs, and exposure assumptions for the SRVs. Minnesota SRVs for carcinogens limit incremental cancer risk to no more than one additional cancer case in 100,000 people. SRVs for non-carcinogenic contaminants take into account that 80% of exposure to an individual contaminant could be from sources other than site soil exposure.

A. Asbestos

Asbestos is a group of fibrous minerals that occur naturally in the environment. Because asbestos fibers are long, strong, flexible, and heat-resistant, they have been used in a wide range of building materials, including roofing shingles, ceiling and floor tiles, and cement products (ATSDR, 2001a). Inhalation exposure to asbestos has effects on the lungs, including pleural thickening and asbestosis. Asbestos also causes mesothelioma and lung cancer. Both short-term inhalation exposure to high levels and long-term inhalation exposure to low levels can result in lung disease.

Asbestos containing building materials (ACBM) can be observed on the ground surface in many locations at the site. ACBM was likely used in most of the GOW buildings because of its properties as a thermal insulator and fire retardant.

Asbestos was sampled in two stages at many of the GOW building remnants throughout the UMore property in 2006 (Peer, 2006). A total of 156 samples of concrete, soil, and building material debris such as insulation, tar paper, mastic (a construction adhesive and joint-sealer), wallboard, and Transite (an asbestos-cement product) found on site were tested to determine asbestos content. Eighty-two percent (23 of 28) of the building remnant samples contained a range of 1 to 45 percent asbestos. No asbestos was found in any of the concrete. Only two of the soil samples contained asbestos. One surficial soil sample contained less than one percent asbestos and one sediment sample at depth of four feet near a sewer pipe contained two percent asbestos (Peer, 2006).

In January 2009, the University signed a Stipulation Agreement with the MPCA regarding alleged violations of asbestos regulations at UMore Park. In response, the University developed an Asbestos Emission Control Plan, which was approved by the MPCA in July 2009. Requirements of the Stipulation Agreement were completed and it was terminated by the MPCA in December 2011.

Prior to the 2011 Remedial Investigation work, an asbestos hazard assessment was completed to protect field representatives and to prevent asbestos from being disturbed (Barr, 2012). This included a visual inspection of the land and documentation of ACBM debris or possible ACBMs in many places on the site. Five samples were that suspected to contain asbestos were analyzed and two were found to be ACBM (Barr, 2012). The University states that asbestos identification and characterization were not a focus of this most recent RI (Barr, 2012).

There is evidence of trespassing on the site among the building remnants that contain asbestos; there are also workers and tenants near areas where ACBM may be found. However, it is likely that any exposure to the asbestos would be too infrequent and in a dose too low to cause adverse health effects. Direct handling of pieces of ACBM could be a concern if asbestos fibers are released into the air, but it is unknown if this has occurred. Asbestos materials in pipe wrap are friable, which means it is possible for fibers to become easily separated and more likely to enter the air and ultimately the lungs. Much of the ACBM found on the ground at the GOW site are materials that are considered to be non-friable in their original state, but these materials can be friable if damaged or weathered. A licensed inspector is needed to determine what material is friable.

MDH Recommendation: Despite the current low exposure risk to people at the site, the asbestos in the soil and debris needs to be removed before the public is allowed open access to the site. In the future, risks from asbestos are expected to increase as continued breakdown and disturbances release asbestos fibers into the soil. Therefore, MDH recommends removal of asbestos materials. Open areas on the site without GOW ruins or former GOW infrastructure are not expected to contain asbestos in the soils. However, it is possible during demolition and removal of GOW structures ACBM was dispersed in site soils from the consolidation or removal of building materials. Future development plans will need to take the potential for asbestos in soils in consideration, especially for residential or other land uses where future soil disturbances are likely.

B. Metals: Lead, Mercury, Arsenic, Antimony, Thallium

All soils naturally contain trace levels of metals. In general, metals do not degrade but have different levels of mobility in the soil. Below is a summary of the metals that have been found as contaminants at the site and information regarding soil reference values and soil concentrations.

Lead

Subtle neurobehavioral effects in children can occur at very low blood lead levels. Although the most sensitive target for lead toxicity is the developing nervous system in children, the nervous system of adults is also a main target of lead. Lead can affect almost every organ and system in the body, with other sensitive targets being the blood and cardiovascular systems, and the kidneys (ATSDR, 2007a). Very high exposure levels to pregnant women may cause miscarriage.

EPA has developed the *Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children* to assess risk from lead. The IEUBK Model is designed to model exposure from lead in air, water, soil, dust, diet, and paint and other sources to predict blood lead levels in children 6 months to 7 years old. The IEUBK Model is used to estimate risks from childhood lead exposure to soil and household dust that might be encountered at contaminated sites and to predict the probability that a typical child will have an elevated blood lead level when exposed to specified lead concentrations. Current EPA policy uses the IEUBK model to estimate the highest lead concentration in site soil that is based on no child having a greater than 5% probability of having a blood lead concentration of 10 micrograms per deciliter (µg/dL). Using that criteria, the MPCA used the IEUBK model to develop a protective residential screening value of 300 ppm of lead in soil. However, new Centers for Disease Control and Prevention (CDC) guidance in 2012 has changed from identifying a blood lead level of concern at 10 µg/dL to identifying a reference level for elevated lead in children at 5 µg/dL (CDC, 2012). It is unclear whether EPA or MPCA will lower soil screening levels in future in response to CDC's new guidance.

MDH Recommendation*:* As the UMore site is developed into residential yards and playgrounds for children, MDH recommends remediating soils with lead to levels lower than the residential SRV of 300 ppm. It is also recommended that the highest concentrations of lead at the site (19 samples between 730-8090 ppm lead in multiple subareas) be removed or fenced to prevent exposures (see Current Exposures section below). The current industrial SRV for lead is 700 ppm.

Mercury

The toxic effects of mercury depend on its chemical form and the route of exposure. Although mercury is often reported as total mercury in environmental samples and the different chemical forms are rarely identified, most mercury in air, water, and soil is inorganic or elemental, while significant levels of methyl mercury are only typically found in organisms that are high on the aquatic food chain (NJMTF, 2002). Research has indicated that the methylmercury contribution from biosolids (sewage sludge) application is a very small fraction of the total mercury concentration in soil (Carpi et al., 1997). Elemental mercury poses a risk primarily through inhalation of vapors, but if ingested may simply pass through the body due to low gastrointestinal uptake. Ingestion of other inorganic forms of mercury, such as mercury salts, can damage the gastrointestinal tract and kidneys.

The residential mercury SRV is 0.5 ppm and the industrial mercury SRV is 1.5 ppm. The highest levels of mercury, found at a depth of two feet near the former waste water treatment plant in the 2003 sampling (420 and 590 ppm), could not be located in 2011 during the RI and could not be confirmed.

Surface soil samples had elevated mercury throughout the former GOW drainage basin. Two samples in the northern section of the drainage basin, at the lower process wastewater ditch, had the highest concentrations (7.3 and 11 ppm). Three more samples in the middle section in the primary settling basin were slightly elevated at 1.5 and 1.9 ppm. Lower concentrations were found further south in the drainage basin; however, as with most discrete sampling efforts, it is difficult to determine if the sampling is adequate to represent concentrations in the soil or sediment. Exposure to soil in this area may occur from occasional recreational activities and any contact with mercury in the soil is likely to be rare. The bioavailability of the mercury in the soil in the drainage basin is unknown; however it is likely to be poorly absorbed (ATSDR, 1999).

The largest exposures to mercury that most people have throughout their lives are from consumption of fish contaminated with methylmercury. It is always a good idea to limit the amount of mercury that gets into a watershed to prevent it from being transformed into methylmercury and bioaccumulating in fish.

Arsenic

As the level of arsenic increases above the range of natural background concentrations (about 20 ppm), there is some slight increase in the likelihood of chronic health effects from contact over many years. This could include a very small increase in the risk of certain cancers, and cardiovascular disease. EPA has determined inorganic arsenic is a known carcinogen. Studies have shown the ingestion of inorganic arsenic can increase the risk of skin cancer and cancer in the liver, bladder, and lungs. These diseases are widespread, have many risk factors, and take many years to develop. Ingesting arsenic over many years is also known to cause skin discoloration and/or skin growths (ATSDR, 2007b).

The risk of exposures to arsenic at the site is very low. The residential SRV of 9 ppm is within the range of natural background. Only seven soil samples contained arsenic over the industrial SRV of 20 ppm, ranging from 21 ppm to 140 ppm, with the highest concentration detected at a depth of 1 foot below grade. The samples were collected primarily in the ABC Line (particularly the northern half of that area) and GOW East areas, but also at one location on the west side of the DEF Line area. Only two surface samples exceeded the industrial SRV, with the highest surface soil concentration at 43 ppm.

Antimony

Ingesting large doses of antimony is known to cause vomiting. Other health effects of ingesting antimony are largely unknown. Animal studies have reported liver damage and blood changes when animals ingested antimony. Antimony can irritate the skin (ATSDR, 1992).

Very few soil samples on the site have been analyzed for antimony. Antimony was found above the residential SRV of 12 ppm in the soil at three locations (28-676 ppm) at GUE and at five locations (19-36 ppm) in the GOW wastewater drainage area during the 1984 sampling of the former NPL site (TCT, 1986).

Most studies indicate a low potential for antimony to leach from soil to groundwater, except under certain conditions such as sewage sludge land application or areas with acid mine drainage (ATSDR, 1992a; WHO, 2003). Once in water, soluble forms of antimony are reportedly quite mobile, while less soluble forms are adsorbed onto clay or soil particles (WHO, 2003).

Elevated concentrations of antimony exceeding the HRL of 6 ppb were detected in groundwater samples collected from monitoring wells at GUE, Coates Dump Site, and the Process Water Lagoon area. Although no recent groundwater samples were collected in the UMore East or Vermillion Highlands areas, elevated antimony was detected in samples collected in the UMore Mining Area (west of UMore East) in 2009 (Barr, 2009b and 2010b). Antimony was not detected in samples from monitoring wells sampled to provide background water quality data during those investigations nor was it detected in samples collected from private wells northeast of UMore East in 2013. Naturally occurring concentrations of antimony in groundwater are quite low (MPCA, 1999a).

Thallium

Exposure to thallium has been shown in human and animal studies to cause hair loss, neurological effects, and kidney damage, although in general the available studies on thallium are of poor quality. There is a lack of data to determine whether thallium is carcinogenic (USEPA, 2009b).

Thallium was found above the residential SRV of 3 ppm in the soil at seven locations (4-36 ppm) during the 1984 sampling of the former NPL site (TCT, 1986). Concentrations of thallium exceeding the HRL of 0.6 ppb were detected in groundwater samples collected from monitoring wells at GUE, Coates Dump Site, and the Process Water Lagoon area. Although no recent groundwater samples were collected in the UMore East or Vermillion Highlands areas, elevated thallium was detected in samples collected in the UMore Mining Area (west of UMore East) in 2009 (Barr, 2009b and 2010b). Thallium was not detected in samples from monitoring wells sampled to provide background water quality data during those investigations nor was it detected in samples collected from private wells northeast of UMore East in 2013. Naturally occurring concentrations of thallium in groundwater are quite low (MPCA, 1999a).

C. Carcinogenic Polycyclic Aromatic Hydrocarbons (cPAHs)

PAHs are produced by the incomplete combustion of organic materials such as coal, oil, wood, tobacco, and cooked food. They are also found in petroleum products such as asphalt, coal tar, creosote, and roofing tar. PAHs are found in the environment as mixtures. PAHs fall into two groups: those that are carcinogenic (cancer causing, known as cPAHs), and those that are not (non-carcinogenic PAHs, or nPAHs). While short-term dermal exposures to PAHs can irritate the skin, the health outcome of primary concern for people exposed to PAHs is cancer (ATSDR 1995).

PAHs that are elevated at the Gopher site are cPAHs. The toxicity of PAH mixtures is measured as the sum of the concentrations of each cPAH multiplied by its potency factor relative to the toxicity of benzo(a)pyrene (BaP). This sum is called benzo(a)pyrene equivalents (BaPE).

Historically, the cPAH potency of a mixture has been estimated using the sum of potency equivalents of seven cPAHs typically analyzed in the EPA recommended suite of PAHs. This is the way it has been calculated at GOW. This method has most likely resulted in an underestimation of the potency of cPAHs in a mixture (USEPA, 2010), and therefore comparing site concentrations to the BaP SRV is not health protective.

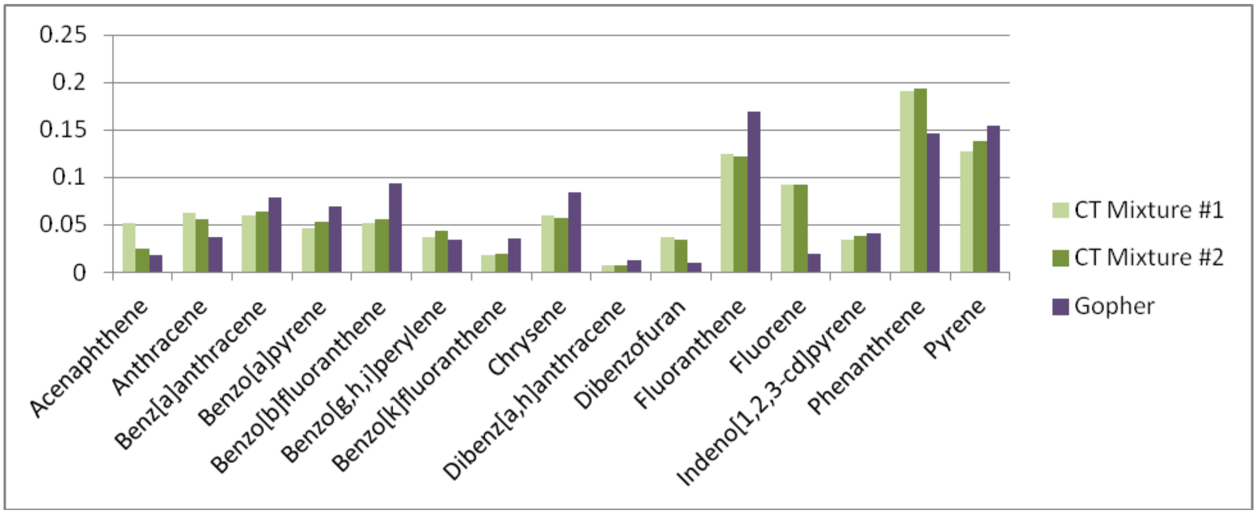
Previous MDH guidance recommends analyzing for an extended list of 25 cPAHs to more fully evaluate the cancer risks (MDH, 2001). In a recent draft toxicity assessment of PAH mixtures, EPA also uses a similar approach for calculating a cancer risk estimate from a draft list of 24 recommended cPAHs; 12 of which are additional cPAHs that are not evaluated using current MDH guidance (USEPA, 2010). MPCA also recommends the use of the extended list of cPAHs to evaluate risk to human health at sites where a combustion process (incinerator, open burning, etc.) was the source of the soil contamination (MPCA, 2002, 2011). However, it can be difficult to find an analytical lab that has the capability of measuring additional cPAHs beyond the seven that have historically been tested; approved methods for analysis do not exist for all of them.

The World Health Organization International Agency for Research on Cancer (IARC, 2010) discusses the importance of considering potent carcinogens when evaluating cPAH risk: "Although benzo[a]pyrene is the marker of PAH exposure that is most often used, there is evidence that a few PAH congeners, for example, dibenzo[a,l]pyrene, are more potent in their ability to induce lung cancer or skin cancer in experimental systems. These potent congeners should be measured in environmental and biological samples, as they may contribute substantially to the risk of human cancer attributable to PAH mixtures."

The University suggests that sources of BaPE could be from building materials such as waterproofing tar (Barr, 2012). Roofing tar is typically manufactured from coal tar. There will be variability in the potency between different coal tar mixtures, and these may be due to the age of the contaminant mixture as well as the source of the original mixture. As PAH mixtures age in the environment, the lighter weight constituents are weathered. This process typically leaves a higher proportion of heavier cPAHs on site. On the GOW site, it appears that materials and a limited number of structures were burned during decommissioning at the Burning Grounds. This combustion activity may have created pockets with different PAH constituents.

An analysis of the concentrations of individual cPAHs relative to each other at GOW indicates that PAHs are likely coal-tar based because the ratios of the seven cPAHs correlate well to other known coal-tar based mixtures. In Chart 1, below, 15 PAHs analyzed in GOW soil samples (Barr, 2012; Peer, 2006) are compared with the two mixtures of coal tar that were used in a two-year chronic mouse cancer study (Culp et al., 1998). Table 4 shows the correlation coefficients between the plotted data sets. Note that the correlation between the two coal tar mixtures used by Culp at al. is quite good (0.98), and the correlation between the Culp et al. data and GOW data are not as strong (0.78 – 0.81). The 4-6 ring PAH fractions in the GOW data is greater than the 4-6 ring PAH fraction found in coal tar (Table 4) (fluoranthene, a 3-ring PAH, is also increased). This may suggest that some of the differences between coal tar and the GOW data may be the result of weathering.

Chart 1: Fingerprint comparison (15 PAHs) of Coal Tar Mixtures and 10 PAH samples at GOW (see Appendix D for data)



CT (Coal Tar) Mixtures from Culp et al. (1998)

Table 4: Correlations between PAHs in Coal Tar and GOW data

	Coal Tar Mixture #1	**Coal Tar Mixture #2**	**GOW data**	**% 4-6 ring PAHs**
Coal Tar Mixture #1	1			44%
Coal Tar Mixture #2	0.98	1		48%
GOW data	0.78	0.81	1	60%

Cancer potency data for coal tar mixtures, relative to the BaP concentration in the mixture, have been calculated from the Culp et al. study with mice (Schneider et al., 2002). The upper limit cancer slope factor for ingested coal tar was calculated to be 11.5 (mg BaP mixture/kg-d)$^{-1}$. These data suggest a "rule of thumb" such that the cancer potency of coal tar, measured in BaP equivalents in the mixture, is about seven times more potent than BaP (MDH, 2013).

MDH Recommendations: As portions of the site are slated for redevelopment and remediation, MDH recommends that cPAHs either be further investigated with additional analytes measured or a mixtures approach be used. A policy option would be to estimate that the cancer potency of the cPAHs at GOW is about seven times the potency of the BaP soil concentration. These recommendations are consistent with updated MDH guidance that was posted in 2013, which includes an updated list of priority cPAHs (MDH, 2013).

MDH recommends that the highest levels at the site be removed or fenced to prevent exposure (see Current Exposure section below). PAHs in the form of BaPE were found in 56 soil samples above the residential SRV of 2 ppm, and in 46 samples above the industrial SRV of 3 ppm in the dataset. The range was from just over 2 to 710 ppm, with a median concentration of 13 ppm. Much of the BaPE contamination is concentrated in the ABC Line and GOW East (Figure 28 of Barr, 2012).

D. Polychlorinated Biphenyls (PCBs)

PCBs are a class of 209 compounds with a range of physical and toxicological characteristics. Each specific PCB compound is called a congener. Commercially, PCBs were sold as mixtures of congeners graded by the percent of chlorine in their total mass. Aroclor is the industrial trade name for the PCB mixtures that were produced by Monsanto from 1930 to 1977. For example, Aroclor 1260 and Aroclor 1254, identified at the George's Used Equipment site, are mixtures of PCBs containing 60 percent and 54 percent chlorine, respectively (an exception is Aroclor 1016, which has about 41 percent chlorine). The Porter Electric site contained Aroclors 1242, 1248, 1254, and 1260, and United States Transformer PCB contamination was identified as Aroclor 1260 (USEPA, 2007). The Agency for Toxic Substances and Disease Registry (ATSDR, 2000) and the EPA have published extensive reviews of PCBs and their behavior and fate in the environment. PCBs always appear in the environment as mixtures. The manufacture of PCBs in the United States was banned in 1977 because they are persistent, accumulate in the environment, and are toxic to humans and other animals. Low levels of PCBs are found throughout the environment because of long-range atmospheric transport from sources such as waste incinerators.

PCBs are very persistent chemicals. Degradation half-lives for PCBs are typically 2 to 10 years in soil (ATSDR, 2000). Higher chlorination of PCBs equates with greater toxicity, lower vapor pressure (and therefore less rapid evaporation), and slower degradation. The composition of a mixture of PCBs in the environment will therefore change over time, not only because of selective decomposition of PCB congeners but also because of different evaporation rates. Therefore, as an exposed PCB source ages, the ratio of highly chlorinated congeners to congeners with lesser chlorination may increase.

PCBs are lipid (fat) soluble chemicals and are therefore directly absorbable by inhalation, ingestion, and through the skin of animals, including humans. PCBs are stored in the fat of animals, including humans, and they bind preferentially to the organic fraction of soil and sediment. The half-life for PCBs is very long (about 7 ½ years in humans), and accumulation of PCBs can continue over an entire lifetime. The MDH fish consumption advisory contains strict advice on eating fish from the Mississippi River due to developmental effects on the children of women who consumed large amounts of PCB-contaminated fish.

When PCBs are heated, some are changed into other compounds known as polychlorinated dibenzofurans (PCDFs). In the presence of chlorobenzenes, polychlorinated dibenzodioxins (PCDDs) can also be formed (Erickson et al. 1989). These reactions can occur as a result of the overheating of electrical transformers or from fires. Typically, only a small percentage of PCBs are converted to PCDFs or PCDDs. PCDFs are also known to be contaminants of commercial PCBs, especially those manufactured before 1970 (ATSDR, 2000). While the percentage of PCDFs and PCDDs present in PCBs is likely to be small, they are of concern because some PCDFs and PCDDs are significantly more toxic than PCBs.

In 2013, IARC categorized PCBs as carcinogenic to humans based on sufficient evidence in human and animal studies (Lauby-Secretan et al., 2013; IARC, in press). PCBs can also cause adverse effects to the immune system and the endocrine system. Studies of workers who worked directly with PCBs suggest that exposure at high concentrations could cause irritation of the skin, nose, and lungs, gastrointestinal discomfort, and changes in blood and liver (ATSDR, 2000).

The screening level used for PCBs (SRV of 1.2 ppm) is based on developmental effects. This is lower than the screening value for cancer risk based on an IRIS cancer slope factor for "high risk and persistent" congeners. Certain PCB congeners act like dioxin. Calculations of PCB toxicity equivalence to dioxin (Prignano, et al., 2008; Van Den Berg, M. et al., 2006) suggest that the non-cancer SRV is protective for cancer risks. However, these calculations do not take into account environmental weathering, which can change the composition of Aroclors over time and may lead to an increase of dioxin-like congener concentrations (Rushneck et al., 2004). Ideally, PCB risk is best estimated using site-specific PCB congener data.

The highest samples of PCBs (273 and 128 ppm) were located at GUE, the former NPL site (Figure 30 of Barr 2012), and subsequently removed in 2013. Additional samples collected in 2013 on the north side of GUE ranged from 3-60 ppm PCBs and therefore additional investigation and response actions are planned in 2014 for the GUE area (Janet Dalgleish, personal communication, 2/7/14). Eight additional soil samples over the residential SRV of 1.2 ppm are located in AOC-7, which includes a sample at 26 ppm. One elevated sample was found at UST, two at transformer sites, two in the Laminex sewer, and one at the former wastewater treatment plant.

MDH Recommendation*:* There are a number of locations throughout the GOW site where PCBs are at levels over the SRV of 1.2 ppm. As redevelopment occurs, MDH recommends further investigation and possible removal of PCBs in areas that correspond with past use of PCBs or have a history of PCB detections.

E. Dioxins/Furans

Dioxins are a family of chemicals (including some PCBs) that share a similar chemical structure and common mechanism of toxic action (USEPA, 2011a). Dioxins occur as contaminants in the manufacture of certain organic chemicals or as unintentional byproducts of combustion. Exposure to dioxins occurs mainly from our food supply, but dioxins are widely distributed throughout the environment in low concentrations. Dioxins are persistent and bioaccumulative.

Dioxins have been characterized by EPA as likely to be human carcinogens and are anticipated to increase the risk of cancer at even background levels of exposure. Animal studies have shown that exposure to dioxins at high enough levels may cause a number of other adverse effects, including changes in hormone systems, alterations in fetal development, reduced reproductive capacity, and immunosuppression (USEPA, 2011a).

EPA has recently provided a new screening value for 2,3,7,8-TCDD toxicity equivalence of 50 parts per trillion (ppt) in soil based on the new EPA IRIS reference dose (USEPA, 2012a). The Agency of Toxic Substances and Disease Registry (ATSDR) screening value in soil for dioxins and furans is also 50 ppt. The MPCA's SRVs for 2,3,7,8-TCDD toxicity equivalence are 20 ppt for residential land use and 35 ppt for industrial land use.

Dioxins were found in the initial investigation at GUE at the former NPL site. Much of the soil around the GUE slab was excavated to a depth of 15 inches and/or covered with 10 inches of clean top soil (UMN, 2013a). However, there is known dioxin/furan contamination remaining beneath the soil cover south of the concrete slab (UMN, 2013a). It is possible that there may be additional elevated levels of dioxins in the soils near the concrete slab at GUE.

In addition to the areas of dioxin/furan contamination detected by past sampling at the former NPL site, there are other portions of the site where it is reasonable to consider dioxins/furans as a potential contaminant of concern. No dioxin sampling has occurred in any of the more recent sampling events.

MDH Recommendation: MDH recommends targeted dioxin sampling near the concrete slab at GUE and in other areas that have been suspected of burning of PCB oil or other chlorinated compounds. For example, according to the Phase 1, it was reported that PCB oil may have been used to heat a residence in GOW North (Barr, 2011a). The University Burn Pit may also be a source of dioxins.

F. Trichloroethylene (TCE)

Trichloroethylene (TCE) is a nonflammable, colorless liquid used primarily in degreasing metal parts (ATSDR, 1997b). It was also used for dry cleaning, as a carrier solvent for the active ingredients in pesticides, as an extractant in food products and for decaffeinating coffee, and as an inhalation anesthetic, but such uses have been discontinued (ATSDR, 1997b).

TCE is a common environmental contaminant, widespread in ambient air, indoor air, soil, and groundwater (USEPA, 2011b). TCE is extremely volatile, and most TCE released into the environment will evaporate into the air. TCE released to soil or leaking from underground storage tanks or landfills can also migrate through the soil into groundwater due to its moderate water solubility. TCE degrades slowly and therefore can persist in groundwater, and is one of the most frequently detected groundwater contaminants.

The EPA recently completed a thorough toxicological review of TCE, compiling available human epidemiologic data and experimental animal data (USEPA, 2011b). EPA concluded that TCE poses a potential human health hazard for non-cancer toxicity to the central nervous system, kidney, liver, immune system, male reproductive system, and developing fetus. The most sensitive effects appear to be developmental, kidney, and immunological (adult and developmental) effects. TCE is also considered a carcinogen by all routes for exposure. High exposures to TCE can cause kidney cancer in humans. There is also evidence of a strong causal association of human TCE exposure at high levels and non-Hodgkin's lymphoma. Less human evidence is found for an association between TCE exposure and other types of cancers (USEPA, 2011b).

MDH's 2013 toxicological review of TCE in drinking water agreed with EPA's conclusions. Immune effects were identified by MDH as the most sensitive health effect caused by exposure to TCE. MDH has developed a Health Based Value (HBV) for TCE in drinking water of 0.4 ppb, which is a safe level, and is protective for immune system effects as well as other health effects. This value is safe for all life stages, including developing fetuses, infants, children, and those with impaired immune systems. MDH determined that 2 ppb is protective for cancer for all individuals, even those exposed for an entire lifetime. A TCE drinking water concentration of 2 ppb is also a safe level for healthy adults who are only exposed after age 18; this level is also safe for pregnant women, to protect the developing fetus from heart defects.

TCE at concentrations above the HBV has been detected in on-site and off-site monitoring wells as recently as 2011 (Barr, 2012). Earlier sampling of residential wells also detected TCE at concentrations above the HBV (ATSDR, 1989; TCT, 1985). Although most of the affected residences were connected to city water, information provided by the city of Rosemount indicates that some homes may still be using private wells for their drinking water supply.

G. Dinitrotoluene (DNT)

Dinitrotoluene (DNT) is made by mixing toluene with sulfuric and nitric acid and is commonly used to produce explosives (ATSDR, 2013). 2,4-DNT and 2,6-DNT are two of six forms of DNT, and make up about 95% of technical grade DNT. DNT is also used in the bedding and furniture industry to produce flexible polyurethane foams (ATSDR, 2013). DNT does not accumulate in the environment and is broken down in soil by sunlight and bacteria. It can be transported to groundwater, where it is much less likely to breakdown, and therefore can remain for long periods of time.

The EPA considers mixtures of 2,4-DNT and 2,4-DNT to be "likely to be carcinogenic to humans." The Minnesota screening value of 0.5 ppb in groundwater for both compounds is taken from an EPA assessment of cancer risk based on mammary gland tumors in female mice (USEPA, 2008).

USACE (2006) states that in the nitrocellulose manufacturing process, rifle powder would be blended with DNT in a mixer to obtain specified burning characteristics. It is unclear how much DNT was actually used at GOW, and the little found in the soil suggests that the use was either limited or that it has degraded over time. GOW also produced reclaimed gunpowder that may have contained DNT.

2,4-and 2-6-DNT have been found in the soil at the former GOW at levels below the SRVs. Most detections of the DNTs are less than 1 ppm. The greatest detection of DNT is 10 ppm of 2,4-DNT (the SRV for 2,4-DNT is 50 ppm and the ATSDR Comparison Value is 100 ppm). The highest levels are found at the ABC Line. The soil leaching value (SLV, a screening tool to evaluate the potential for contaminants in soil to leach to groundwater) for DNT is 0.0001 ppm. Although the concentrations of DNT detected at the site are quite low, many of the samples exceeded this SLV, suggesting the potential for DNT to be present in the groundwater.

USACE detected 2,4-DNT (0.26 ppb) in only one groundwater sample located near the former drainage ditch (AOC-1N) at the GOW site (USACE, 2009a). However, the reporting limits for most of the 2,4-DNT and 2,6-DNT samples collected by the USACE were 20 ppb, well above the Minnesota screening values of 0.5 ppb for both compounds. The reporting limits for samples collected by Barr generally have been 0.42 and 0.49 ppb, respectively, which are below the screening levels and provide better assurance that DNT is not present in samples reported as "non-detect".

Potential degradation products of DNT (nitroanilines, 1,3-dinitrobenzene, nitrotoluenes, nitrobenzene) (ATSDR, 2006a) have not been found in the groundwater. Although degradation of DNT may contribute to nitrate levels in groundwater (ATSDR, 2006a), the current nitrate concentrations in groundwater at the site appear to simply reflect background concentrations related to agricultural activities in the area, rather than GOW-related activities or degradation of DNT. Concentrations of nitrate resulting from the degradation of DNT are expected to be similar to the levels of DNT in the groundwater (ATSDR, 2006a). Therefore, even if degradation of the DNT currently detected in the groundwater did occur, it would not result in any significant increase in existing groundwater nitrate levels.

H. Nitrocellulose

Nitrocellulose (NC) is an explosive derived from the reaction of cellulose with nitric acid. GOW manufactured nitrocellulose by treating either cotton or wood fibers with a specific mixture of nitric and sulfuric acid (USACE, 2006). NC is resistant to environmental degradation and thus persistent in the environment. EPA's National Center for Environmental Assessment completed a Provisional Peer-Reviewed Toxicity Value support document for NC in 2009 (USEPA, 2009a), which found that it is relatively nontoxic. Exposure to people from contaminated sites is limited and extremely unlikely to cause an adverse effect.

However, NC is highly flammable and explosive. Safety precautions need to be taken at levels over 10% of fine particles of NC in soil (or 100,000 ppm) because of detonation potential (USEPA, 1996), especially during demolition on formerly used ammunition sites (MacMillan et al. 2008). NC analytical results within the Vermillion Highlands drainage ditch are as high as 18,000 ppm (or 1.8%), but everywhere else NC is not detected or is at very low levels without an explosion potential.

MDH Recommendations: NC is challenging to measure in soil and common methods used are not reliable. A newer method has been recommended by the EPA as much more accurate (MacMillan et al., 2008; Harry Craig (EPA), personal communication, 3/2/12).

Because NC grains are discrete particles and amounts could vary greatly over short distances, discrete sampling may not provide good estimates of what is at the site (USEPA, 2012c). Multi-incremental sampling with mechanical grinding of the sample provides much better representation of concentrations present because there is much less likelihood of missing particles.

However, it is more likely that propellant grains, which can be the size of cigarette butts (USEPA, 2012c), and therefore can be found through visual inspection, are more of a concern as the grain materials themselves can be explosive. MDH recommends caution continue to be taken during redevelopment in case there are propellant grains. In the investigations to date, no grains of NC have been reported. It is likely that during the manufacturing and decommissioning of the former GOW the Army was very careful to manage the NC to avoid explosions. It has been recommended by contacts at EPA and USACE that future sampling of unknown substances use the method 1030 ignitability test [Harry Craig (EPA), personal communication, 3/2/12; Marianne Walsh (USACE), personal communication, 4/23/12].

I. Nitrates

Nitrate (NO_3) is a naturally occurring chemical and is also a common contaminant in Minnesota groundwater. There are many potential sources of nitrate in the environment, including runoff or seepage from fertilized soil, municipal or industrial wastewater, landfills, animal feed lots, septic systems, urban drainage, or decaying plant material.

High nitrate levels in drinking water can pose a special risk for infants under six months of age. If an infant is fed water or formula made with water that is high in nitrate, a condition called "blue baby syndrome" (or methemoglobinemia) can develop. Bacteria which are present in an infant's stomach can convert nitrate to nitrite (NO_2), a chemical which can interfere with the ability of the infant's blood to carry oxygen. As the condition worsens, the baby's skin turns a bluish color, particularly around the eyes and mouth. Prompt medical attention usually results in a quick recovery; however it can be fatal if nitrate levels in the water are high enough and prompt medical attention is not received (ATSDR, 2011).

Infants are susceptible partly because their stomach juices are less acidic. As an infant ages, its stomach acidity increases, reducing the numbers of nitrite-producing bacteria. After six months, the conversion of nitrate to nitrite in the stomach no longer occurs. Most adults can consume larger amounts of nitrate with no ill effects. The average adult in the U.S. consumes about 20-25 milligrams of nitrate-nitrogen every day in food, largely from vegetables. Women who are pregnant already have elevated methemoglobin levels in their blood. That may make them more susceptible to methemoglobinemia after the 30th week of pregnancy.

The MDH HRL and the EPA MCL are both 10,000 ppb for nitrate in drinking water. Seven of the 15 monitoring wells in the 2011 UMore East Remedial Investigation exceeded the standard. The source of the nitrate at the former GOW is likely regional agricultural activities rather than GOW-related activities, based on the fact that some of the highest concentrations (22,000 ppb) were detected in an upgradient monitoring well at the site.

J. Other Contaminants of Public Health Interest

Diphenylamine (DPA) and N-Nitrosodiphenylamine (NDPA)

Diphenylamine (DPA) is a stabilizer commonly used in nitrocellulose-based propellants. DPA was reportedly mixed in with the NC during the solvent process stage of powder manufacturing at the former GOW (USACE, 2006). DPA degrades to N-Nitrosodiphenylamine (NDPA), which also serves as a stabilizer (USEPA, 2012c). DPA is not expected to move through soils to groundwater and has been reported to be degraded in soil (USEPA, 2012c).

DPA and NDPA were detected at GOW but far under ATSDR's Comparison Values of 1,300 ppm and 140 ppm, respectively. DPA was rarely tested for in 2011 during the RI, and was only detected in four samples in soils at very low levels from 0.16-0.58 ppm. A larger number of samples were analyzed for NDPA, but NDPA was also only detected in four soil samples at concentrations ranging from 0.057-0.96 ppm. DPA was not analyzed for in the Laminex Woodbox sewer samples, but NDPA was detected in three samples there from 0.017-0.8 ppm. Other samples of NDPA in VH datasets were below detectable levels. There were very few other samples tested for DPA in VH's datasets, these were also below detectable levels. No DPA or NDPA was found in groundwater.

Dibutylphthalate (DBP)

Another additive to the NC gun powder is dibutyl phthalate (DBP). According to the EPA (USEPA, 2012c), DBP is one of a few non-energetic binder and plasticizers that are included to make the propellant grains less brittle. DBP has many uses, and because of this it is widespread in the environment and most people are probably exposed to low levels in air (ATSDR, 2001b). DPB appears to have relatively low toxicity and is readily broken down by bacteria in soil (ATSDR, 2001b).

DBP was detected in 55 soil samples at very low levels in the 2011 RI, ranging from 0.048-9.2 ppm. It was also found in eight sediment samples in the Laminex Woodbox Sewer from 0.085-23 ppm, and in one sample under the sewer at trace levels. DBP was detected several times in the Vermillion Highlands, but all levels are less than or equal to 0.4 ppm. ATSDR's soil screening level for DBP is 5,000 ppm. DBP was not found in groundwater.

Perchlorate

Perchlorate is mainly used in the production of rocket fuel, fireworks, flares and explosives. A concern has been raised about the potential for perchlorate in groundwater. Groundwater was sampled for perchlorate in the 2011 Stage 1 RI (Barr, 2011b), but the reporting limit was 100 ppb which is not low enough to determine the presence of perchlorate at relevant levels. No soil has been tested. However, despite the lack of sampling, the type of gunpowder produced at Gopher was single-base, which is comprised mainly of nitrocellulose and does not contain perchlorate (USEPA, 2012c).

VI. Discussion

A. Current Exposures

The data collected at this site are generally not adequate to form confident conclusions on potential contaminant exposure and health risk. However, current exposures are limited. According to the UMore East Phase I (Barr, 2011a) the UMore Park portion is currently used for agricultural production, agricultural research, University operations and University tenant operations. Public access is discouraged in this area with signage and security patrols. Nevertheless, much of the Vermillion Highlands is open to the public for recreation, and several contaminants exceed screening values. While these screening values incorporate assumptions that likely overestimate exposures, more information is needed to better understand current land uses and potential exposures.

The evaluation of public health hazards by sites listed in Appendix A is summarized in Table 5, below.

Table 5: Summary of the Evaluation of Public Health Hazard Categories[a]

Subarea	# of Sites with Data[b]	No Public Health Hazard	No Apparent Public Health Hazard	Indeterminate Public Health Hazard	Public Health Hazard	Public Health Hazard Contaminants
GOW East	16	3	7	4	2	lead, cPAHs, PCBs
ABC Line	46	14	19	10	3	lead, cPAHs, PCBs
GOW Central	8	1	2	5	0	--
DEF Line	4	1	1	1	1	cPAHs
Navy/Burning Grounds	9	2	2	3	2	lead, cPAHs
GOW West	3	2	0	1	0	--
GOW North	2	2	0	0	0	--
Site Wide	4	0	2	2	0	--
VH - Area 1	9	4	1	3	1	physical hazards
VH- Area 2	2	0		2	0	--
VH - Area 3	2	0		1	1	physical hazards
VH- Area 4	5	0		3	2	physical hazards
Groundwater	16	8	2	6	0	VOCs

[a]No Public Health Hazard: Sites for which data indicate no current or past exposure or no potential for exposure and therefore no health hazard.
No Apparent Public Health Hazard: Sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.
Indeterminate Public Health Hazard: Sites for which no conclusions about public health hazard can be made because data are lacking.
Public Health Hazard: Sites that pose a public health hazard as a result of long-term exposures to hazardous substances.
[b]Not every identified site has data. Some sites have minimal data. It is possible additional sites may be identified during redevelopment.

Physical safety

MDH recommends that physical threats be removed. At a minimum, it is recommended that areas that are physically unsafe be fenced to prevent public access.

Physical safety is a primary concern for those trespassing or otherwise walking through the property. The Vermillion Highlands Phase 1 investigation (Barr, 2010a) noted the potential for physical safety risks, in particular due to the farmstead remnants, which may include fall hazards for site visitors. Physical hazards include unsafe terrain, open pits, debris, abandoned equipment, or unsafe structures. The U.S. Army left numerous structures in place throughout the former GOW, most in unusable condition. Several structures are easily accessible because of their close proximity to public roads. The Northern Notch Area in Area 1 of the Vermillion Highlands is fenced off to control public access in part to prevent contact with physical hazards such as open pits, and impaling hazards (Barr, 2010a). In addition, there are a number of dump sites (10th St. Dump, B Street Dump, 30th St. Dump, 160th St. Dump, etc.) with surficial debris where it is recommended that public access be prevented.

University Staff and Agricultural Use

The University estimates about 25 University employees work in the agricultural fields or as researchers on the site (Janet Dalgleish (UMN), personal communication, 6/13/12). In addition, there are several staff working in University offices on site and several maintenance workers.

In response to the data from the 2011 RI (Barr, 2012), the University has decided to stop harvesting crops for consumption in two areas in the ABC Line subarea north of 152nd Street because of lead contamination from the former lead burner shop and mercury and arsenic contamination from the former auto body shop (Janet Dalgleish (UMN), personal communication, 12/12/12). The field will still be cultivated and planted in order to keep weeds from blowing into other fields. There have not been other contaminants found in cultivated fields that would warrant special land use considerations. It is unknown if there is asbestos in soils in the fields that could be dispersed during agricultural activities.

Current Residences

There are two residences on the former GOW site that are being leased out by the University. One is adjacent to the former GOW wastewater treatment plant building. There are elevated levels of mercury (23-30 ppm) east and northeast of the home. No soil testing has been done right next to the home; but the nearest samples show no evidence of contamination. The second residence is located near the Beef Barn in GOW Central. No soil or groundwater samples have been collected in the area of this home. The source of drinking water for both homes is the University system. Other homes had been leased by the University in the past, but have since been demolished.

Current Tenants

People who are leasing property or land from the University may be the most likely to be exposed to soil contaminants. There are 18 current tenants on the site. Carcinogenic PAHs are found in surface soil above the industrial SRVs in two locations (5.5, 5.7 ppm) at building 707FFF, which is currently leased for a machine shop (Figure 22). Contaminated soil in this area should be removed to prevent exposure to those on the site. The same tenant occupies building 704F; this is the closest tenant to the elevated PCBs (up to 60 ppm) associated with the GUE, part of the former NPL site. PCBs are also found at levels above the residential SRV but below the industrial SRVs (1.3-4.8 ppm) northeast of GUE. One detection of PCBs at 1.3 ppm is on the dirt road (see "Roads" below). Since most tenants are using the space for storage, it is expected that exposure to the soil would be infrequent. However, tenants should be made aware of the soil contamination in the vicinity of their rented property.

Some University tenant sites were not included in the RI. It is unknown if there is soil contamination at these tenant sites and whether people present at the sites are currently exposed to contaminants.

Drinking Water

There is no evidence that any public or private drinking water wells on or near the site currently exceed health based drinking water limits. However, concentrations of site-related contaminants in some private wells did exceed current MDH health-based drinking water criteria in the past. Furthermore, there appear to be a number of wells on and near the site for which little is known regarding their current use and water quality. Sampling of drinking water wells is discussed in greater detail in Section IV ("Groundwater") and Appendix B. Table 6, below, summarizes MDH's understanding of the status of wells on and near the site.

Table 6: Summary of Drinking Water Well Use and Water Quality

Well Type	Location (Unique Numbers)	Current Use	Water Quality	Recommendations
Off-Site Wells:				
Community public water supply (Rosemount city wells #1 and #2)	North of UMore property (457167, 474335)	Water supply for most properties north and northeast of UMore property	MDH tests regularly for VOCs, SVOCs (including pesticides), metals, radionuclides, nitrate, and bacteria. Meet federal drinking water standards.	No additional action required; continue routine sampling.
Private wells north & northeast of UMore Park	North & northeast of UMore Park (yellow shaded parcels on Fig. 21)	City records indicate several properties in this area still rely on private wells for drinking water supply.	MDH sampled 4 wells in 2013 for VOCs, antimony & thallium – 3 wells had no detections; 1 well had combined VOC levels that triggered a drinking water advisory	MDH will sample additional private wells as warranted and test for VOCs (incl. 1,4-dioxane) and metals (incl. antimony & thallium)
Private wells downgradient of Coates Dump and GOW Drainage Ditch sub-sites	East and northeast of the former Coates Dump (pink dots on Fig. 21)	Drinking water in this area is supplied by private wells.	MDH has sampled 15 wells in this area since 1988. Elevated nitrate, low level VOCs, and trace levels of PFBA detected in some of the wells; levels have decreased over time.	MDH should continue monitoring affected wells to confirm water quality trends and also test for 1,4-dioxane, antimony, and thallium.

Table 6: Summary of Drinking Water Well Use and Water Quality (continued)

On-Site Wells:				
Community public water supply (UMore Park wells #1 and #2)	Northern edge of UMore East (207618, 207611)	Supply water to UM and on-site tenant buildings except barns.	MDH tests regularly for VOCs, SVOCs (including pesticides), metals, radionuclides, nitrate, and bacteria. Meet federal drinking water standards.	No additional action required; continue routine sampling.
Non-transient, non-community public water well	Riaten, Inc. at former Navy/Burning Grounds area (UN 208403, 270266, 270267)	No longer used; buildings demolished and wells sealed in 2009	MDH sampled 1995-2003; low levels of disinfection byproducts and 1,2-dichloropropane below HRLs and MCLs.	No action required.
Private well in GOW North	Northeast corner of GOW North [2 shallow wells without UNs (sealed in 2006 & 2013) and 745851]	No longer used; house demolished in 2013 and shallow well sealed, 745851 converted to monitoring well (Janet Dalgleish, UMN, pers. comm., 2/7/14).	Unknown; MDH did not locate any sample records.	No action required.
Private well in GOW Central	Residence adjacent to the Beef Barns on 160th St., GOW Central; no UN)	House now connected to UM water supply; well used only for barn, but incidental use by workers may occur	Unknown; MDH did not locate any sample records.	Near former UM Burn Pit and 160th St. Dump - water should be tested for VOCs, bacteria, and nitrate OR taps should be posted to indicate water is not tested and may not be potable.
Private well in Vermillion Highlands – Area 2 (RROC Research Area)	MPR radio transmitter building (490565)	Incidental use by MPR employees may occur	Unknown; MDH did not locate any sample records.	Near sewage sludge application study area - water should be tested for bacteria, nitrate, PFCs, and barium OR tap should be posted to indicate water is not tested and may not be potable.

Livestock watering wells	Ag barns throughout UM property (207605, 207608, 207609, 207610, 207617, others?)	Although CWI lists many of these as "public supply", apparently used primarily for livestock, but incidental use by workers may occur	Unknown; MDH did not locate any sample records.	Water should be tested for bacteria, nitrate, and any site-related contaminants relevant to well location OR taps should be posted to indicate water is not tested and may not be potable.
Private wells	Several UM buildings in UMore Mining Area (207607, 208402, 208405)	No longer used; buildings use UM water supply or were removed for mining. Unclear if all wells were sealed.	Unknown; MDH did not locate any sample records.	Status of wells should be confirmed and any unused wells properly sealed.

CWI includes records for a number of wells, the current use and status of which are unknown and for which MDH has no sealing records (Figure 21). Six of these wells are located in the Vermillion Highlands: four in Area 1/ Former GOW Operations Area (UNs 235759, 235760, 235761, 235762), one in Area 4/GOW Drainage Area (UN 235766), and one in Area 3/Lone Rock Area (UN 235764). Four more wells are located in UMore East: three in GOW East (UNs 227460, 270244, and 235758) and one in GOW West (UN 767876). However, there are conflicting records for UN 767876 and it may have been only an environmental borehole (as recorded in the MDH Wells Database), rather than a completed well (as recorded in CWI).

Barr also identified several former farmstead sites which may have "abandoned", but unsealed, wells (Barr, 2010a). Unsealed wells represent potential conduits for contaminants to reach the groundwater. A thorough well survey is needed to determine the location and status of the wells listed in CWI and at the former farmsteads; all wells not in use need to be properly sealed in accordance with state law.

Roads

Generally gravel roads were not sampled at this site. However, it was common in the 1970s and 1980s to apply waste oil on gravel roads as a dust suppressant. Roads near GUE were suspected of having PCB-containing waste oil applied and therefore five samples from these roads were analyzed for PCBs. PCBs were detected in three of the five samples at low levels (0.32, 1.0, and 1.3 ppm). The University states that traffic is this area is limited to University vehicles and a few tenants. Exposure to PCBs in dust from the road should be less than the amount of exposure used to calculate the residential SRVs; therefore, PCB concentrations equal to the residential SRV (1.2 ppm) on these roads is not expected to be a health concern. ATSDR uses a Comparison Value of 0.35 ppm to screen for PCBs in soil; however, this value is based on a cancer risk level of one in a million. Minnesota screens at a cancer risk level at 1 in 100,000 which results in higher screening values. As EPA suggested in the 2012 Five Year Review, the University reviewed historical data for indications of contaminated oils used for dust control and to determine if there are other roads on site that should be investigated. Based on this review, the

University believes that with the exception of the roads that were previously tested, most other roads were paved at the time the PCB site tenants were operating (UMN, 2013d).

Current Recreational Use in Vermillion Highlands

Within the Vermillion Highlands boundary is the Lone Rock Trail, a recreational trail for horseback riding, hiking, and cross-country skiing (see Figure 23) (UMN, 2010b). The trail is adjacent to and twice crosses the former GOW drainage ditch in the middle and southern sections. In addition to the trail use, special permits are available for wildlife hunting throughout the year (DNR, 2011). A number of soil samples were analyzed on or near the Lone Rock Trail and there are no findings of contaminants at concentrations that would be of health concern to recreational users. However, soil data is limited and some areas are considered to be an indeterminate risk because of the lack of data and potential for contamination (see Appendix A). More investigation in the Vermillion Highlands is recommended, especially if the land use changes in the future where exposure to the soil may increase (e.g. a playground is built).

The Northern Notch area of the Vermillion Highlands is fenced to protect the public from physical hazards and asbestos. There are additional areas within the Vermillion Highlands where physical hazards have been identified but the property is not restricted.

It is unlikely that children would be wading in any surface water present in the former GOW drainage ditch. It is unclear, however, whether the few surface water and sediment samples are representative of the former drainage ditch as a whole. However, since the public's exposure to the former drainage ditch's sediments and surface water is expected to be minimal, and the contamination found is at low levels, this area is not expected to pose a public health threat.

The MPCA has recommended that further evaluations of these drainage basins be conducted by the U.S. Army Corps of Engineers.

Contaminants at concentrations above the Industrial SRVs

There are a number of areas where contaminants (arsenic, lead, PCBs, mercury, and BaP equivalents) have been found over industrial soil screening levels and a question has been raised about the safety of these areas. Appendix E lists levels of contaminants in surface soil above the Industrial SRVs. Although only a few samples with exceedances were reported relative to the total number of surface soil samples tested, because of the size of the site, there are still areas requiring further investigation (see Conclusions and Recommendations).

Exposures in most areas where these contaminants are found are expected to be limited to the occasional trespasser or University staff. Because current exposure is expected to be very limited and infrequent, acceptable concentrations in surface soils (0-6 inches) should be based on an assessment of acute or short-term health risk. However, data to develop acute risk levels are lacking. Therefore, professional judgment and chemical-specific information is used to determine if current concentrations pose a health risk. Table 7 summarizes the data in Appendix E and provides conclusions regarding short-term health risks from soil contamination throughout the site.

Figure 24 maps the highest PCB, lead, and cPAH concentrations in surface soil that are recommended to be removed.

Table 7: Summary of Surface Soil Contaminants above the Industrial SRVs (0 - 0.5 ft. below grade)

Contaminant in surface soil	Industrial SRV	Number of surface soil samples*	Number of samples > Industrial SRV	Max. conc. (ppm)	Conclusions/Recommendations regarding short-term health risks
Arsenic	20 ppm	682	2	43	No potential short-term health risk; used 110 ppm in the past to address immediate risks for residential arsenic (ATSDR, 2006b).
Mercury	1.5 ppm	596	16	42	EPA's industrial screening value for elemental mercury is 43 ppm; no potential short-term risk unless exposures can occur within an enclosed structure where air concentrations may become elevated.
PCBs	8 ppm	99	4	60	Remove or prevent access to soil with levels of PCBs over the industrial SRVs.
Lead	700 ppm	688	18	8090	Remove or prevent access to soil with levels of lead above the industrial SRV
BaPeq	3 ppm	717	32	260	Remove or prevent access to soil with the two highest concentrations, 260 and 130 ppm. The SRV is based on cancer risk, which is generally not a concern for short-term exposures.

BaPeq = Benzo(a)pyrene equivalency, a calculation to evaluate mixtures of PAHs by comparing their relative toxicity to that of benzo(a)pyrene.
*Numbers approximate as sample depth data not always available.

B. Community Engagement

A public meeting was held to introduce the remedial investigation and to take comments on May 19, 2011. A transcript of the meeting is available online (UMN, 2011). Questions about the soil sampling were asked, and there were comments regarding the University's inaction regarding site cleanup.

On June 28th, 2012, the MPCA and the University held a public meeting at the Rosemount Community Center to describe the remedial investigation and the results. An estimated 20 community members participated, along with many government representatives from the City of Rosemount, Dakota County, EPA, MDH and MPCA. Community members expressed mistrust of the University and felt there was a lack of clear communication regarding contamination found on site. Additional community concerns included:

- air emissions from the adjacent UMore sand and gravel operations
- the effect of site contaminants on drinking water in a housing development northwest of the site and north of the sand and gravel operations

- the lack of investigation of asbestos, nickel, zinc, copper, aluminum, tin, perchlorate, nitrates, and herbicides that Barr stated were associated with GOW during an earlier critique of the USACE's work
- the safety of the land that was recently donated to the City of Rosemount for ball fields
- the asbestos in the soil
- the failure to investigate thoroughly, and
- the site not getting cleaned up

Local news sources also reported on community discontent at the meeting (Rosemount Town Pages, 2012; Apple Valley-Rosemount Patch, 2012). The University responded to several concerns raised at the meeting in a follow-up letter that was posted on the UMore Park Online Information Repository (UMN, 2012b).

VII. Conclusions and Recommendations

The investigations on this site have generally been targeted towards the areas where contamination is suspected based on historical land use. All soil samples have been discrete samples, and there is generally very little data given the large acreage of the site. For future investigations, composite or multi-incremental sampling would allow for coverage of more land area, and more confidence that contaminants have not been missed. The University has identified data gaps where the contamination has not been delineated and some areas that have not been investigated. The University has stated that additional investigation will be needed as development occurs to make sure that the land is health protective for the desired use in the future. Although the new discovery of significant contamination is not expected, there are many potential sub-sites that are not listed in Appendix A that may ultimately be shown to need future remediation.

Health Hazard Conclusions:

Selected areas of the site present a public health hazard or an indeterminate public health hazard for possible exposures to contaminated soils and physical safety hazards. Contaminated groundwater poses an indeterminate public health hazard. An evaluation of health hazards by sub-sites can be found in Appendix A.

Soil Conclusions and Recommendations:

- In limited areas, PCBs, lead, and cPAHs are present in surface soils above levels of concern for industrial land use.
    1) Recommendation: Remove PCBs, lead, and cPAHs that are present in surface soils significantly above levels of concern for industrial land use to prevent exposure (see Table 7).
- Soil near building 707FFF (currently leased as a machine shop) contains cPAHs above the industrial SRVs (5.5, 5.7 ppm).
    2) Recommendation: Remediate soil near building 707FFF to protect the tenants on the site.
- There are no soil samples in the two residential areas on the site that are leased.
    3) Recommendation: Sample the residential yards to ensure the soil surrounding the homes is safe.
- Asbestos containing building materials are present at the site.

4) Recommendation: Remove asbestos containing building materials present at the site. Future development plans will need to take the potential for asbestos in soils in consideration, especially for residential or other land uses where future soil disturbances are likely.

- Because only seven cPAHs have been measured at the site, cPAH risk is likely underestimated.
  5) Recommendation: As portions of the site are slated for redevelopment and remediation, further investigate cPAHs with additional analytes measured or use a mixtures approach (see discussion in section IV. C.).
- Potential still exists for the discovery of nitrocellulose grains that could be explosive.
  6) Recommendation: Continue to take safety measures in areas where nitrocellulose grains may exist.
- PCBs likely remain up to 10 ppm below the 10 inch covered areas in the former NPL areas.
  7) Recommendation: PCBs in the former NPL areas will need to be addressed during redevelopment.
- Consider dioxin/furans as a potential contaminant of concern, especially near the PCB incineration area of the former NPL site.
  8) Recommendation: Measure dioxins/furans in the soil in the PCB incineration area.

Additional Soil Recommendations:

9) Recommendation: Notify tenants near the former NPL site of the contamination in the vicinity of their rented property.
10) Recommendation: Further soil investigation is recommended in select areas of the Vermillion Highlands where the data are limited (see Appendix A) to provide more confidence in the safety of the area for public use.
11) Recommendation: If the UMore site is developed into residential yards and playgrounds for children, care should be taken to remediate soils with lead to levels lower than 300 ppm. EPA/MPCA may update their guidance on acceptable lead levels in residential soils in the next several years.
12) Recommendation: Incorporate composite or incremental sampling in future soil sampling to gain more confidence that contamination is not missed over large land areas.

Groundwater Conclusions and Recommendations:

- There is no indication that site-related groundwater contaminants (chloroform, TCE, carbon tetrachloride, PCE, 2,4-DNT) are currently adversely affecting the drinking water of nearby residents.
- City records indicate that at least a dozen properties located down-gradient of the site are not connected to city water.
  13) Recommendation: Complete a thorough private well survey Sample any private wells on properties within 1,000 feet of the north boundary of UMore Park for VOCs (including 1,4-dioxane) and metals (including antimony, cadmium, chromium, copper, lead, thallium, and zinc).
- High levels of benzo[a]pyrene (up to 490 ppm) and other PAHs exceeding the SLVs were detected in the deepest soil samples collected by the USACE in the GOW West area / 154th St. Dump (AOC-6-S-TP5 and surrounding area). There are no groundwater data from this area or directly downgradient of it. While the potential is low for PAHs to migrate as deep as the water table, without additional information it cannot be ruled out.

14) Recommendation: Complete vertical soil sampling in this area to define the magnitude and extent of soil contamination horizontally and vertically. If contaminants have migrated downward to any significant extent install a monitoring well immediately down-gradient of this area.

- Liquids with a "mothball" odor (likely naphthalene or a related PAH) were reported in soils between 25-45 feet below grade in the area of former Building 237G in the ABC Line area. There are no groundwater data from this area or directly downgradient of it. While subsequent sampling in this area did not detect PAHs, only one deep soil boring was advanced.

15) Recommendation: Given the reported depth of the contamination observed in the initial soil boring, the absence of any water quality data for this area, and the presence of many residential drinking water wells less than one mile down-gradient, install a monitoring well immediately down-gradient of the former Building 237G area to evaluate the water quality.

- Earlier sampling events (TCT, 1985) detected trichloroethane (TCA) in on-site monitoring wells and off-site private wells. 1,4-dioxane was commonly used as stabilizer in TCA.

16) Recommendation: Because 1,4-dioxane is more mobile and persistent than TCA, include 1,4-dioxane as an analyte in any future groundwater sampling event.

- Elevated metal levels were detected in the groundwater at the GOW Garage/GUE sub-site, several above MDH drinking water criteria.

17) Recommendation: include antimony, cadmium, chromium, copper, lead, thallium, and zinc as analytes in future groundwater samples collected from monitoring and private wells located down-gradient of this area.

- Nitrates are above risk-based values in groundwater, but appear to be the result of agricultural, rather than site-related activities.
- A number of wells reportedly are, or were, present at the site for which no current information is available regarding their use or status. Unused, unsealed wells represent potential conduits for contaminants to reach the groundwater.

18) Recommendation: locate wells at abandoned farmsteads and insure that all wells not in use be properly sealed. Use tools including geophysical surveys, to locate wells.

Additional Groundwater Recommendations:

19) Recommendation: MDH should analyze for 1,4-dioxane, antimony, thallium, and zinc in future MDH sampling of residential wells downgradient of the Coates Dump and GOW Drainage Ditch Sites.
20) Recommendation: Test water in all livestock barns and the MPR radio transmitter building for bacteria, nitrate, and site-related contaminants relevant to the area where they are located OR all taps in the barns should be posted to warn workers that they are not tested and may not be potable.
21) Recommendation: Clarify the status of the wells (UNs 207605, 207607, 207617, 208402) in the UMore Mining Area. If the wells are still in use, re-sample the wells for metals, including antimony, thallium and lead, to confirm concentrations and ensure exposures above levels of health concern are not occurring.

General Conclusions and Recommendations:

- Physical hazards may be the most important health threat. Because exposure to soils in UMORE East is thought to be limited, no one is likely to be exposed to contaminants at sufficient doses to cause adverse health effects.

22) Recommendation: Remove physical hazards and/or restrict access.

- For recreational users in the Vermillion Highlands area, no adverse health effects are expected from exposure to contaminants in the soil, sediment, or surface water.
- More information is needed to better understand current land uses and potential exposures.
- Many data gaps exist and no conclusions can be drawn about public health hazards in many areas of the site.
    23) Recommendation: More investigation will be needed before developing the property for unrestricted land uses.

VIII. Public Health Action Plan

- MDH will continue to review environmental data and land use plans for this site as they are available.
- MDH will work with the MPCA to support the implementation of recommendations in this report.
- MDH will communicate with the community regarding health risk as needed.
- Future MDH sampling near the site will include the recommended additional analytes.

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REPORT PREPARATION (ATSDR CERTIFICATION PAGE)

This Public Health Assessment for the Gopher Ordnance Works Site was prepared by the Minnesota Department of Health under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented. ATSDR's approval of this document has been captured in an electronic database, and the approving agency reviewers are listed below.

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